



Beef Breeder Manual

FOR COLD WINTER CLIMATES

BEEF BREEDER HUSBANDRY

MANUAL FOR OVERSEAS MARKETS

COLD WINTER CLIMATES



**Beef Breeder Husbandry
Manual for Overseas Markets
Cold Winter Climates**

AUTHORS

Dr Sean Miller,
International Agriculture
for Development,
Adelaide, SOUTH AUSTRALIA

Dr Michael Cobiac,
International Agriculture
for Development,
Adelaide, SOUTH AUSTRALIA

Dr Bazarbai Inerbaev,
Siberian Division of the
Russian Academy of Sciences,
Novosibirsk, RUSSIA

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Score illustrations
by Brigit Pitman.

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Introduction to the Manual

AUSTRALIAN BEEF CATTLE are in strong demand as foundation breeding stock to develop and redevelop beef industries in a number of countries.

Many of these countries have previously had substantial cattle industries of their own. However, economic circumstances have led to declines in cattle numbers, and production systems have not kept pace with modern beef cattle breeding and management.

Countries such as Russia and Kazakhstan have recently emerged as significant export destinations for live beef heifers in particular; in response to strong Government support programs that aim to reduce their reliance on imported beef.

In addition to lagging technologies and management systems, these countries are set apart from Australia by their extremely cold winters, thus increasing the challenges for managing young, imported cattle from Australia.

Presently, there is a need to provide buyers of Australian cattle in these countries with support that enables them to ensure that imported Australian cattle adapt effectively to the local environmental conditions, that they can be managed successfully to breed and rebreed in their new surroundings, and contribute positively to the development of local cattle industries.

Many cattle exported from Australia, particularly breeding cattle, are farmed in regional areas of destination countries by producers with a range of expertise in animal husbandry. Opportunities exist to build their knowledge base and to provide advice that will result in improved welfare and productivity.

This Beef Cattle Breeding Manual for countries with cold winter climates will contribute to improving animal welfare outcomes in our overseas markets by providing importers with the knowledge to manage Australian cattle in their local environment. It will also contribute to add efficiency and productivity to the customers receiving Australian cattle through exposure to improved



management methods that are focused on optimising enterprise health, welfare, productivity and profitability.

The Manual comprises three resources including;

1. Beef Cattle Breeding Manual - providing high level theory and application of modern beef cattle management principles and practices.
2. Technical Notes - providing practical and applied instruction on important management and husbandry practices.
3. Train-the-Trainer presentation materials - providing instructional material for use to build capacity amongst industry practitioners in-country to support adoption of the practices outlined in the Manual.

1. Receiving Australian Cattle

BEEF CATTLE EXPORTS TO COUNTRIES with cold winter climates are predominantly young heifers that have the intended purpose of improving the genetic basis of local beef cattle breeding industries.

Depending on the mode of transport, either by sea or by air, heifers will be in a weight range of between 240kg to 380kg, and in most circumstances will be unmated at the time of departure from Australia. A limited number of pregnant heifers are exported, and liveweight for these animals will reflect their older age and pregnancy status.

A lesser quantity of slaughter cattle are exported for the purpose of short-term feeding, and to generate cash flow for several large beef development projects until their own-production comes online and supports these vertically integrated breeding, feedlotting, and processing enterprises.

A small number of breeding bulls are exported in conjunction with the heifer trade. These are predominantly young bulls with a focus on use with exported heifers. However, a proportion have a wider intended use in crossbreeding programs with selected local cattle.

Whilst the majority of live breeding cattle exported to cold climate countries in recent years have been of Angus breeding, demand also exists for other breeds such as Hereford, Limousin, and Simmental in particular.

A concurrent demand for Holstein dairy heifers also exists in these markets, and heifers with similar specifications as beef cattle are exported to these climates.

1.1. Importance of Planning

To successfully receive imported Australian beef cattle it is essential that adequate prior planning takes place, and that facilities, staff, and feed resources are well prepared beforehand.

The first 12 months following import are critical to the lifetime productivity of these breeding cattle. The majority of these animals will be young heifers, and managing these animals to acclimate rapidly and effectively to their new environment will ensure that they continue to gain weight, conceive at the earliest opportunity, and successfully re-breed.

In the vast majority of cases, businesses receiving cattle will have existing cattle enterprises that they wish to improve by using imported cattle to develop local genetics. They also have staff with experience managing cattle under local conditions using traditional husbandry methods and facilities. However, the facilities and management of local cattle in countries with a cold winter climate differs substantially from the management of beef cattle under Australian conditions.

For the past two decades, beef has largely been a by-product of the dairy industry in these countries. Cull cows and heifers, and weaner bulls provide the majority of beef available, and a substantial proportion of beef is processed into small-goods.

These cattle are typically housed indoors in large sheds from October to May each year (late autumn to early spring, Fig. 1.1). As a consequence of this intensive management and daily handling from birth, local cattle are highly domesticated, they are well accustomed to physical contact with humans, and husbandry activities are comparatively easy to apply.

By contrast, imported beef cattle, whether they originate from Australia, or Canada and the USA (the other major suppliers of beef breeding cattle), are managed under extensive systems and remain undomesticated. Therefore they are not used to physical human contact. Consequently, the facilities and handling techniques required to effectively manage imported cattle in these receiving countries requires fundamental changes to



Figure 1.1. Calves of dual purpose Russian Simmental breeds housed in a typical cow shed in the Republic of Bashkortostan.
Source: International Agriculture for Development.

be made that benefit both animal and human health, safety, and welfare.

With these conditions in mind, importers need to plan carefully and begin preparations in the 12 months prior to receiving Australian beef cattle so that sufficient time is available to develop the required infrastructure, feed resources, and animal handling skills to safely receive cattle.

The following section describes the planning that needs to take place in the period before cattle arrive, and in the immediate period after arrival.

1.2. Planning for Arrival

1.2.1. Timing

The timing of arrival of cattle in countries with extremely cold winter climates is crucial. The optimum time to receive cattle from Australia is in spring and early

summer, when pasture growth has commenced and temperatures are rising. If imported at this time of year, the cattle have ample time to recover from the travel under optimum local conditions, enabling them to continue to grow and mature prior to experiencing their first cold winter.

Cattle that arrive later in the year, in late autumn and winter for example, have little time to recover and adapt to often extremely cold local temperatures. Cattle imported during these periods must therefore receive a very high level of care and attention as they transition from the Australian spring/summer.

If cattle are imported in winter, it is recommended that they are housed indoors for the duration of the cold conditions, and particular care and attention must be paid to ensure that the cattle are fed sufficient energy to maintain the higher maintenance energy requirement associated with cold weather. They should also not be

exposed to sub-zero conditions without appropriate shelter.

1.2.2. Trained Staff

To ensure the greatest chances of success during the first six months and beyond, it is essential that adequately trained staff are available and utilised to manage imported beef cattle. Skills required include:

- Animal handling techniques, including safety of operations in confined spaces
- Using cattle yards safely and efficiently
- Husbandry operations including weighing animals, placing ear tags, treating for external and intestinal parasites, administering vaccinations, collecting blood samples, identifying and isolating sick animals for treatment, handling bulls, and managing bulls for mating
- Managing nutrition and feeding cattle to reach target weights
- Maintaining and repairing fences.



Figure 1.3. Cattle should arrive in the warmer months to avoid exposing cattle to cold conditions immediately after arriving, particularly if indoor facilities are not available. Source: Bruce Creek, Kazakhstan.



Figure 1.2. Cattle arriving in spring and summer have more time to adapt to local conditions before winter, and allows more time to prepare the facilities required to manage the cattle during the cold winter conditions. Source: Bruce Creek, Kazakhstan.

1.2.3. Quarantine Facilities

The requirements for quarantine facilities for cattle on arrival in country vary depending on local authorities. In many cases, the importer will be required to establish a quarantine facility on their property under the guidance and approval of the local veterinary authority.

The quarantine facility will normally be one or more pens that are able to contain the cattle under daily supervision for the duration of the quarantine period. In some circumstances, allowance may be made by local authorities to quarantine the cattle in paddocks. In both instances, the quarantine facilities must;

- Be able to contain the cattle securely
- Provide adequate space for the cattle
- Prevent contact between the imported cattle and local animals
- Provide a clean and reliable supply of good quality water
- Provide shelter against adverse weather conditions
- Allow the animals to be fed and monitored daily
- Have facilities that enable individual animals to be handled safely and treated for illness or injury as required
- Have isolation pens/areas that can accommodate individuals that need to be separated from the herd and treated differently
- Be accessible to farm staff and Government Authorities at all times

- Control access to the site by authorised persons only
- Implement adequate site entry and exit biosecurity measures.

Where the quarantine facility needs to be constructed on the property and it is required to be a confinement feeding facility, consideration should be given to making the facility a long-term asset for subsequent use to support the ongoing management of the herd, such as for confinement feeding of the herd during winter, or backgrounding and feedlot finishing.

Specific planning and construction considerations for confined feeding yards are provided in the **TECHNICAL NOTE - Planning Confinement Facilities**.

1.2.4. Water on Arrival

To accommodate for the effects of dehydration during the journey, cattle must be provided with an unrestricted supply of good quality water. In addition glucose can be added to the water to aid in rapid recovery of animals on arrival.

The water requirements of cattle varies with the age and physiological status of the animals, air temperature, and the type of forage consumed. For practical management, the following table provides estimations of the daily water requirements for a range of cattle (Table 1.1). These quantities may be used to plan the water needs for imported cattle in the period immediately following their arrival.

Table 1.1. Estimated water requirements of beef cattle. Source: Adapted from National Research Council (2000).

Water intake (L/day) for a range of air temperatures				
Type of Cattle	5°C	15°C	25°C	35°C
Calves 2 to 6 months of age	23	30	45	67
Weaners 7 to 11 months of age	26	34	50	74
Yearlings 12 months of age	34	39	56	85
Pregnant Heifers and Dry Cows	24	27	38	59
Lactating Cows	45	52	69	95
Bulls	34	39	56	85



Water troughs should be long enough to provide drinking space for 10% of the yard at any one time. Allow 300mm length of trough for every 10 head in the yard. That means that one 3m trough section will water 100 head, provided there is enough volume and pressure of water to keep the trough filled, around 10 L/head/hour (Source: New South Wales Department of Primary Industries - Opportunity lot feeding of beef cattle, 2004).

Glucose consumed in the water will provide a readily absorbed energy supplement to assist with the recovery of the cattle following travel, and its taste may also encourage cattle to drink from an unfamiliar water source on arrival. It is recommended to continue glucose for 3 to 5 days following arrival at the quarantine facility. A daily intake of 50 to 100grams of glucose per head per day is recommended, and can be administered by mixing glucose powder with water and mixing into water troughs, with reference to the estimated daily water intake for different types of cattle and prevailing air temperature in Table 1.1.

Regular cleaning of the water troughs is a priority for the first few days after arrival to ensure that cattle remain well watered.

1.2.5. Management of Health on Arrival

On arrival at the quarantine facility, the cattle need to be drafted according to their health status, with particular attention being paid to lameness, dehydration, and general ill health. Any cattle that are identified to be suffering from these conditions must be separated from the remainder of the herd so that treatments can be administered and the animals monitored closely for recovery.

Cattle showing visual signs of stress or ill-health must be inspected by a qualified veterinarian and treated according to the veterinary diagnosis. These cattle should be isolated from the remainder of the herd so that they can be supervised and not cause undue stress to the other cattle.

In the case of severe lameness, this condition may be treated with anti-inflammatory drugs under veterinary supervision, including administration with antibiotics if it is appropriate to do so.

Whilst it is strongly recommended to separate sick and injured animals from the main group, a single animal should not be left alone in a pen or paddock, particularly if they are unable to interact with others. Such isolation of an individual can lead to significant stress and panic.

1.2.6. Feeding on Arrival

On arrival at the quarantine facility, cattle will have empty stomachs and may have been off-feed for as long as 48 hours. Consequently, it is recommended that all cattle are provided with a dietary induction period of five days, whether they are destined for pasture or feedlots, so that good rumen function can be re-established.

An induction diet that has worked successfully for Australian beef cattle exported to countries with cold winter climates is a 70/30 mixture of straw and high quality hay for the induction period. For the first day, this combination is 70% straw and 30% hay, by weight, as the cattle will tend to lay and rest whilst they recover from the journey. In subsequent days, the ratio of straw to hay is adjusted to reach 70% hay and 30% straw by day five.

In the case that a quarantine agreement is reached that enables the cattle to be placed on pasture rather than fed

in confinement for the entire quarantine period, this five-day induction procedure should still be implemented as this period also allows time to monitor the health of the cattle closely prior to being released to pasture. This can be facilitated by constructing a suitable size temporary pen using conventional fencing materials or electric fencing.

An adequate supply of hay should be available to allow continued *adlibitum* feeding for the first two weeks in the paddock also.

1.2.7. Winter Feeding

If the cattle arrive in the period leading into winter, a grain introduction program can commence during the quarantine period, and may commence on day four of the induction feeding period. This provides the additional energy required to cope with the cold weather conditions experienced during winter, and allows continued growth of heifers.

An initial allocation of 0.5kg of a cereal grain such as barley (or wheat) can be introduced on day four, and this may be raised in 0.5kg steps every 3 to 5 days thereafter until the desired grain supplement level is reached. This will typically be between 3kg and 4kg depending on the weight of the heifers and the targeted weight gain for the group.

Introducing cattle to cereal grains in a gradual, stepped procedure allows the microorganisms in their rumen to adapt to the increasing quantity of readily fermentable carbohydrates in the cereal grain, and avoid the occurrence of acidosis, or grain poisoning (Refer Section 4.5.6). This condition results from the absorption of excess lactic acid produced by fermentation of grain in the gut, and cattle are most at risk when grain is first introduced into their diet.

A basal winter diet for heifers that has worked successfully for Australian heifers during winter in countries with cold winter climates is based on providing 2.5% to 3.5% of bodyweight, on a dry matter basis, and providing yearling heifers with approximately 90 MJ (21.5 MCal) of metabolisable energy (ME) per day, and pregnant heifers with approximately 100 MJ to 110 MJ (23.9 MCal to 26.3 MCal) per day depending on body weight. In addition to the prepared ration, good quality hay should be provided in hay feeding racks at all times.

Prior to December, up to 3kg of barley per head will provide sufficient energy in the ration for cattle to continue to grow and cope with the energy demands of early winter. In December these quantities will need to be increased to 3.5kg, and will be sufficient to manage daytime winter temperatures down to -20°C.

With attention paid to seven-day weather forecasts during the coldest winter months, the grain component of the diet can be increased safely in 0.5kg increments prior to the onset of the colder weather to compensate for the increased energy demand. This will allow for an increase in grain consumption of up to 1.5kg, and is sufficient to accommodate a 15 degree drop in midday temperature (to -35°C). Further increases in energy consumption may be required in extreme weather events, and may be managed by further increasing the grain ration by 0.5 kg for every additional -5°C midday air temperature.



Figure 1.4. Radio Frequency Identification (RFID) ear tag - all cattle will have an RFID ear tag on arrival. Source: Leader Products.

1 Megajoule (MJ) is equivalent to 239 Calories (Cal), or 0.239 Megacalories (MCal)



Figure 1.5. Freeze brand applied to the upper rump area on a beef bull. Source: Guide to Best Practice Husbandry in Beef Cattle. Meat & Livestock Australia.

1.2.8. Monitoring In Quarantine

It should be anticipated that cattle imported from Australia will take about 2 to 4 weeks to recover and return to full production. So that their recovery can be monitored and assessed, when the cattle arrive at the farm they should be thoroughly inspected and weighed and body condition scored (refer section 4.1.1) at least twice during the quarantine period; i.e. on arrival at the farm, and upon release from quarantine.

Some additional information may also be available from the previous owner/s of the cattle in Australia. This may be provided from the National Vendor Declaration (NVD) that the Australian seller will provide to the exporter, and may include details such as previous vaccinations. This information may be useful for the short and long term management of the animals.

All of the animals will be identified by radio frequency identification (RFID) tags and Australian Export Tags (Fig.

1.4). The number on these tags should be noted, and records of each animal should be kept so that animals can be traced for the remainder of their life in their destination country.

The importer may subsequently elect to use their own Management ear tags, or alternatively, the cattle may be freeze branded (Fig. 1.5) so that they can be visually identified with ease. In either case, these identification numbers and the original identification numbers must be recorded alongside the importation identification so that the identity of the cattle can be substantiated in the future.

In a number of countries, freeze brands are currently applied to the cheeks of dairy cattle to identify the animals. Animal welfare standards in Australia currently propose that a permanent brand is not permitted to be located anywhere on the head of cattle.

1.2.9. General Health and Husbandry

Critical disease prevention activities need to be carried out as soon as possible after the cattle arrive. These activities will be determined based on local veterinary regulations and documented animal histories provided by the importing agent.

These may include vaccination of heifers with clostridial vaccinations (for example 5, 6, 7 or 8 in 1 vaccines), and treatment for lice and intestinal nematodes (worm treatment - drenching).

It would be advisable to administer a number of additional vaccinations to the cattle on their arrival if they have no previous record of having received them. These may include some of the vaccinations listed on the right.

Advice should be obtained from local veterinarians as to whether any additional animal health treatments are required upon arrival.

If any cattle die in the period immediately following importation, all cases must be thoroughly investigated by local veterinary authorities, and steps taken to ensure minimal deaths occur.

✓ **BOVINE RESPIRATORY DISEASE**

Cattle may be housed and may therefore be at an elevated risk of contracting respiratory infections. Products include Vira Shield (Novartis Animal Health), Feeder Guard, or Bovilis MH+IBR (Coopers Animal Health).

✓ **SALMONELLOSIS**

Where cattle are housed, pigeons frequently co-inhabit the sheds, thus salmonellosis risk is prevalent. Products include Bovilis S (Coopers Animal Health).

✓ **LEPTOSPIROSIS (COMBINATION WITH CLOSTRIDIAL DISEASES)**

Precaution for staff handling the cattle; products include Ultravac 7 in 1 (Pfizer), Cattlevax LC 7 in 1 (Coopers Animal Health).

✓ **PESTIVIRUS (BOVINE VIRAL DIARRHOEA)**

Bovine viral diarrhoea virus is capable of causing a range of disease 'syndromes' in cattle herds, including acute diarrhoea, abortion, and mucosal disease. Products include Pestigard (Zoetis/Pfizer).

✓ **VIBRIOSIS**

Bovine Venereal Campylobacteriosis (BVC) is an important infectious venereal disease of cattle that causes infertility and abortion. Products include Vibrovax (Zoetis/Pfizer).



Figure 1.6. Unloading beef heifers in Kazakhstan. Source: International Agriculture for Development.

1.2.10. Arrival Checklist

The following checklist can be used to ensure that all of the tasks required to receive cattle from Australia are well planned and completed prior to arrival of the cattle.

	REQUIREMENT	MORE INFORMATION
1	Quarantine area is of sufficient size to contain all of the imported cattle for the required containment period.	TECHNICAL NOTE 2
2	Quarantine area is securely fenced. If yarded during cold weather, wind fencing is required, and under-cover shelter.	TECHNICAL NOTE 2
3	Sufficient feed of good quality has been procured to feed all cattle for the duration of confinement.	Section 9
4	Reliable water supply is installed.	TECHNICAL NOTE 2 Section 2.2.11
5	Handling facilities are adequate to enable cattle to be unloaded on arrival at the property, assessed, and treated individually if required. Facilities include; <ul style="list-style-type: none"> • Stable and safe unloading ramp • Secure raceway leading to confinement yards • Crush, or sliding gates installed in race to allow an individual animal to be isolated for handling. 	Section 2.2 Section 2.2.5 Section 2.2.4 Section 2.2.3 Section 2.2.10
6	Isolation pen/s are available to separate sick or injured animals for specialised treatment.	TECHNICAL NOTE 2
7	Staff have been trained to work with cattle so that animal stress is minimised during handling.	Section 4.2
8	Adequate supplies of veterinary pharmaceuticals are on-hand to enable all animals to be treated (as required), including; <ul style="list-style-type: none"> • Vaccines • Veterinary medicines (e.g. antibiotics, anti-inflammatories) • Other treatments that may be required by local veterinary authorities. 	Section 4.5 TECHNICAL NOTE 7
9	Veterinary equipment, including; <ul style="list-style-type: none"> • Vaccination equipment • Blood collection tubes • Syringes and needles • Disposable gloves • Other veterinary consumables as required. 	Section 4.5 TECHNICAL NOTE 7
10	Property infrastructure is developed and is adequate to manage the cattle on their release from quarantine/containment, including; <ul style="list-style-type: none"> • Yards • Fences • Water • Pasture and forage • Human resources. 	Section 2 Section 9

2. Planning a Beef Enterprise

2.1. Planning Requirements

When deciding to go into cattle production the local environment will determine the type of enterprise and the management system required to ensure long term sustainability and profitability. Amongst other considerations, the enterprise will be impacted by the following;

- Where the farm is located
- Climatic conditions
- Rainfall
- Soil type
- Area available
- Water availability and water storage
- Road access and positioning of infrastructure
- Type of production system - feedlotting, grazing, or a combination of both.

Time spent planning the locations of key infrastructure in the early stages will reap long term dividends.

For both new and existing enterprises a number of essential sites and facilities need to be identified, planned, and developed so that imported beef cattle can be run successfully. These include;

- Grazing and forage production areas
- Cattle yards and handling facilities
- Feed and farm machinery storages
- Access to on-site utilities (e.g. power and water)
- Availability of water for cattle all year round
- Winter shelter and wind protection, either constructed or provided by topography or stands of mature trees
- Access to transport (road)
- Access to trained staff.

2.2. Developing the Property

Beef enterprises should aim to have enough land to hold all the buildings for the animals and feed storage, and be able to grow the forages and crops needed to feed all the animals until they are sold. Under suitable circumstances, smaller areas of land can be used to farm larger numbers of animals if the producer is able to buy in feed from other properties, or concentrates and grains from other sources.

In most cases, importers of beef cattle will have existing land resources and farm infrastructure on which to base further development. Where these resources are based on traditional management systems, significant upgrades to farm infrastructure are likely to be required, and these should be planned and developed well before imported cattle arrive on the property.

Amongst the early decisions to be faced by importers, a decision on whether to continue to practice traditional cattle farming, or whether to adopt lower cost, modern beef farming methods needs to be addressed. In most cases, traditional management is highly seasonal, and relies upon;

- Shepherds and shepherding methods to manage grazing of extensive natural and native pastures during late spring, summer and early autumn
- Sheds, confined feeding yards, and intensive management during late autumn, winter and early spring.

Modern beef cattle management techniques are highly adaptable and applicable to cold climate countries, and systems such as fenced paddocks, managed grazing rotations, winter grazing, swath grazing, and paddock-based management of cattle during winter provide new opportunities to substantially lower the cost of

Adoption of modern beef management systems are also likely to require substantial upgrading of animal handling facilities, farm infrastructure, fencing, and improvements in pasture and forage resources and forage conservation so that the benefits of the importation of the pure-bred beef cattle can be captured, and the animals managed safely, productively, and profitably.

Where producers have the flexibility to plan the establishment of new facilities, suitable locations can be planned with the aid of resources such as publically available satellite images (e.g. Google Earth), or aerial photographs. This will enable grazing and cropping areas (boundaries and size) to be allocated to the enterprise, and central locations for infrastructure such as permanent yards, machinery sheds, and other necessary facilities can be mapped out in advance (Fig. 2.1).

- The current use of the areas; for example whether they are used for crop production or grazing
- The soil type and land class; for example well drained arable soils, waterlogged low lying soils etc
- Land tenure; for example freehold or leasehold
- Existing vegetation; for example trees and forests areas
- Water availability and quality; for example lakes, streams, bores.

Once this process is complete, the annual and seasonal forage production (pasture and crop) can be estimated with reference to recent yield data for each of the locations, and used to compare against the anticipated feed requirement of the herd. This feed budgeting



approach will enable the producer to forecast feed demand by the cattle and to plan to have adequate feed reserves on-hand throughout the year.

Importantly, feed production will vary from year to year due to the effects of climate on plant growth, pasture quality, and soil fertility. Therefore it is advisable that a reserve of feed is planned each year to accommodate for reduced plant growth caused by any of these factors. In any one year, this may amount to as much as 100% of the anticipated feed requirement being stored for emergency use.

Each farm should have good road access to ensure that vehicles, including heavy trucks, can easily enter to load or unload animals or feed. Property roads may need to be upgraded or re-sited if trucks are unable to get to the cattle yards. Boggy areas can either be drained or driven around, or they may have to be filled in with rock or gravel to prevent injury to animals and damage to trucks and other vehicles.

2.2.2. Paddocks and Fencing

Traditional management in many countries with cold winter climates has relied on shepherds to manage

cattle during spring and summer whilst the animals graze pasture resources during the day, before returning them to simple wooden pens or sheds at night. With an abundant labour resource utilised in the past to manage cattle, and low labour costs continuing to the present day, significant numbers of cattle remain under the control of shepherds during the May to October period in these regions.

With beef cattle, shepherding may remain a viable management tool in the short to medium term or may be combined with low cost portable electric fencing as a means to control grazing throughout the year. This technology provides more flexibility to the shepherds in being able to manage larger mobs of animals, and minimise the need for many permanent overnight pens at fixed locations, to which the cattle are often moved each night. In other words, the cattle can be left grazing 24 hours a day.

Recent cattle importers in these regions are installing fencing to control animal movement as labour availability declines and costs of employment increase (Fig. 2.2, 2.3). Where fencing does not currently exist



Figure 2.2. Fence construction for cattle projects in Kazakhstan. Source: Bruce Creek, Kazakhstan.



Figure 2.3. Large distances can be fenced quickly using simple construction methods - fence construction for cattle projects in Kazakhstan. Source: Bruce Creek, Kazakhstan.

in any form, the initial capital cost and the ongoing maintenance and depreciation costs associated with fences are high. In order to evaluate whether fencing is a viable alternative to shepherding for this development, financial evaluation is required during the farm planning process.

Simple post and wire fences that are electrified offer one of the lower cost alternatives to large scale fencing for beef cattle enterprises (Fig. 2.4, 2.5). Fences of this type of construction can be erected quickly, enabling large areas to be fenced economically. To remain effective, the fences must be well maintained, and the integrity of

the electric current needs to be preserved to maintain the control of livestock. It is also important that all cattle must be educated with electric fencing to maximise their effectiveness.

Barbed wire fences have long been used to fence large areas of land for use by cattle. However, damage caused to cattle hides by cattle rubbing against the barbs is seeing the replacement of barbed wire fences with electrified plain wires to realise improvements to animal welfare and financial return from all components of the beef animal when sold.

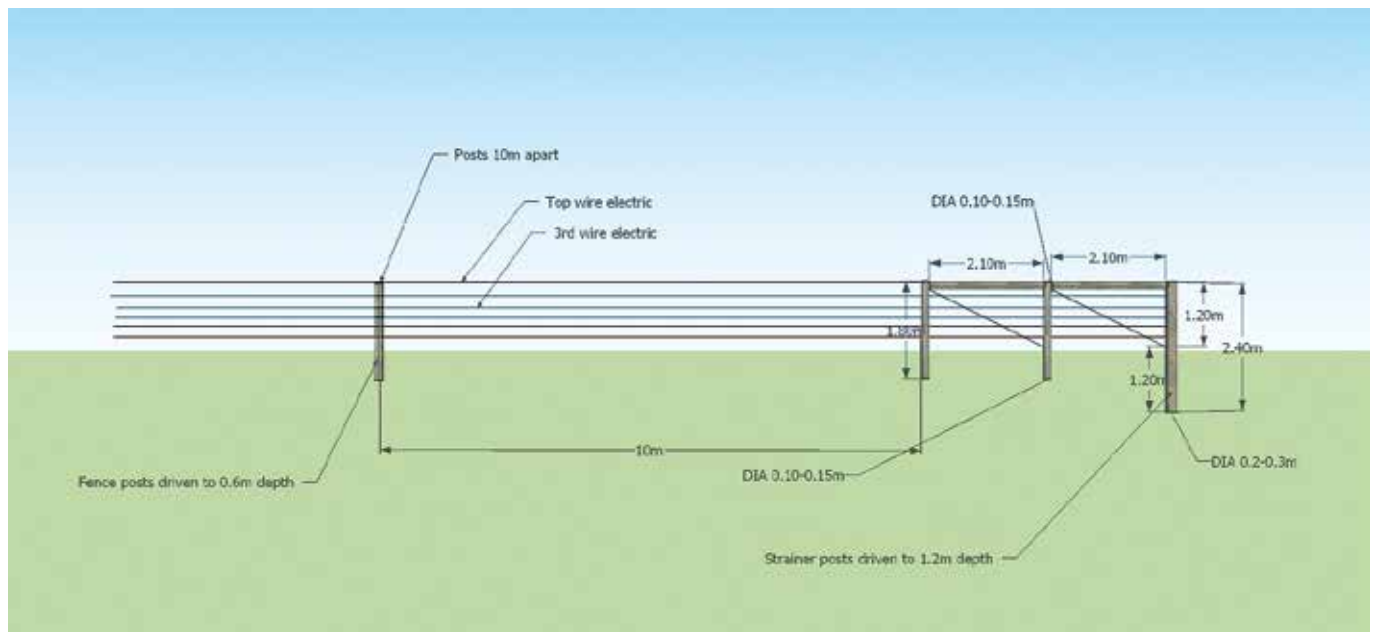


Figure 2.4. Design for six-strand boundary fencing using post and electrified plain wire construction. Source: International Agriculture for Development.

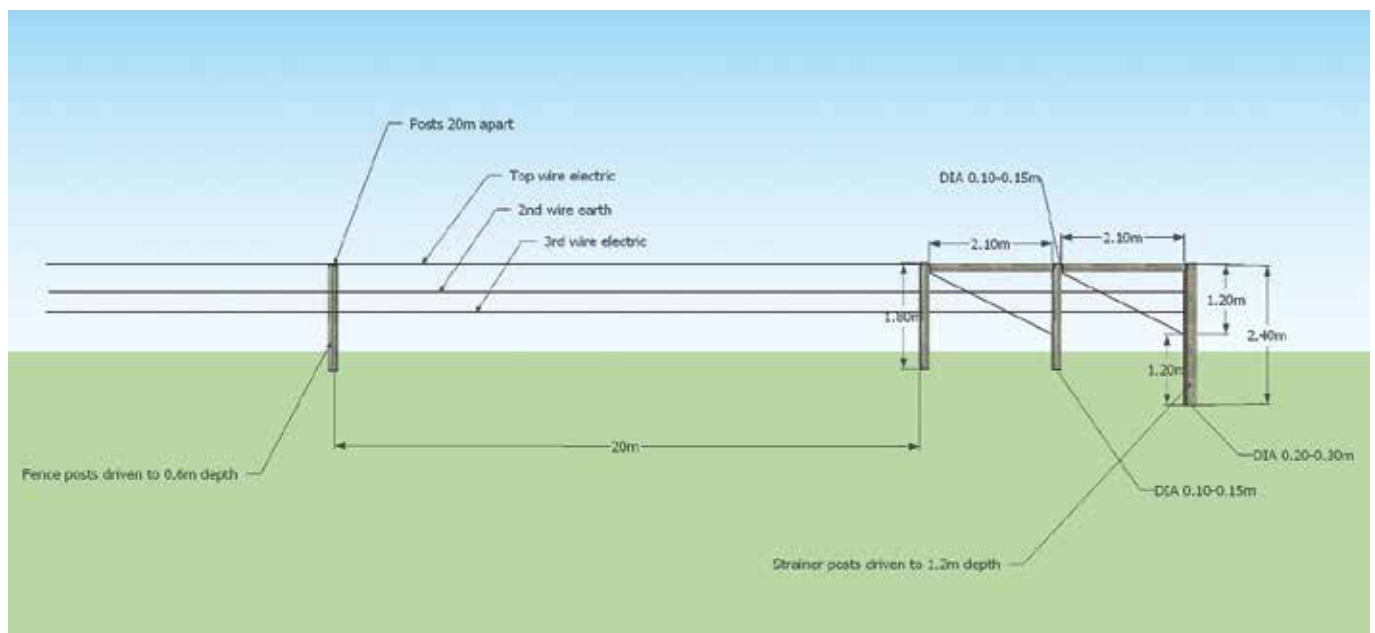


Figure 2.5. Design for three-strand internal fencing using post and electrified plain wire construction. Source: International Agriculture for Development.

2.2.3. Cattle Yards

Cattle yards, and handling and weighing facilities are a major capital investment for a beef cattle enterprise. This investment is well targeted when managing large herds as

the labour efficiencies, animal welfare, and workplace safety outcomes achieved when good facilities are constructed and used offer a high return on the investment.

Yard Placement

Yards should be located on well drained areas that will not become boggy in wet weather (Fig. 2.6). Working cattle in muddy yards is difficult for both the operator and the cattle. In these conditions, it is difficult to move the animals through the yards as they tend not to want to walk through the mud. Also, working cattle in muddy yards increases the risk of infection in the animals as bacteria in the mud can infect existing wounds or skin

abrasions, and mud can accumulate on the coats of the cattle as it is flicked up as cattle walk through it, or if animals lay down.

In areas where high soil moisture is a problem, a layer of compactable, non-pervious material may need to be spread over the selected site to allow water to drain off, and prevent animals from pugging or going through the surface as they move through the yards. Where this is required, the base should be prepared prior to the



Figure 2.6. Muddy yards are difficult for people and animals to work in, and pose a health risk to cattle. Preparing a properly compacted, non-pervious pen floor is a fundamental requirement. Source: International Agriculture for Development.

erection of the yards, and with an engineered slope (of 2 to 3%) and compacted to allow the yards to drain in wet weather.

When looking for a yard site it is important to take into consideration local terrain and existing infrastructure. Yards should not generally be located near water courses, lakes or dams, or other noisy operations such as factories, airports or busy roads.

Where possible, power and water supplies added to yards increase their function and utility. For example, power can be utilised to add lighting and heating to enable the yards to be used during winter operations, and water can be used to support yard weaning operations by providing drinking water to weaners or other cattle during confinement in the yards.

Where cattle are trucked to or from the property, the entry and exit to the yard should enable the truck driver to see other vehicles approaching from any direction. The driver should then have enough time to drive onto the road slowly and not have any animals fall over in the process.

Loading ramps should be placed on level ground so that trucks are able to load and unload cattle safely without a risk to roll over if the cattle move in the wrong direction, and to enable trucks to have sufficient wheel traction to access and leave the yards unassisted in all weather.

Yard Design

The design of cattle yards has progressed substantially over recent years and there are many designs to choose from. Beef managers have individual preferences for cattle yard design, thus an ideal set of yards is subject to personal opinion.

Regardless, all good cattle yards have a number of common elements that together form the foundation of successful designs that utilise the natural herding behaviours of cattle and their instinct to follow other cattle.

These features create an impression in cattle that they can escape from the perceived threat that close contact with people creates, and help reduce the amount of time animals spend in a yard, increase the efficiency of husbandry procedures, and reduce the risk of injury to animals and people.

KEY DESIGN ELEMENTS INCLUDE:

- ✓ A forcing pen (Fig. 2.7)
- ✓ A raceway
(straight or curved, Fig. 2.8)
- ✓ An immobilizing cattle crush and veterinary access gates (Fig. 2.9)
- ✓ Electronic (load bar) weighing scales (Fig. 2.10)
- ✓ Drafting gates or a drafting pound (Fig. 2.11)
- ✓ Sliding gates installed in the race (Fig. 2.12)



Figure 2.7. Forcing pen prior to the race and sliding gate. Source: International Agriculture for Development.



Figure 2.8. S-shaped curved race to encourage smooth cattle flow. Source: International Agriculture for Development.



Figure 2.9. Cattle Crush. Source: RPM Rural Products.

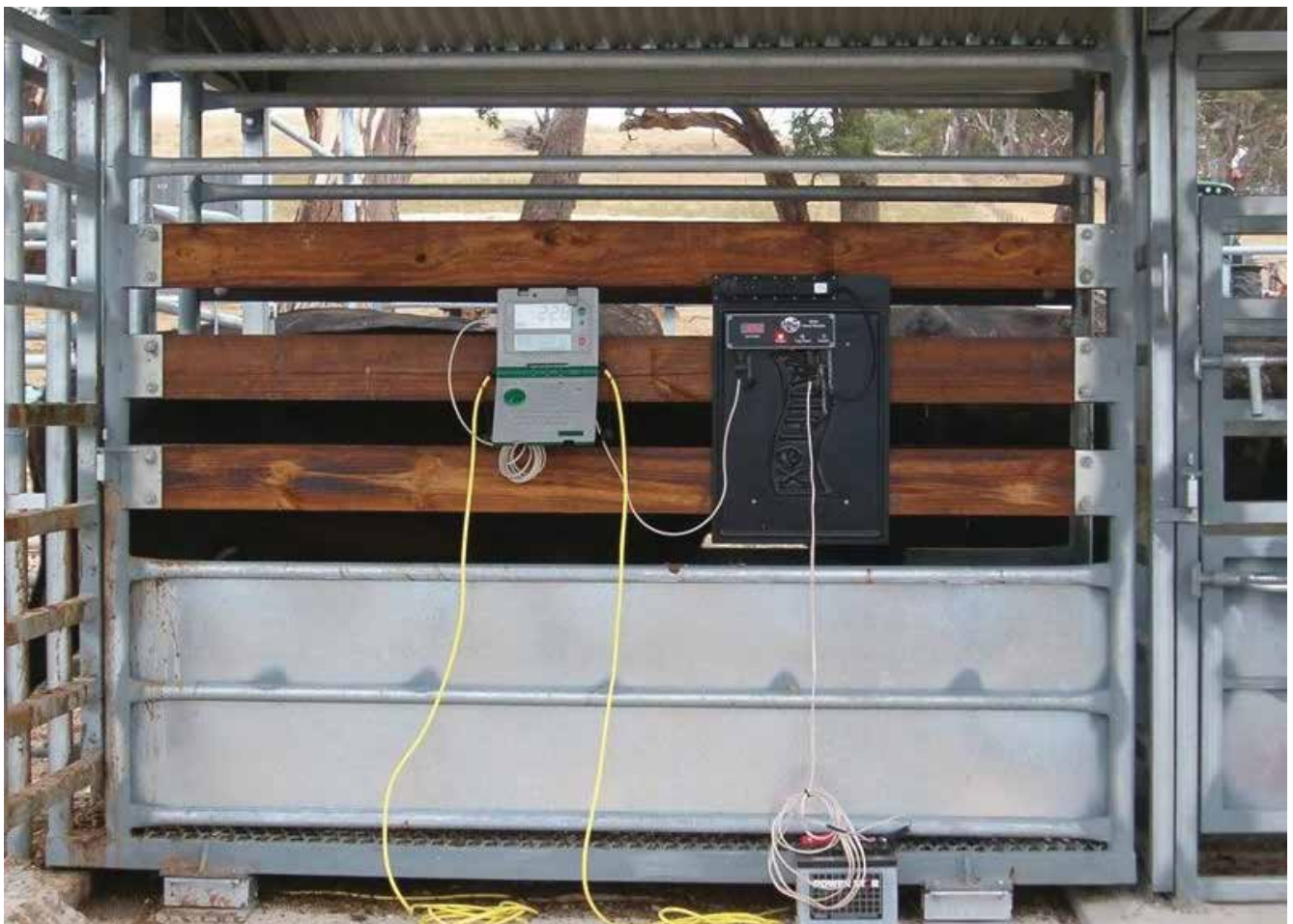


Figure 2.10. Liveweight scales installed under a weighing crate. Source: Magnus Australia.



Figure 2.11. A drafting pound installed in cattle yards. Although there are too many cattle in the yard to draft efficiently in this photograph, a drafting pound can be used to sort animals into groups by separating them into different adjoining holding pens. Source: M&M Stockyards.



Figure 2.12. Sliding gate placed in a race to prevent cattle from moving backwards out of the race. Source: International Agriculture for Development.

Optionally, yards may also incorporate features such as;

- Anti-backing devices in the race (Fig. 2.13)
- Sheeted V-shaped paneling in the race to prevent animals from turning around (Fig. 2.14)
- Exterior elevated walkway along the inside curve of the race (Fig. 2.15)
- Separate weighing crate before the crush (Fig. 2.10)
- Manually or hydraulically operated squeeze on the crush
- Electronic tag reading and data recording equipment.



Figure 2.13. An anti-backing device in a cattle race. Cattle can walk forward through the race pushing the anti-backing device out of the way easily, and with the aid of light spring pressure the device 'springs back' into position behind the animal preventing it from moving backwards. Source: Holdem Cattle Handling Equipment.



Figure 2.14. Sheeted V race. Note the textured finish to the concrete floor of the race to prevent animals slipping. Source: Proway.



Figure 2.15. Elevated walk platform along the race allows easy access to cattle in the race. Source: Eco Enterac.

Any unnecessary loose material must be removed from the yard. This includes logs, sticks, rocks, paper, feed bags and plastic, especially plastic bags. If left lying around they tend to distract or baulk the animals and can cause injury to the handler and animals if they trip or fall over them. Similarly, water pools and boggy patches should be drained and then filled with gravel to prevent water accumulating there again.

For high use areas in the yards, concrete flooring in the forcing yard, race, crush and drafting areas are valuable additions to the design. Where concrete is used, the surfaces must have a rough or marked surface to prevent slippage by animals and handlers.

For very cold winter climates, the working area (crush, curved race and pound) should be contained inside a shed to allow for year-round operation (Fig. 2.16). Inside, the addition of radiant heater elements installed above the main working areas will provide comfort to staff when conducting winter operations.

Yard Construction

Yards can be constructed from either wood or steel components, with choice dependant on the price and availability of suitable quality materials. In both cases, the interior sides of the yards must be smooth to prevent trauma and bruising of animals as they move through the yards. Holding or receiving yards should allow about 3.5m² per animal and about 2m² per animal in the forcing or working yards. The height of these yards should be a minimum of 1,600mm to discourage animals from trying to escape. Yard panels that appear to be low encourage animals to try to escape, particularly if they are under stress. Injury or death can often occur if they try to escape.

Rail spacing should be close enough to prevent animals, even calves, from escaping. To achieve this, the lower rails will need to be closer together and closer to the ground. Examples of rail spacing for wooden and steel rails are shown in Fig. 2.17 and 2.18.



Figure 2.16. Cattle handling equipment located indoors for winter use. Source: International Agriculture for Development.



Figure 2.17. Example of wooden rail spacing for cattle yards. With a post height of 1.6m, rails are 200mm wide, and spaced 200mm apart. Source: International Agriculture for Development.

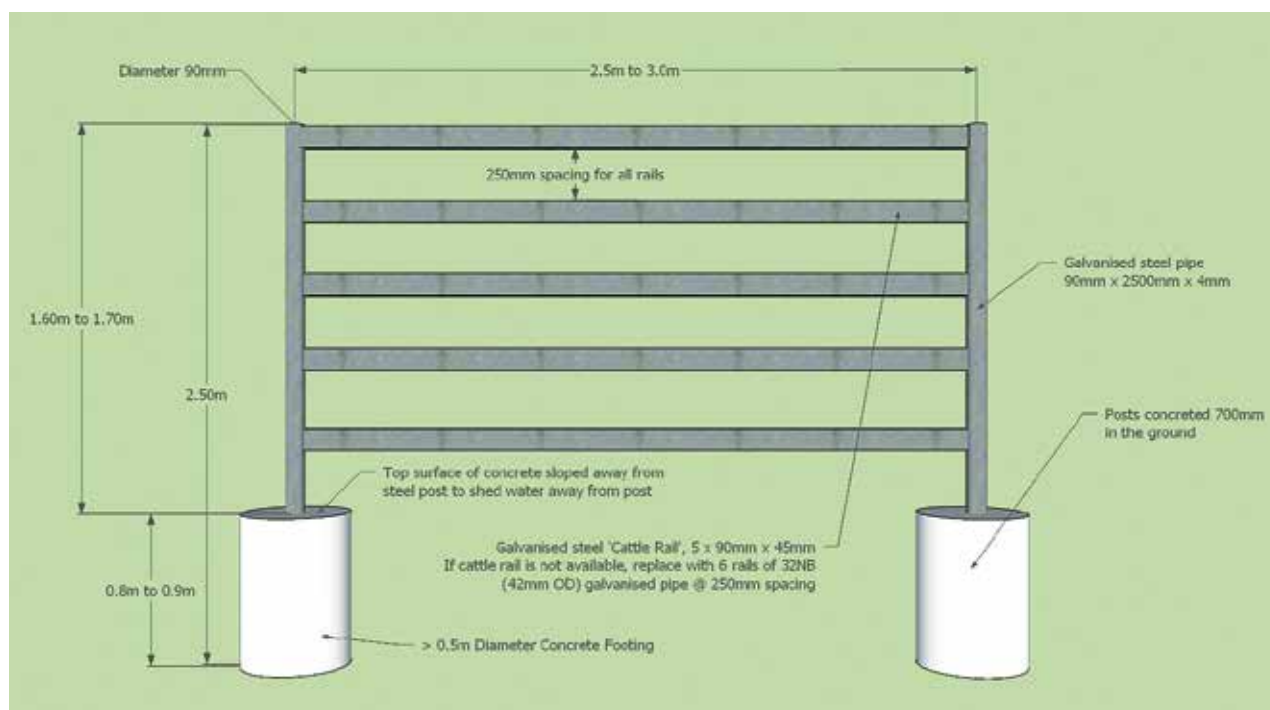


Figure 2.18. Example of steel rail spacing for cattle yards. For a fence height of 1.7m, five rails each 90mm wide are spaced 250mm apart. Source: International Agriculture for Development.

2.2.4. Raceways

Where a lot of animals are to be handled, races should be 10m to 15m in length to efficiently handle and process the animals. Shorter races may be used for smaller herds. As with ramps, the materials used for the sides of the race should be strong enough to prevent the animals from escaping. The sides should be a minimum of 1,600mm high and 760mm to 800mm apart.

As the race is a high pressure area posts should be cemented into the ground 800mm to 900mm deep and heavy walled pipe is one of the easiest materials to use. If timber rails are used, the rails need to be at least 50mm thickness to withstand the pressure applied to the rails and posts spaced no more than 1.5m apart. All pipe posts should be capped or filled with cement to prevent them filling with water and rusting out.

The bottom one or two rails on the working side of the race can be made to be removable so that animals can be released if they go down or turn over. The remainder of the rails should be secured in place to give the race a smooth internal surface.

Older style cattle yards have tended to utilise straight races (Fig. 2.19). However, curved races have gained widespread favour, and combined with sheeting of fences in strategic positions, makes use of the animals natural behaviour and will allow animals to move in a yard more easily. It will reduce stress and injury to both animals and people. It also removes hold-ups where animals can be distracted or attempt to join with other animal groups (Fig. 2.20).



Figure 2.19. Straight race in an older design of cattle yards. Source: International Agriculture for Development.



Figure 2.20. Modern designs utilise curves and strategically placed sheeting to use the behavioural instincts of cattle to move more easily along the race. Source: Commander Ag-quip.

2.2.5. Loading and Unloading Ramps

Regardless of whether the ramp is to be used to load or unload at the wharf, farm, feedlot or processing plant, most features are the same (Fig. 2.21). Ideally the ramps should have a slope no greater than 20 degrees. For

unloading at a farm or processing plant they can be up to 3m wide, but for loading they should only be 760mm wide. Mature cattle should not be able to turn around in them.



Figure 2.21. Loading ramp for cattle with a 20 degree elevation to allow cattle to load onto a truck with ease. Source: Magnus Australia.

The sides can be made from wooden rails, pipe, or sheeting strong enough to stop the animals from escaping, and should be at least 1.6m high. If sheeting is used on the side that the animal handlers work on it should only be sheeted to half the height to allow the handlers easy access to the animal.

The inclined surface of the ramp must be non-slip so that the animals can walk up the ramp in all conditions without risk of slipping and injury (Fig. 2.22).

Ideally, the ramp should have a flat area at the top of about 1m in length (Fig. 2.23). This level area helps when cattle unload from trucks as they are able to step onto

a level surface and steady themselves before moving down the inclined ramp. The height of this level area should be the same as the floor height of the trucks that would be used to deliver and cart away the animals. This height should be determined correctly when building the ramp as it will help to reduce injury, bruising and stress, and involves checking the floor height of local trucks before building the ramp. The sides of the ramp should also be constructed so that there is no significant gap between the end of the ramp sides and the truck that would enable an animal to attempt to escape through during loading and unloading.



Figure 2.22. A non-slip surface created using narrow tread boards installed across the floor of a wooden loading ramp. Source: International Agriculture for Development.



Figure 2.23. Cattle loading ramp with a level platform at the top of the ramp to assist cattle to steady themselves as they step off the truck. Source: Magnus Australia.



Figure 2.24. Poorly designed and constructed handling facilities such as the flimsy, low-sided loading ramp (left) and poorly maintained race (right) are unsafe for cattle and people and must be replaced. Source: International Agriculture for Development.

2.2.6. Laneways

Laneways to and from the yards should be planned to give animals quick and easy access to the yards from paddocks and other areas on the property. This will ensure that their movement is as stress free as possible for both the animals and the animal handlers.

The width of the lanes will vary according to the amount of space available but should be about 6m wide if possible. Wider laneways can be used but more

people will be needed to control the animals and get them to the desired destination. Laneways must also be constructed to a standard that prevents cattle from escaping as they are moved through the laneway.

Gates in laneways can also be used to assist handlers to move or control the animals with minimal stress or danger.

2.2.7. Gates

When designing a yard, it is important that animals can see where you are trying to move them to. Gates should be placed in corners so that animals can move along a fence line and then through the gate that is wide enough to allow a number of animals through at any one time. Where this is done, the fences will assist the handler to maintain control of the animals.

In most cases the gateway entrance to a yard needs only to be about 3m wide. Most other gates will vary between

2m to 2.5m wide depending on the number of animals to be handled and where they are being used in the yard design. It is important that fencing immediately adjacent to gates should be reinforced to handle the pressure of cattle as they move through the gate. Examples of steel gates and gate latches are shown in Fig. 2.25 and 2.26.

An additional consideration for cattle yard safety is the installation of smaller escape gates for people to quickly get access between yards, or escape from the cattle in



Figure 2.25. Steel cattle gates in cattle yards are practical and cost effective to manufacture and install. Source: International Agriculture for Development.



Figure 2.26. Chain latches and spring-loaded 'slam shut' latches are the common closure mechanisms for cattle yard gates.
Source: International Agriculture for Development, Commander Ag-Quip.

the event that an animal becomes aggressive. These gates may only be 700mm to 800mm wide, but should have a strong spring attached to ensure they are self-closing and remain closed to prevent animals becoming stuck in this small gap. An alternative solution is

installation of strong rubber sheeting, such as conveyer belt rubber, across a smaller gap width of about 600mm (Fig. 2.27). The solid rubber effectively 'hides' the escape route from the cattle.



Figure 2.27. An 'escape gate' in cattle yards allows easy access between pens by people whilst cattle remain unaware of its presence. Source: International Agriculture for Development.

2.2.8. Yard Posts

Gateway posts should have a cap rail attached to prevent posts from spreading or moving apart. The cap rail should be high enough that it will allow a person, a horse, or a small vehicle or tractor to drive under without touching it (Fig. 2.28). If the cap rail is made of pipe it can be bolted or welded to the gate posts. All pipe posts should be covered at the top or filled with cement to prevent water getting in and rusting them out.

The base of all posts should be surrounded by a ring or collar of concrete to prevent rusting and rotting at ground level. This collar should be 200mm to 300mm high for both steel and wooden posts, and 200mm to 300mm in diameter for a steel post or 75mm to 100mm around the base of a wooden post.

2.2.9. Electronic Scales

An electronic weighing facility is an essential component of any cattle yard design. The weigh crate or pen can be constructed as a fully contained module that is mounted on top of the weighing load bars. Load bars may be

installed under a crush that has an internal floor, or installed inside the crush and with a weighing platform mounted on top of the load bars (Fig. 2.29).

In each case, a sliding gate must be installed at the entry and exit of the weighing unit. In the case of load bars installed under or inside a crush, the sliding gate at the entry to the crush and the head bail will serve the same function.



Figure 2.28. Example of cap rails on gates to stop posts from spreading. Source: Proway.

2.2.10. Crush and Head Bail

A cattle crush or at the very least a good quality, secure head bail is an essential management tool for beef cattle, and a central part of good cattle yard design. They are used for many procedures such as administering vaccines and oral anthelmintics, treating sick or injured animals, pregnancy diagnosis, and also artificial insemination. In both cases the crush or head bail should be made of strong material capable of holding a large bull securely and safely.

An investment in a quality cattle crush that has good operator comfort and safety is highly recommended at the outset.

KEY ATTRIBUTES OF A DESIRABLE CRUSH INCLUDE:

- ✓ Strong, robust construction
- ✓ Split level opening side gates on both sides
- ✓ Drop-down squeeze (head bail) handle (for operator safety)
- ✓ Operation of the squeeze from the front and rear
- ✓ Vet access compartment, with sheeted lower (kick) door
- ✓ Anti-backing device
- ✓ Side squeeze mechanism

Examples of veterinary crushes and head bails are shown in Fig. 2.30 and 2.31.



Figure 2.29. Weighing load bars installed under a cattle crush equipped with an internal floor. Source: National Stockyard Systems.



Squeeze – head bail

Split level, opening side gates

Front and rear operated squeeze, with drop-down handles

Vet compartment with sheeted lower (kick) door

Anti-backing devices



Figure 2.30. Desirable attributes of a high standard cattle crush with veterinary access. Source: Magnus Australia.

Figure 2.31. A head bail may be installed at the end of a race instead of a crush, but it has limited functionality, and is best suited for small cattle herds. Source: Holdem Cattle Handling Equipment.

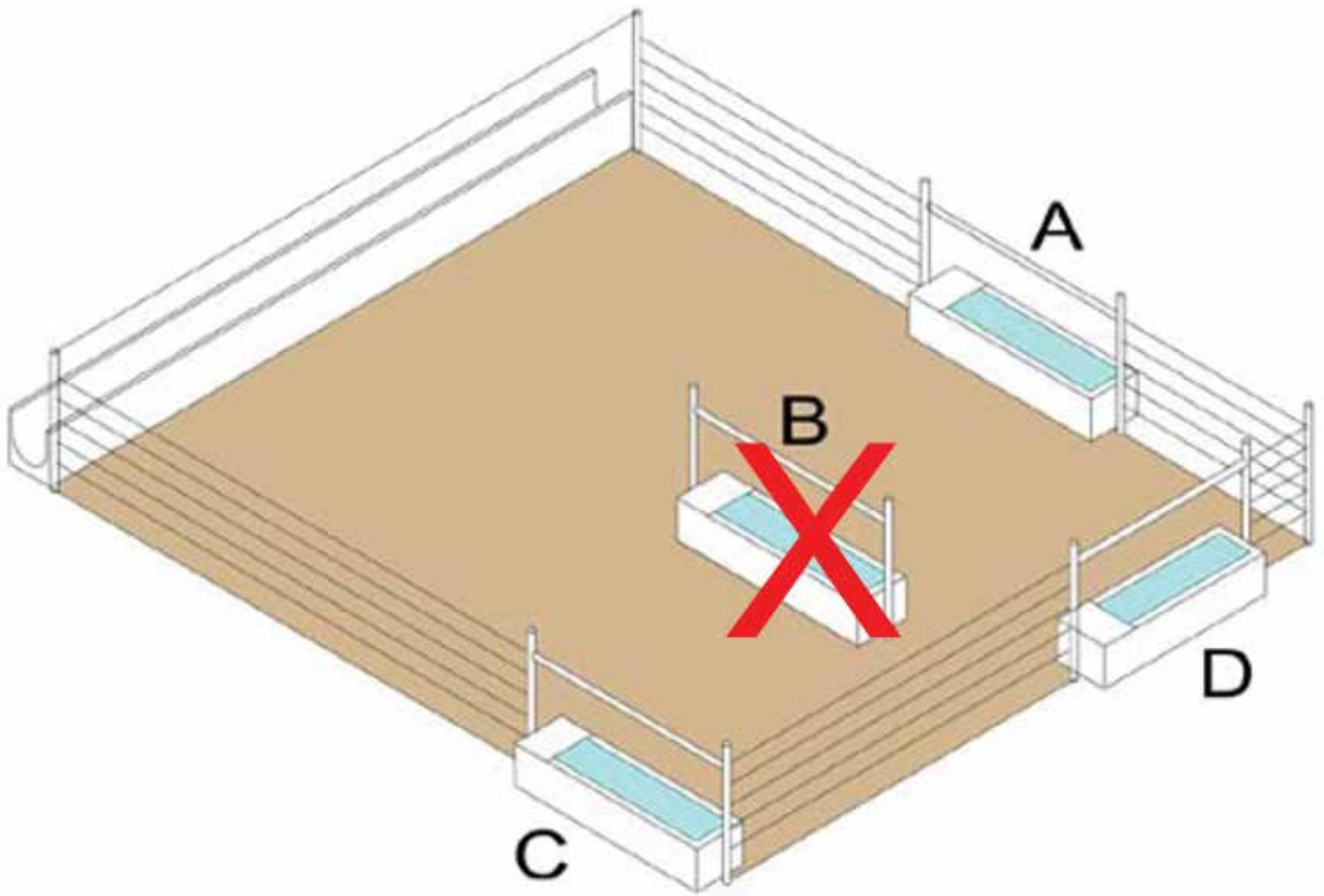


Figure 2.32. Water trough positions. Water troughs should be placed in fence lines (A, C and/or D) and not in the middle of the pen (B).

The cattle crush should be installed on and bolted securely to a reinforced concrete plinth to ensure that it is not able to be moved by cattle when they are contained inside. Similarly, because head bails are affixed to the end of a race, the end posts of the race must be well reinforced and cemented in the ground so that they cannot be moved or broken when animals are restrained in the head bail.

2.2.11. Water Troughs

Depending on the age and physiological status of the animals, cattle will drink between 20 and 100 litres per head per day (Table 1.1 Page 12). This will also vary depending on the air temperature, humidity and importantly the dry matter content of the ration being fed. With this in mind, water supplies must therefore be sufficient to accommodate these demands.

In cattle yards, water troughs can be placed in larger receiving yards and are useful where practices such as yard weaning are implemented, or where there is a need to keep animals contained in the yards for more than 12 hours. In these situations, water troughs are best placed along or in fence lines so that animals in several larger yards can share the trough, and so that they do not impede the movement of animals through the yards (Fig. 2.32). With water troughs placed in this position, the fence structure needs to be able to prevent animals getting into the other yards or pens, whilst allowing animals to easily drink from them.

If these troughs are to be used during winter, the selection of the type of trough and the installation of water supply pipes is critical to prevent freezing of the water. A range of 'frost-free' water troughs are available, including heated water troughs, and supply lines must

be installed to a depth in the ground that is below the frost line to ensure that water does not freeze in the pipes leading to the trough.

Water troughs should not be placed in the middle of yards or in areas where cattle can defecate or walk or fall into the trough. This will prevent contamination of water and the spread of parasites and diseases. Where possible, troughs should not be in the corner of yards.

Water troughs should be cleaned at least once every week, or more often if water becomes fouled. In winter, the water troughs should be inspected daily to ensure that the water in the trough is not frozen. This is particularly important where cattle are overwintered in confinement yards, or when cows are lactating and their daily water demands are substantially increased.

In addition to ensuring that there is a water supply, regular inspection will also allow for the removal of any dirt, algae or dung that has accumulated in the water supply. The water trough should have a drainage outlet with a plug that can make cleaning easy. The plug should be big enough to let the water drain out quickly, and not leak once the plug has been put back.

Dirty water should be drained away from the yards, and waste water from cleaning should not be left in pools around the trough to cause wet, boggy areas.

2.3. Winter Facilities

2.3.1. Modernising Traditional Winter Facilities

Traditional management systems for cattle throughout many countries with very cold winter climates have been based on sheltering cattle indoors from mid-October to mid-May; for example countries of the former USSR, including Russia and Kazakhstan. Consequently, significant and degraded infrastructure remains in many areas where cattle were previously held in overwintering facilities.

In some cases these facilities have been renovated. However, many are beyond economic repair and either new facilities are required to be built, or new management systems that are less reliant on indoor management of cattle are implemented.

Where these facilities continue to be used for cattle, typical structures include a large enclosed shed with an outdoor loafing yard attached to the shed that enables the cattle to exit the barn during winter and spend time in the adjoining yard. Wind protection measures for the cattle are restricted to the wall of the shed adjoining the yard (Fig. 2.33).

A flaw in traditional cattle barns throughout former USSR countries is poor ventilation and lighting (Fig. 2.34).





Figure. 2.33. Winter shed and outdoor feeding yard in Russia. Source: Dr Bazarbai Inerbaev, Siberian Institute of Livestock.

With large numbers of cattle maintained in these older structures during winter, the cumulative effect of body heat, humidity, and condensation resulting from the extreme cold on the exterior of the shed, often causes acute respiratory problems for cattle and other related illnesses.

The condition of these older facilities can be substantially improved with a few key modifications that contribute to better health and welfare outcomes for cattle. These include installing;

- Ventilation (vents) in the roof or walls, to allow for ventilation by convection through the roof vents, or cross ventilation through wall vents (Fig. 2.35)
- Skylights in the roof to allow for better lighting (Fig. 2.36)

- Wind fencing in the adjoining containment yard.

Where there are existing cattle sheds, producers may still use these facilities in the future with imported beef cattle. However a number of key design changes are required to improve the welfare of animals that are housed. These include;

- Where vertical poles exist within the pen space these need to be removed so that they are not damaged or knocked over by cattle rubbing against them, and additional support provided to the roof so that it does not collapse (Fig. 2.37)
- Where the outer roof covering needs to be removed or replaced, special precautions need to be taken where the existing roofing material is of asbestos construction due to the danger posed to human health from inhaled asbestos fibres (Fig. 2.38)



Figure 2.34. Traditional Russian winter cattle sheds are dark and poorly ventilated. Source: International Agriculture for Development.

- If the shed does not have an outer loafing yard, a yard needs to be constructed to enable cattle to move outside at their own will (Fig. 2.39)
- Loafing yards should be fenced with wind fencing to minimise the effects of wind chill, particularly if the shed and yard are not oriented to utilise the wind protection offered by the adjoining shed wall (Fig. 2.40)
- Composting bedding mounds to create heat sources are established in the loafing yards (Fig. 2.40, 2.41, Refer Section 7).





Fig. 2.35. Roof vents improve ventilation and air quality in the shed. Source: International Agriculture for Development.



Figure 2.36. Skylights improve lighting in traditional cattle sheds, and a central laneway assists feeding and feed management where cattle are fed inside. Source: International Agriculture for Development.

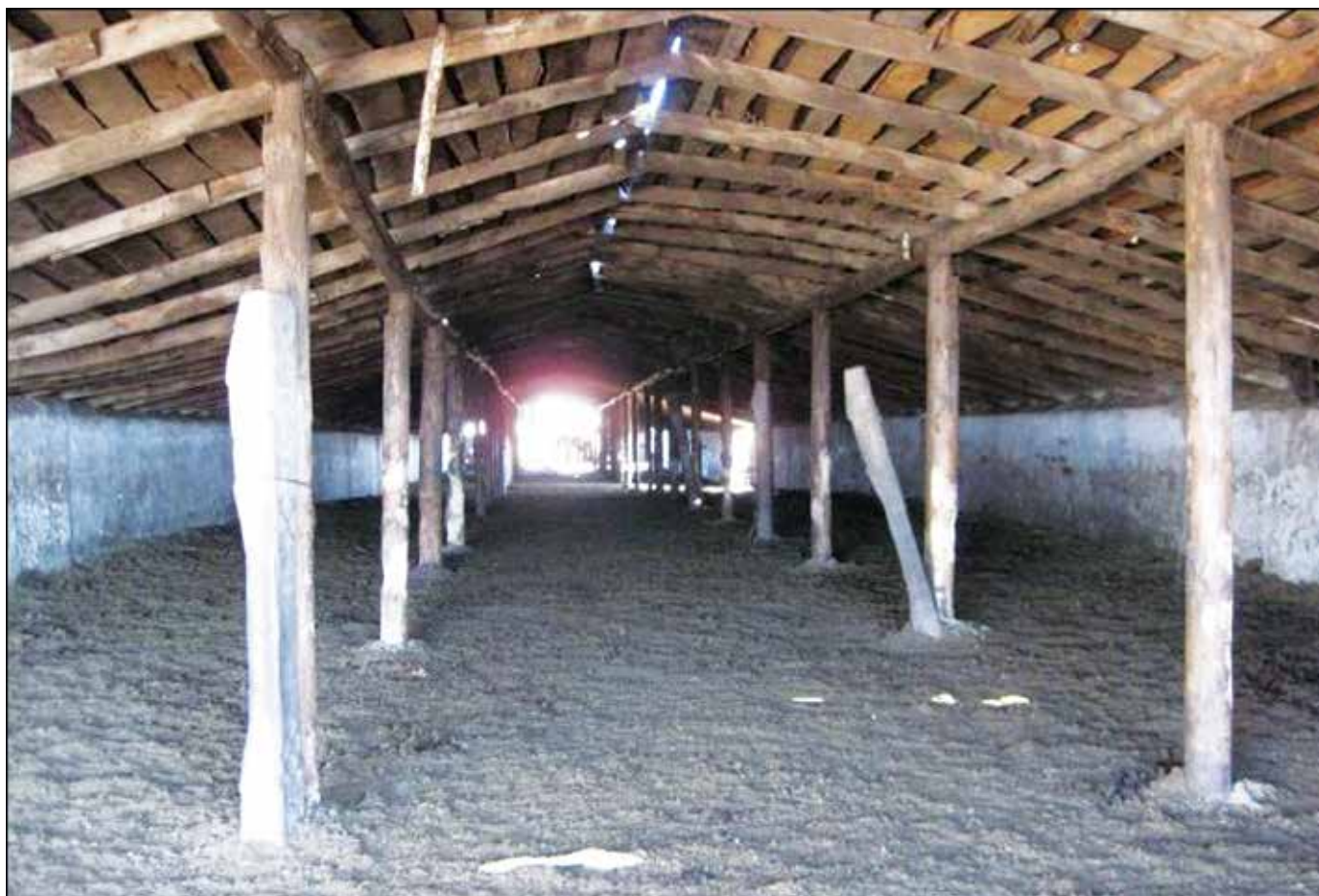


Figure 2.37. Vertical poles (roof supports) in sheds should be removed and the roof reinforced, or pens created inside that exclude the poles from being able to be rubbed against by cattle. Source: International Agriculture for Development.



Figure 2.38. Many older sheds have asbestos roofing materials that need to be handled carefully if it is disturbed during a renovation project. Source: International Agriculture for Development.



Figure 2.39. Outdoor loafing yards that are accessible by cattle improve animal health and welfare in confined winter sheds. Source: International Agriculture for Development.



Figure 2.40. Loafing yard fitted with wind fencing to reduce wind speed and wind chill, and central bedding mound. Source: International Agriculture for Development.

- Feeding cattle outside will encourage cattle to spend time in the yard. Hay feeders placed on the bedding mound contribute to its development and function (Fig. 2.41)
- If cattle are fed inside sheds, a central laneway through the shed assists feeding out of prepared rations (Fig. 2.36)
- Frost-free water troughs installed in the outside yard encourage cattle to move outdoors (Fig. 2.42)
- Concrete aprons should be installed under troughs and extending away from them to prevent muddying (Fig. 2.43)
- The surface of loafing pens should be engineered with non-permeable surface material with slopes that allow the drainage of water and manure out of the pen during the shoulder periods of autumn and spring, when periodic thawing has the ability to generate surface runoff. This prevents muddy conditions developing in the yards (Fig. 2.44)
- Where pens are subject to muddy conditions during thawing conditions, options to remove the cattle to pasture areas should be pursued.



Figure 2.41. Hay feeders placed on the bedding mound and moved periodically contribute to its development and the composting activity that generates heat in the bed. Source: International Agriculture for Development.



Figure 2.42. Cattle drinking from a Siberian-designed frost-free water trough in winter. Source: International Agriculture for Development.



Figure 2.43. Muddying should be prevented around water troughs by installing a concrete apron extending up to 3m away from the trough. Source: International Agriculture for Development.

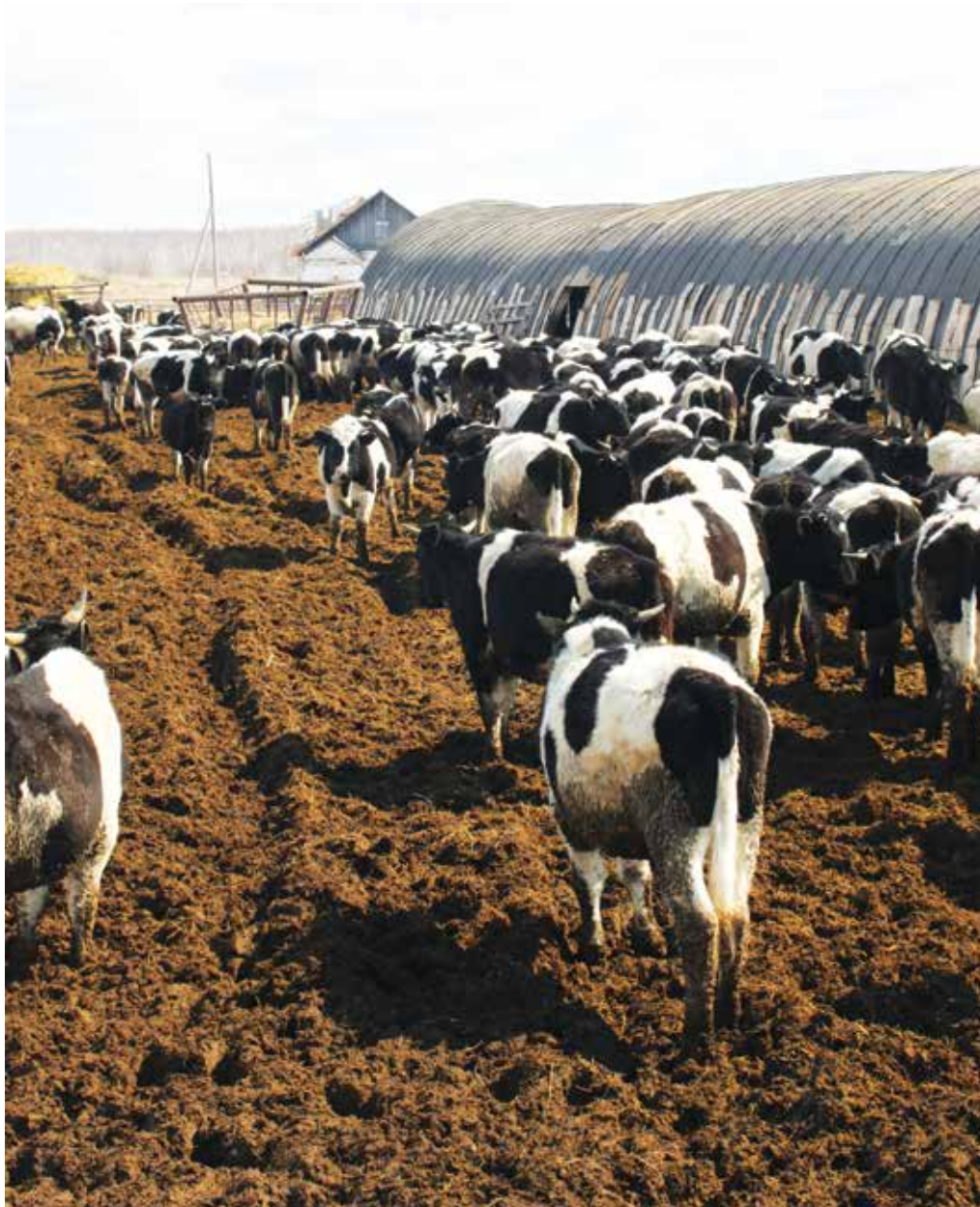


Figure 2.44. Pens with surfaces that are poorly designed create unsanitary muddy conditions for cattle during thawing periods. Source: International Agriculture for Development.

2.3.2. Winter Confinement Feeding Sites

As an indirect consequence of the BSE outbreak in Canada in 2003 and the subsequent crisis in the Canadian beef industry, many beef producers examined ways to reduce the costs of production of beef in order to remain profitable. One of the notable innovations was to move away from high cost shedding systems, to lower cost confinement yard feeding and paddock management of cattle during winter.

Over the past decade, these systems have been developed and adopted widely across Canada and

the northern states of the USA, and have led to both the lowering of the cost of production of beef, and improved herd health.

Wintering sites are simply classified as areas where cattle are fed during the winter months outdoors, and require;

- A feeding area of adequate size
- Appropriate and adequate shelter
- A frost-free water source
- Winter access for machinery to provide feed and bedding materials.

Wintering sites may either be full confinement yards, easily accessible paddocks where feed can be taken to the cattle daily and fed out on top of the snow, or where they can utilise stockpiled pasture, forage crops, or bales of hay (Refer Section 7).

Wintering sites accumulate manure in the feeding and resting areas and around the water source. Because of this, it is necessary to establish systems to contain effluent onsite as temperature increases and effluent thaws in spring. Where this cannot be done the runoff water should be collected and the solids allowed to settle to avoid causing pollution.

Waste water (effluent) can be used to irrigate pastures or crops in the dry season, and the solids collected can also be used as a natural fertiliser.

Consideration must be given to the position of existing water courses such as drainage lines, creeks, rivers and lakes, or water storages such as dams. The drainage from yards or cattle sheds must not be allowed to run into these areas and contaminate those waters. Similarly, where run off is collected in a dam or pond, the dam or pond should be constructed so that it does not leak, and even with heavy rainfall they will not overflow or fail and create additional problems further downstream.

2.3.3. Confinement Yards

Confinement feeding yards enable cattle to be managed in a small area over the winter period with considerably smaller investment in infrastructure than if sheds are constructed. Experience in North America shows that well designed and managed confinement facilities can produce excellent outcomes in terms of animal health and productivity.

Key features of confinement yards include;

- Pen surface constructed from compacted, impermeable materials, with a slope of between 2% and 6%
- Laneway access for feed distribution (5m to 6m width) that allows ease of movement of animals to pens and out again
- Adequate size pens to accommodate cattle comfortably
- Feed bunks located on the outside of the pens on the upslope to allow filling of the troughs with

machinery, and to enable cattle to eat in a non-competitive environment

- A minimum feed trough length of 150mm is required per animal for young cattle, and 180mm for steers and bullocks if fed twice daily. Up to twice this length is required if animals are fed once daily
- Frost-free water source placed away from the feed bunk on a concrete apron extending up to 3m away from the edge of the water trough
- Water troughs should be positioned in the shade where possible and the design should be such that the water is replenished frequently. Troughs used in watering systems should be drained and cleaned regularly
- Wind fencing on all sides to mitigate the effects of winter winds and prevent snow accumulation against the fence
- Height of fences to be 2.4m to 3.6m in height, with 20% inter-board spacing (Fig. 2.45)
- Bedding mound centrally placed in the pen, with straw added to the bed daily at a rate of 2kg per animal in the pen
- Catchment pond down-slope of the pens to contain surface run-off of effluent during thawing period for subsequent disposal (including use as fertiliser)
- Sufficient area adjacent to the site to stockpile any snow that does accumulate on-site
- Accessible throughout winter
- Storage area for forages and grains required to feed the cattle through winter.

Winter confinement yards may add additional utility to the cattle enterprise by being able to be used as a feedlot to finish young cattle during spring and summer, and spreading the investment cost across the enterprise. Additional detail for developing confinement feed yards is included in *TECHNICAL NOTE 2 - Planning Confinement Facilities*.

Pen Stocking Rate and Minimum Area Requirement

The area required for cattle in confinement varies with the size of the animal, with larger cattle requiring greater areas than smaller cattle. To accommodate the variation in size of different classes of animals, a simple

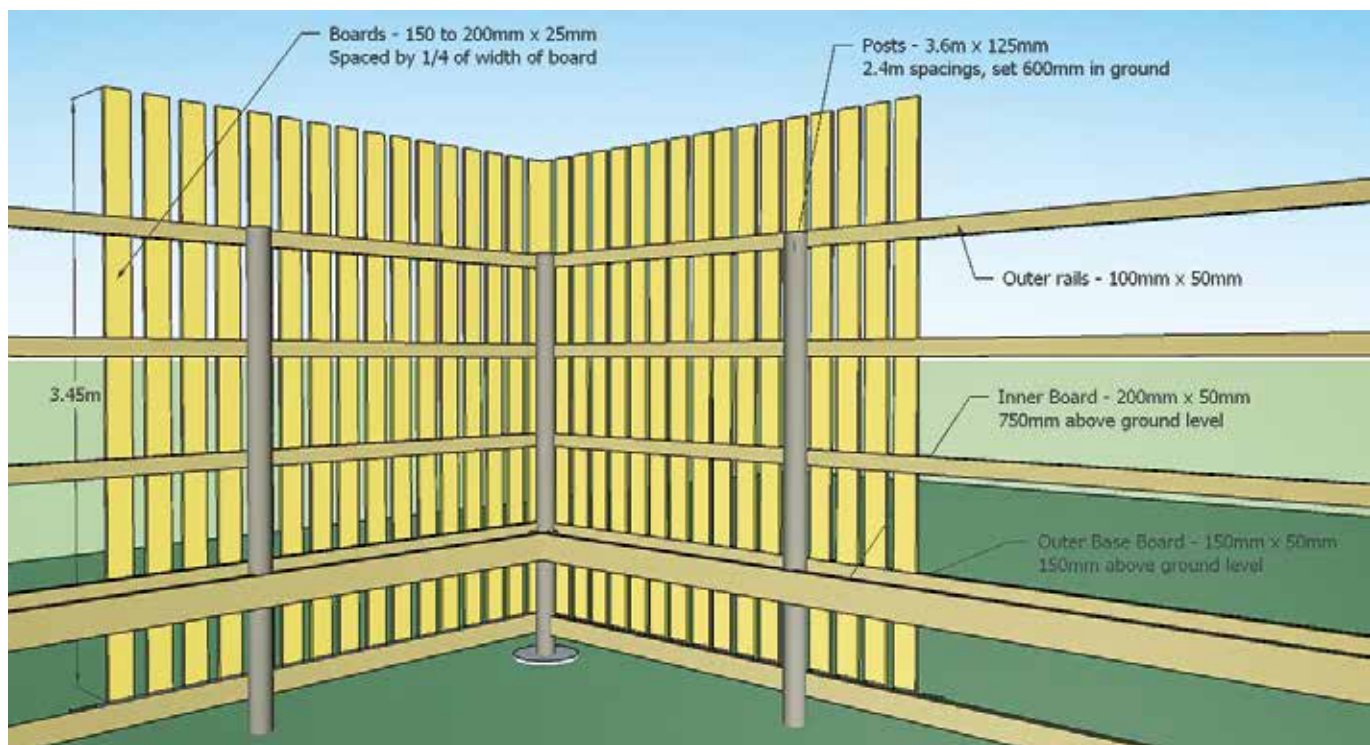


Figure 2.45. Cross section detail of typical confinement yard fence construction. Source: International Agriculture for Development.

conversion is required to equate cattle on a Standard Cattle Units (SCU) basis. An SCU is defined as an animal with a liveweight of 600kg, and a minimum area of 10m² should be provided per SCU in confined feeding yards. If additional land is available, this area per SCU may be increased, but should not fall below 10m².

This requires that the approximate weight of the cattle to be fed in confinement to be known for the feeding period, and this may be estimated by weighing or estimating the weight of the cattle at the commencement, estimating the target weight of cattle upon completion, and determining the average value for the period. This is represented by the equation seen below.

Once the average weight of the cattle during confinement is known, the corresponding SCU equivalent can be determined (Table 2.1), and the area required for the herd can be estimated on the basis of a minimum of 10m² per SCU. This area should also include an allowance for bedding if the animals are to be confined during freezing winter conditions.

Feed Troughs (Bunks) in Confinement Yards

Large cattle require a minimum of 300mm of trough (feed bunk) space when fed once daily. More frequent feeding will allow the trough space per head to be reduced. For twice daily feeding a minimum of 150mm of space is required for young cattle, and 180mm spacing

$$\text{Average Weight (kg)} = \left(\frac{\text{Weight at commencement} + \text{Weight on completion (of confinement feeding)}}{2} \right)$$

Table 2.1. Equivalent Standard Cattle Units for cattle of various liveweights.

Liveweight of Animal (kg)	Number of Standard Cattle Units	Minimum Area Per Animal (m ²)	Additional Area for Bedding Per Animal (m ²)
750	1.18	11.8	4.0
700	1.12	11.2	3.9
650	1.06	10.6	3.7
600	1.00	10.0	3.5
550	0.94	9.4	3.4
500	0.87	8.7	3.2
450	0.81	8.1	3.1
400	0.74	7.4	2.9
350	0.67	6.7	2.7
300	0.59	5.9	2.6

Source: Guidelines for the Establishment and Operation of Cattle Feedlots in South Australia, and Beef Cattle Housing and Feedlot Facilities, Government of Saskatchewan (2010).

is recommended for steers and bullocks (Guidelines for the Establishment and Operation of Cattle Feedlots in South Australia, PIRSA, 2006).

Prepared rations should be provided on the upslope side of the pens to allow for water drainage away from the feed and feeding area. The feed may be provided either in pre-fabricated feed troughs (Fig. 2.46), or feed bunks along the fence line. These should be placed outside the yards but accessible through the fence. In dry winter conditions cattle can be fed by placing the ration directly on the apron outside the yard if it is constructed of a compacted and impermeable material (Fig. 2.47). Since this method can increase feed wastage, under these circumstances the cattle should be fed smaller rations at least twice daily to minimise wastage.

It is not a good idea to feed prepared rations in troughs inside yards as the animals may stand in the troughs and contaminate the rations, causing economic loss (Fig.

2.48). If feed troughs are used, they should not be too high as cattle need to be able to easily get access to all of the feed.

Feed residues should be cleaned away each day and discarded or composted, since unused food will begin to rot and become stale which will spoil the fresh feed and reduce appetite.

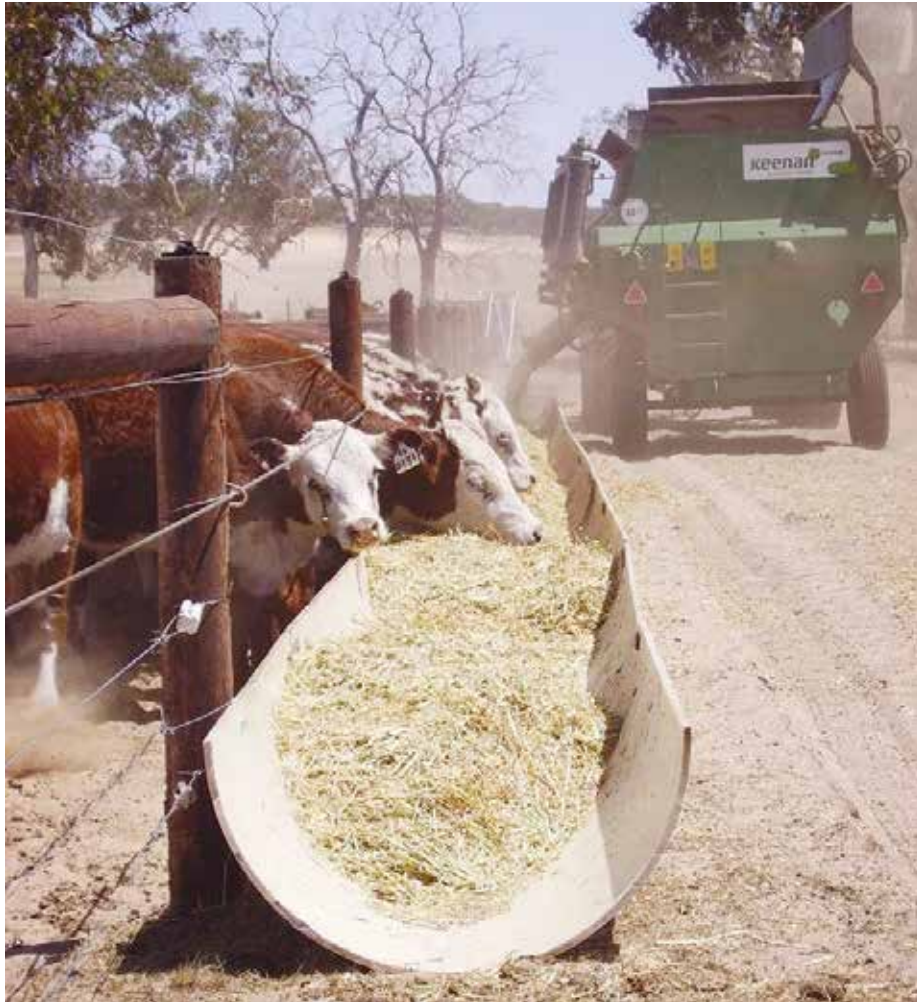


Figure 2.46. Pen-fed cattle utilising a prefabricated feed trough (bunk). Source: Tiffany Bennett, Mundulla, South Australia.



Figure 2.47. Cattle fed in confinement yards adjacent to the outer fence. Source: International Agriculture for Development.



Figure 2.48. Feeding cattle outside the shed encourages cattle to spend most of the day outdoors. However, placing troughs in the loafing pen is not recommended as animals can stand in the trough and contaminate the feed, contributing to feed wastage. Source: Dr Bazarbai Inerbaev, Siberian Livestock institute.

2.3.4. Shelter

It is very important to have shelter and/or windbreaks when grazing pastures in cold winter climates or in a winter-feeding area. Protecting cattle against extreme cold will substantially increase animal production and health and welfare.

Dense stands of trees, even deciduous trees, can provide effective shelter during winter (Fig. 2.49). The reduction in wind speed that shelter provides is critical in enabling animals to effectively cope with sub-zero air temperatures.

Where there are no trees, either fixed (permanent) or portable wind fencing must be used in the coldest winter months to provide shelter to animals grazing open pastures (Fig. 2.50, 2.51). To ensure that the fences act as an effective windbreak, and to also prevent snow

from banking up on the windward side of the fence, the vertical timber slats need to be placed so that some wind passes through the fence.

A porosity of 25% will reduce wind speed by approximately 70% for a distance of 10 times the height of the shelter (Alberta Agriculture and Rural Development). If the windbreak is a solid construction it will force wind over the top, resulting in gusting and snow drifting onto the animals' side of the fence.

Windbreaks need to be positioned perpendicular to the direction of the prevailing wind to be effective, and may be installed in a zig zag pattern to accommodate variances in wind direction if they are unable to be moved easily on a daily basis.



Figure 2.49. Trees providing shelter in a paddock-based winter feeding area in North Dakota, USA. Source: International Agriculture for Development.



Figure 2.50. Sections of wind fencing positioned in a zig-zag configuration at winter feeding sites offer shelter regardless of wind direction. Source: International Agriculture for Development.

To determine the area of shelter required that provides 2.5m² for each animal in the sheltered lee of the fence;

$$\text{Length of windbreak required (m)} = \frac{\text{Number of animals} \times 2.5}{\text{Windbreak height (m)} \times 10}$$



Figure 2.51. Wind fencing in use in open grazing situations in cold winter climates provides protection for cattle against wind chill. Source: Bruce Creek, Kazakhstan.



Figure 2.52. Portable shelters for weaner cattle and heifers in Kazakhstan. Source: Bruce Creek, Kazakhstan.



Figure 2.53. Preferred stacking method for round bales in cold winter climates (left). Bales stacked in configuration on the right tend to freeze together. Source: Creative Commons.

2.4. On-Farm Fodder Storage

Due to both the quantity of feed required during the winter feeding period, and the likelihood that there are periods during winter when forage transport may not be possible due to a depth of snow on roads, on-farm storage of fodder is a requirement for all beef enterprises in cold climate countries. For grain, this requires adequate silo storage capacity. For silage, the preparation of silage bunkers is required, and for hay a sufficient area is required to stack the hay for protection from water and weather until it is used.

When considering any purchase of hay making equipment for a beef enterprise, the storage method of the hay should be considered. If under cover storage is not available, round bales are preferable to large rectangular bales as they survive unprotected conditions better than square bales by shedding water from the curved surface of the bale. Round bales can be stored on their side in rows without stacking, or if stacked they should be no more than two bales high in an end on side configuration (Fig. 2.53 left), and not in pyramids as the increased surface contact between bales will cause them to freeze together in the stack (Fig. 2.53 right).

Large rectangular bales are the preferred shape for road transport on flatbed trailers and well suited to undercover storage as they optimise the storage capacity of the hay shed. This method of storage also limits dry matter loss

due to weathering effects. However, machinery is more expensive than round balers. Rectangular bales stored out in the open suffer greater levels of weather damage than round bales as water is not shed from the surface like round bales, and the bales themselves tend to freeze together when stacked (and to the ground) because of their large surface area (Fig. 2.54).

Traditional silage bunkers are often constructed with cement side walls (Fig. 2.55). However low cost alternatives are also in widespread practice in countries with cold climates; such as storing silage on the ground, compacting, and covering with plastic to maintain anaerobic storage conditions (Fig. 2.56). By adopting low-cost alternatives such as these, the cost of storing silage can be minimised.



Figure 2.54. Storage of hay in sheds reduces dry matter loss of conserved forage. Source: Agnew Construction.



Figure 2.55. Traditional concrete walled silage bunks in Kazakhstan. Source: International Agriculture for Development.



Figure 2.56. Above-ground silage clamps offer a lower cost alternative to concrete bunks. Source: International Agriculture for Development.

3. Beef Cattle Nutrition

BEEF CATTLE NEED AN ADEQUATE SUPPLY of good quality feed if they are to grow, reproduce, and maintain health. Developing balanced, high performing rations for cattle is complicated by the different dry matter content of each feed, the variance in energy, protein, fibre and mineral content of each feedstuff, and the cost of each.

In addition, each type of animal to be fed has a different nutrient requirement, whether they be young, growing animals with high energy and protein needs, mature animals with moderate energy and protein needs, or lactating animals with high energy and moderate protein needs. The cost of feed used in both the breeding herd and the feedlot is a major expense for the business.

The basic sources of feed for beef cattle are native herbage and pastures, crop residues, sown forages, and grains. The most economical sources of feed in most areas are when grasses and legumes are grazed.

3.1. Ruminant Digestive System

Cattle belong to the group of animals known as ruminants, which also includes sheep, goats and deer. Ruminants differ from other animals in having four compartments before the small intestine - the reticulum, the rumen, the omasum and the abomasum, each with a special function (Fig. 3.1). Other animals (monogastric) have a single stomach before the small intestine.

Ruminants take fairly large bites when consuming forages, swallowing the herbage with a minimum of chewing. After eating, ruminants stand or lie down to ruminate or "chew the cud", where boluses of coarse feed are regurgitated, re-chewed and swallowed. This reduces the size of the forage particles and greatly increases the surface area available for microbial digestion.

The reticulum is where all eaten material collects. It interacts with the rumen to push (regurgitate) food back up into the mouth to be chewed again - a process called rumination. Rumination is stimulated by long fibres in roughage; chewing grinds down the fibres and promotes the production of saliva.

The rumen, the largest of the four compartments, contains a concentrated and diverse range of bacteria, fungi and protozoa that are responsible for much of the initial digestion of feed. The capacity of a well-developed adult cattle rumen can be as much as 200L. The presence of a rumen allows ruminants to utilise roughages as a major source of nutrients. Movement of masticated feed and the overall efficiency of breakdown in the rumen are assisted by contractions of the ruminal wall that keep rumen contents moving.

The main purpose of the omasum, with its much folded surface, is absorption of water from the rumen fluid, but some other nutrients are also absorbed. Decreasing the water content of the rumen fluid increases the effectiveness of digestion in the abomasum.

The abomasum or 'true stomach' secretes digestive acids and bile. The microbes are digested, and their protein is used by the animal; fats and remaining starch are also digested at this stage.

Small intestine and large intestine - The intestinal system in a ruminant is somewhat similar to that of a monogastric animal. The small intestine absorbs minerals and proteins while the large intestine absorbs more water along with some energy components, proteins and minerals.

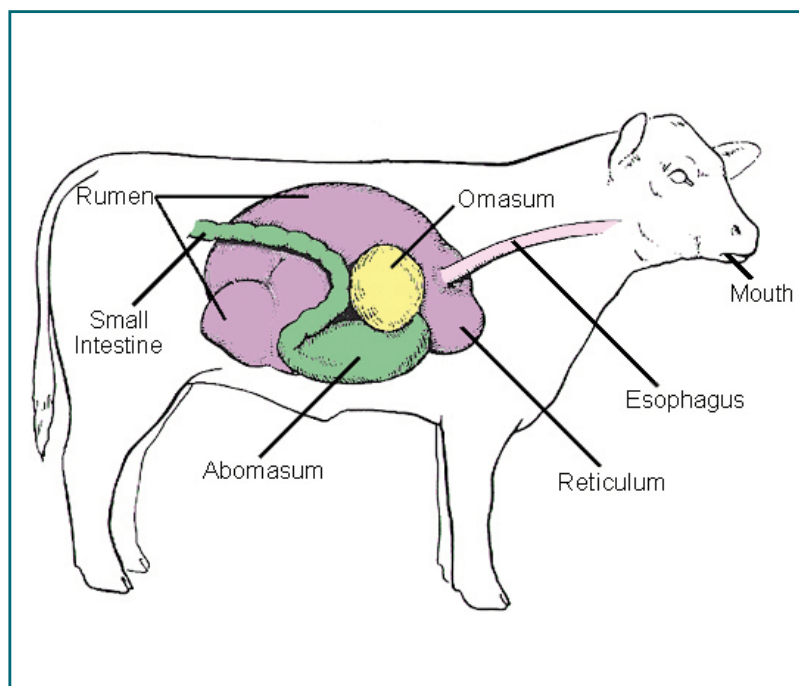


Figure 3.1. The ruminant digestive tract.



Capacity of well-developed adult
bovine rumen:
≈ volume of 200L (44 gal.) drum.

3.2. Concepts of Nutrition and Feeding

3.2.1. Feed Intake

The generally accepted principle is that the amount of feed eaten by ruminants is limited by;

- Rate of feed intake
- Capacity of the rumen
- Rate of passage of digested material from the rumen
- Water intake.

If the rate of digestion can be increased, then the rate of passage will also increase, and which in turn allows the animal to consume more feed. With a higher rate of digestion in the rumen, greater quantities of nutrients are available for absorption in the small intestine, with a consequently higher level of animal production. If the rate of digestion is slow, feed intake is limited by the full rumen.

If the rumen is full of low quality feed, rumen contractions may cease. This is called ruminal stasis, and impaction problems can arise with this condition, sometimes leading to death from starvation or metabolic diseases if cattle are not supplemented with other more nutritious feeds.

Other factors that can have an impact to reduce the intake of a balanced diet, thus leading to production losses are;

- Limiting access to feed or the amount of feed on offer
- Environmental stress, (e.g. heat) which can lead to a reduction in intake
- Plant species selection by the animal
- Moisture content of feed
- The mineral content of feed.

While it may not be important for livestock managers to know the precise nutritional composition of the various feeds, it is important that they understand the concept of different nutrients, the need for general nutrient balance, the classes of feed, and their nutritional strengths and shortcomings. They must also understand how the ruminant digestive system functions in order to understand the impact of poor feeding practice, and how it might be remedied.

3.2.2. The First Limiting Nutrient

In 1843, a German chemist, Justus von Liebig, published the law that bears his name, stating that;

“Growth is controlled, not by the total of resources available, but by the scarcest resource (limiting factor).”

Liebig used the image of a barrel (Fig. 3.2), now called Liebig’s barrel, to explain his law. In simple terms, Liebig’s barrel is used to illustrate that the growth of a living organism is limited by the nutrient in shortest supply (i.e. the first limiting nutrient) in the same way that the

capacity of a barrel with staves of unequal length is limited by the length of the shortest stave.

While this was originally proposed for plants, it also applies to animal growth and activity. Therefore, if any one of the nutrients in Fig. 3.2 is in lower supply than the animal requires for a particular level of performance (e.g. live weight growth, milk production etc.), the animal cannot reach that level of performance until the deficiency is overcome. Increasing the supply of other nutrients does not improve performance, and if the deficiency is extreme, the animal may die.

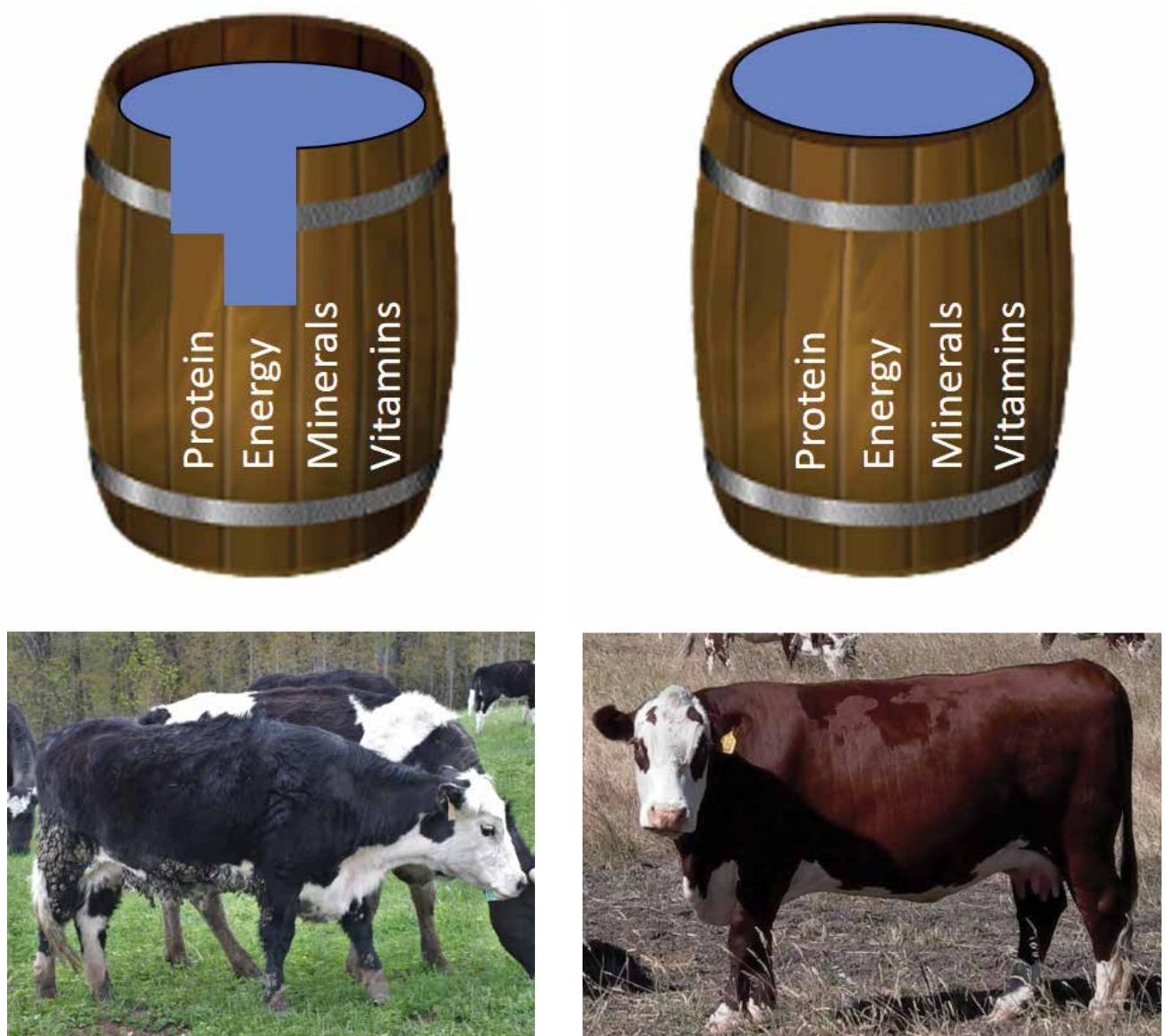


Figure 3.2. Liebig’s Barrel - The volume of liquid held by the barrel can only be increased once the “Energy” stave is repaired. The barrel can only be filled to the top when both “Energy” and “Protein”* staves have been repaired.

*Note: The Liebig Barrel concept is equally applicable to all nutrients. A similar result would be obtained if, for example, the “Phosphorus” stave was incomplete.

3.2.3. Digestibility

Presence of a nutrient in a feedstuff is one consideration, but the availability of that nutrient to the animal is another. Digestibility, the proportion of a dietary component available for animal metabolism, is estimated using various techniques including animal studies and laboratory analyses. It may be expressed as the digestibility of the feedstuff as a whole, or of one or more components of the feedstuff. In general, as digestibility declines so does intake.

Perhaps the most important single factor influencing the digestibility of a feed is the level of lignin in the feed. Lignin is a compound laid down by the plant to give strength to the plant fibres. Unfortunately, lignin is indigestible, and as plants grow older, the level of lignin in their tissues increases. The longer the period from one cutting or grazing of a forage to the next, the lower will be the digestibility of the plant leaves and stems. This in turn leads to reduced forage intake, and poorer animal performance. The balance zone between maximising leaf and minimising stem is shown in Fig. 3.3.

3.2.4. Fibre

Dietary fibre, or sometimes called roughage is the indigestible portion of plants. The most common definition of plant fibre comprises the three polysaccharides cellulose, hemicellulose and pectin, and lignin. Some proteins and waxes are also included in the definition of Plant Fibre.

From an analytical approach to ruminant nutrition, fibre is classified into three categories;

- Crude Fibre - is a traditional measure of fibre content in feeds. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) are more useful measures of feeding value, and should be used to evaluate forages and formulate rations
- Neutral Detergent Fibre - Structural components of the plant; specifically cell walls. NDF is a predictor of voluntary intake because it provides bulk or fill. In general, low NDF values are desired because NDF increases as forages mature

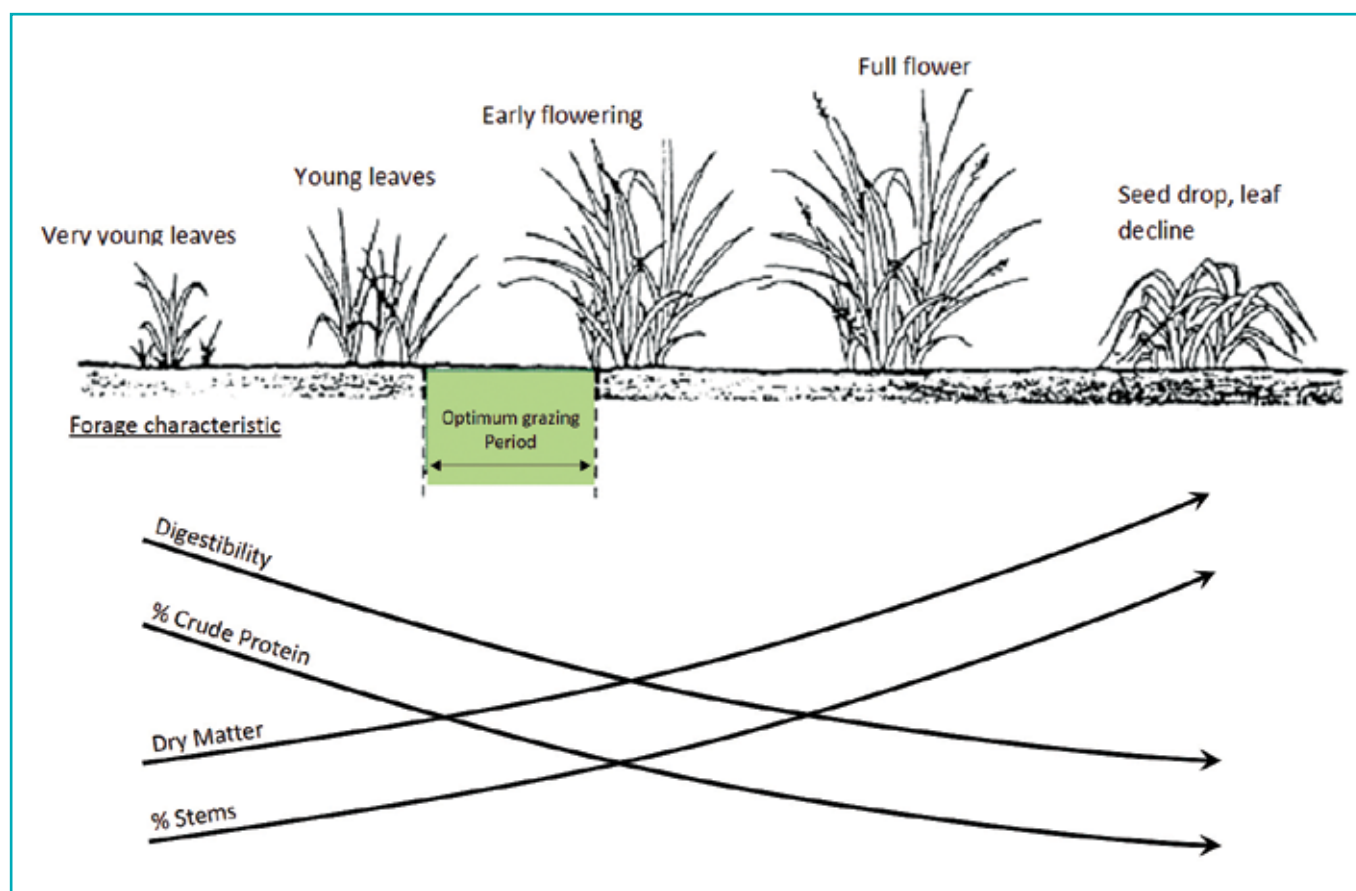


Figure 3.3. Optimum time to cut or graze grass forage is between young leaf and early flowering stages. Source: FAO (<http://www.fao.org/docrep/005/af298e/af298E09.htm>).

- Acid Detergent Fibre - The least digestible plant components, including cellulose and lignin. ADF values are inversely related to digestibility, so forages with low ADF concentrations are usually higher in energy.

Whilst dietary fibre has the ability to depress productivity, particularly plant material high in ADF, fibre is necessary to enhance body function. Adequate fibre level of suitable particle length assures normal chewing activity, saliva production and ruminal function.

Effective fibre is a measure of the feed's ability to stimulate chewing and includes fibre content and texture (particle size). Effective fibre particles are between 10mm and 40mm long, and have a scratchy feel. Symptoms of insufficient effective fibre include:

- Decreased rumination
- Decreased growth rates
- Reduced appetite/intake
- Low body condition score.

The proportion of stem relative to that of leaf increases with age and the onset of flowering in plants generally. Further, the level of lignin in the stems of grasses may be double that of the level in the leaves. The pattern is similar in legumes, but differences are usually less pronounced. In work with the grasses, cocksfoot, perennial ryegrass, timothy and tall fescue, and the legumes, lucerne and sainfoin, *in vitro* digestibility levels of leaf and stem are uniformly high at early stages of growth, but decline as the plants mature.

3.2.5. Palatability of Feedstuffs

An important part of nutritive value is the animal's willingness to eat a particular feedstuff. Sometimes this is simply referred to as "palatability", and is probably confounded by the levels of protein and soluble carbohydrate and digestibility. Given a choice, animals select one feed over another, although not necessarily to the exclusion of the other. This extends through to plant species differences, and to parts of various plants.

When offered a free choice between different forage species presented in a pasture association, ruminants choose a mixed diet, even when one dietary component could meet all of their nutritional needs. Thus, preference and selection cannot be explained simply by the common measures of a species nutritive or feeding value. However, in general, animals select leaf in preference to stem, and legume or young grass in preference to more mature grass. As always, there are exceptions, and it is important to know the feeds available in a particular locality, their approximate nutritional value, and livestock preferences.

3.2.6. "Dry Matter" versus "As-Fed"

Moisture content varies considerably between different types of animal feed, and water may contribute up to 90% of the weight of the feed.

For this reason it is imperative to develop rations on a "Dry Matter Basis". Dry matter is simply the amount of a feed left after all of the water has been removed. By comparing feeds on a dry matter basis, rations can be developed accurately to match the nutrient requirements of the animal, and different feeds can be compared for energy, protein, and fibre content, and cost, on an equivalent basis.

In practice, a ration should be developed on a dry matter basis, and converted back to an "As Fed" basis to make daily feed mixing and feeding a simple task.



3.3. Essential Nutrients

Nutrients are chemical elements and compounds found in the environment that plants and animals need to grow and survive. Animals must have suitable amounts of a given range of nutrients if they are to remain healthy and achieve expected levels of production and reproduction. These nutrients are obtained from the diet consumed by the animal, with each nutrient fulfilling one or more specific roles in the animal's metabolism, and hence on growth, production or reproduction.

THE NUTRIENTS MAY BE DIVIDED INTO A NUMBER OF CATEGORIES:

- ✓ **Energy** - derived from various carbohydrates, fat, and protein
- ✓ **Protein** - true protein and crude protein which includes non-protein nitrogen for ruminants
- ✓ **Minerals**
 - **Macro minerals:**
Calcium (Ca), Chlorine (Cl), Magnesium (Mg), Phosphorous (P), Potassium (K), Sodium (Na), and Sulphur (S)
 - **Micro/trace minerals:**
Cobalt (Co), Copper (Cu), Fluorine (F), Iodine (I), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Selenium (Se), and Zinc (Zn)
- ✓ **Vitamins** - required for efficient immune, hormonal and nervous system function

3.3.1. Energy

Animals need energy, not only to do work, but also for most other body functions. The animal derives energy from the basic energy-containing components of feeds, carbohydrates, lipids (fats and oils), and proteins.

In ruminants, energy is released from these compounds through digestion by micro-organisms in the rumen. Some 75% of the dry matter in plants is composed of carbohydrates, which in turn comprise a range of compounds that serve different roles in the plant. These components are broken down differentially in the rumen (Fig. 3.4).

The energy value of a feed is mostly expressed in terms of metabolisable energy (ME), measured in megajoules per kilogram of dry matter (MJ/kg DM). Metabolisable energy is the proportion of energy in a feed that the animal retains and uses for maintenance and production. In other words, it is the difference between the amount of energy consumed, and the amount of energy excreted in faeces, urine and methane. The energy value of feed is a critical determinant of animal production, and developing rations to match the energy requirements of animals with feed available is a crucial skill.

It is only after all the maintenance needs of the animals are met that energy in the feed can be used for growth, production or reproduction. Cattle energy requirements vary with stage of production, size of the animal, and expected performance (Table 3.1). Growing and lactating animals have a much higher energy demand than mature or dry cattle. Accordingly, additional energy and also protein are often required to balance diets for growing cattle and lactating beef cows on forage-based diets. This is especially true when low quality stored forages make up the majority of the diet.

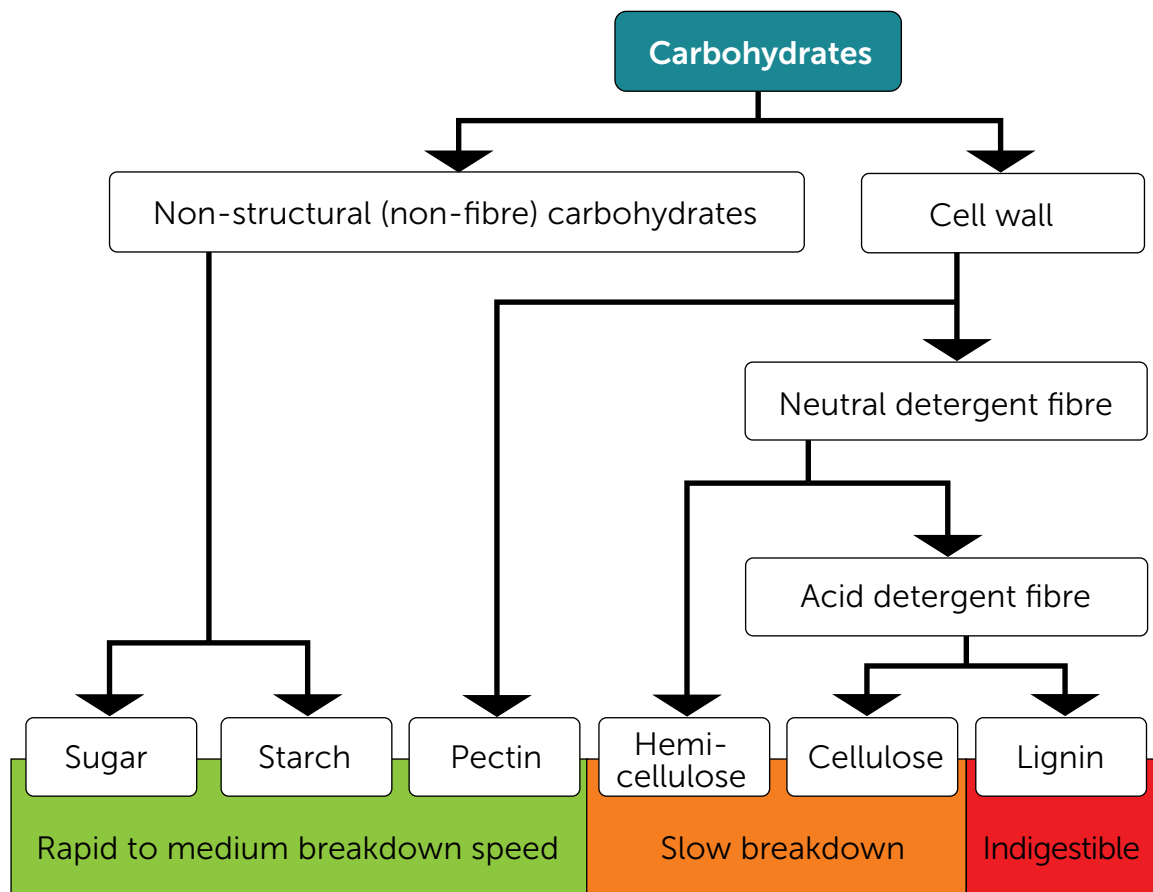


Figure 3.4. Digestibility of carbohydrate components of feedstuffs.

Table 3.1. Estimated energy and protein requirements for various classes of cattle.

Cattle type	Growth Rate (kg/day)	Protein %	Metabolisable Energy (MJ/day)	Dry matter intake (% liveweight)
Non-pregnant cow (550kg)	0.0	8	72	1.8%
Cow and calf (550kg)	0.0	12	110	2.4%
Pregnant heifer (480kg)	0.5	13	85	2.0%
Heifer and calf (500kg)	0.5	13	95	2.5%
Calf weaned (150kg)	0.5	12	37	2.1%
	1.0	13	50	2.6%
Steer/heifer (200kg)	0.5	11	44	2.1%
	1.0	13	59	2.6%
Steer/heifer (300kg)	0.5	10	57	2.1%
	1.0	13	76	2.6%
Young bull (300kg)	1.0	13	76	2.5%
Bull (700kg)	0.0	10	82	1.5%

Source: Grazfeed™, modelled using mild spring conditions in temperate southern Australia.

3.3.2. Protein

Proteins are the basis of all living matter, and therefore are an essential component of the animal diet. Much of the protein in the diet is broken down in the rumen by the rumen microbes. A large proportion of this digested protein is then re-formed into protein in the microbial cells, and digested subsequently by the animal in the abomasum. Some losses occur through the excretion of urea in the urine.

Various terms are used in relation to the protein component of ruminant nutrition:

- **True Protein:** This refers to actual protein that occurs naturally in animal feeds, such as the vegetative parts and seeds of plants.
- **Bypass or Protected Protein:** This is true protein that passes through the rumen to be digested in the abomasum. The presence of condensed tannins in the feed help protect proteins from digestion. Ruminants digest about 30% of their protein as bypass protein. Bypass protein is more efficiently digested than microbial protein because there is less nitrogen loss as ammonia.
- **Microbial Protein:** As the name suggests, this is the protein in the cells of the rumen micro-organisms, and can constitute 50-100% of the metabolisable protein requirements of beef cattle.
- **Non-protein Nitrogen (NPN):** Rumen microbes can utilise non-protein nitrogen such as urea, biuret or ammonium sulphate to produce true protein, which can then be digested by the animal. Nitrogen deficiency in the diet reduces production of microbial protein which, in turn, decreases rumen efficiency. Thus a protein deficiency may also result in an energy deficiency because the microbes cannot maximise fermentation. As little metabolisable protein is stored in the body, it must be fed continuously to be available.
- **Crude Protein:** Since ruminants have the capability to utilise true protein and NPN to meet their protein needs, both components need to be measured in assessing the protein value of their diet. On average, all proteins comprise about 16% nitrogen, so a rough assessment of the protein value of a feedstuff can be calculated by measuring the N% and multiplying it by $100/16 = 6.25$. The resulting figure is known as the crude protein (CP) value of the feed.

The protein content of feedstuffs varies greatly, with high levels in legume leaves and grains, and some by-products such as cottonseed meal. There are moderate levels in grass grains and young grass leaves, and low to very low levels in crop residues like cereal straws. Grasses have lower crude protein levels than legumes at a similar stage of growth.

The presence of a legume in the diet can improve intake of a poorer quality grass. In the longer term, over-sowing of nitrogen-fixing legumes into grass pastures can increase the quantity of grass produced and protein levels in the grass, as well as contributing directly to forage eaten. The protein level of plants declines with plant maturity, and at a greater rate in grasses than in legumes. Likewise, there are also protein level decline differences between parts of the plant. The rate of fall in protein content is less in grass leaves than stems, and is increased at time of flowering in most grasses.

Protein requirements of cattle vary according to the weight and type of animal, as well as its level of production (Table 3.1). Even though a diet may be adequate in terms of energy, if protein is inadequate, then the desired level of production will not be achieved. If protein is the limiting nutrient in a diet, quite often the cattle will not eat to appetite. In general, young cattle need about 14% protein in the diet, and mature cattle about 9% protein.

To achieve the balance, it is best to feed fresh leafy grasses mixed with some legume e.g. clover or medics. Commercial concentrates can be used to increase the protein level in the diet. However, NPN can be a cheaper and viable alternative in protein supplementation.

Urea Supplementation (Non-Protein Nitrogen)

Urea is the most common source of NPN fed to cattle to supplement low dietary protein. It contains about 46% N. However, excess urea is toxic and will kill animals if eaten too quickly or without the basic roughages. It should never be fed to hungry animals. Always offer roughage first to fill the stomach. Animals should always be provided with as much roughage as they will consume (*ad libitum*).

Sulphur is required for rumen bacteria to synthesise certain amino acids necessary for protein production. Consequently, a sulphur supplement may be needed by cattle when they are fed urea in conjunction with roughage low in sulphur. A nitrogen-to-sulphur ratio of 15:1 or even 10:1 is recommended for urea supplements. Sulphur can be obtained from ammonium sulphate



(24% S), sodium sulphate (10% S), flowers of sulphur (100% S) or sulphured molasses (0.7% S as fed) e.g. 1kg of straw needs 10g urea, which yields 4.7g of nitrogen and therefore 1.6g of ammonium sulphate to provide necessary sulphur.

Safe Amounts of Urea to Feed

Urea must be introduced gradually to animals over a period of two to four weeks to allow the stomach to adjust. It should not be fed to animals less than 12 weeks of age and should be fed at a rate no greater than 30g of urea per day in a single feed to animals not used to it. A maximum of 50 to 60g urea/day may be fed to adult cattle adapted to urea in the diet. However, consumption of the urea should be closely monitored at all times to prevent poisoning.

Methods of Feeding Urea

Various methods have been developed to restrict the uptake of urea.

- **Lick blocks (Fig. 3.5)**

A simple method for improving the overall nutrition of cattle on poor quality feed lies with the urea-molasses multi-nutrient block technology. Block mixtures are designed to provide a general protein, energy and mineral supplement. While commercial blocks are available, these tend to be expensive, and it is usually cheaper to prepare home-made blocks or loose licks if materials are available. Details of preparation and feeding of blocks are presented at: <http://www-naweb.iaea.org/nafa/aph/faq-ummb.pdf>

A standard urea-molasses multi-nutrient lick block comprises molasses (30% to 50%), urea (5% to 10%), a protein meal or cereal or legume grain (10% to 20%), salt (5% to 7%), hydrated lime (5% to 10%) and minerals (1% to 2%). Molasses provides a minor energy contribution as well as a range of minerals and vitamins. Protein meal or cereal or legume grains contribute a small quantity of energy, trace minerals and vitamins, and also act as attractants that encourage the cattle to consume the block. Oilseed meals are a good source of phosphorus and soluble and insoluble proteins. Salt acts as an appetite stimulant for cattle to consume the blocks, and hydrated lime contributes dietary calcium, and through a chemical reaction with molasses, acts as a hardener and binder to produce a firm and weather resistant block.

Urea provides the small amount of extra nitrogen, in addition to that present in the forage, that is required to utilise forage dry matter. The multi-nutrient block provides the nutrient requirements of both the microbes and the host animal.

- **Pouring/spraying over low quality roughage**

An alternative to the use of blocks is to spray or sprinkle a mixture containing urea and molasses over the low quality roughage (Table 3.2). This solution needs to be thoroughly mixed to ensure that all the urea has dissolved before applying it to the roughage.



Figure 3.5. Cattle consuming a urea - molasses lick block. Source: International Agriculture for Development.

Table 3.2. Urea-molasses solution for treating low quality roughage.

Component	Quantity
Cereal straw	100kg
Urea	1kg
Water	10L
Molasses	10L

Antidote for Urea Poisoning

The commonly used antidote for urea poisoning is vinegar. At the first sign of urea poisoning (convulsions), the affected animal should be administered one litre of vinegar as an oral drench.

3.3.3. Minerals

Calcium (Ca) and Phosphorus (P) are necessary for livestock growth, bone formation, reproduction and various other body functions. All macro and micro minerals are essential, and the animals' needs for most are met through normal grazing. However, several attract more attention than others because they are more commonly deficient in ruminant production systems, and consequently are more commonly associated with reduced animal performance. These are phosphorus, calcium and sodium. The concentration of these minerals in the plant varies with species, stage of growth and the availability of the element in the soil. Symptoms often associated with deficiency of these minerals in animals are shown in Table 3.3. The symptoms of magnesium deficiency are included because they can be associated with calcium deficiency in animals fed lush ryegrass or oats forage.

Calcium (Ca)

Calcium and Phosphorus are the major mineral constituents of bone, and so Ca requirements cannot be considered independently of P since these two minerals work hand in hand. Ca also plays an important role in muscle function. Ca demands change with age and production status of the animal e.g. non-

lactating, pregnant cows require about 0.18% Ca in the total dry matter intake, lactating cows 0.27% Ca, and growing and finishing cattle 0.31% Ca. The ratio of Ca to P in the feed should ideally be in the range of 2:1 to 1:1. However, performance typically is not adversely affected unless the dietary Ca:P ratio exceeds 6:1. For grazing ruminants, Ca is generally adequate in forages, especially in legumes that tend to have higher Ca levels than grasses. If the legume is deficient in P, a wider Ca:P ratio may result, requiring a supplement of dietary P for optimum animal performance.

Phosphorus (P)

Apart from its role in bone formation, P is the key to major metabolic functions throughout the body (carbohydrate, protein and fat metabolism, and nerve and muscle function). Concentration of P in the plant is strongly influenced by the level of available P in the soil, and the level of P in the plant tissues may be insufficient to meet the needs of the grazing animal, resulting in poor growth and milk production, and low conception rates. Highest levels in the diet are required by lactating cows and growing animals e.g. a 180kg liveweight calf requires 0.28% P in its diet for non-limited growth (National Research Council, 1976); as a steer, its dietary P requirement would increase from 0.15% P to 0.24% P to accommodate a liveweight rate increase from 0.4kg/day to 1.0kg/day.

Table 3.3. Some mineral deficiency symptoms.

Mineral	Deficiency Symptoms
Calcium	<ul style="list-style-type: none">• Poor growth• Bowed leg bones• Brittle bones
Phosphorous	<ul style="list-style-type: none">• Poor growth & milk production• Poor conception rates• Craving for bone, tree bark, wood, hair, soil
Magnesium	<ul style="list-style-type: none">• Muscle tremors• Staggering, convulsions (grass tetany)
Sodium (salt)	<ul style="list-style-type: none">• Poor growth• Chewing or licking of wood• Attracted to brackish water, saline soils

P levels in the diet can be increased in two ways:

1. Fertilising the forage with phosphatic fertiliser. While this method will usually increase the amount of improved forage produced, as well as increasing the P level in the forage, it is a relatively expensive way of improving dietary P levels.
2. Feeding supplementary P using products including mono-ammonium phosphate (MAP), di-ammonium phosphate (DAP) and dicalcium phosphate (DCP). MAP and DAP have the advantage of providing some additional non-protein nitrogen that can be converted to protein. Rock phosphate is not recommended as it contains less available phosphorus than the alternatives, is insoluble in water and is relatively unpalatable. Some sources also contain potentially toxic impurities such as fluorine and cadmium. Care should be taken to maintain the appropriate balance between dietary phosphorus and calcium if using these supplements.

Sodium (Na)

Sodium or salt deficiency is relatively common in animals fed grass and legume forage, since many species have inherently low levels in their tissues. Provision of salt licks can greatly improve performance of animals on pastures low in Na.

3.3.4. Vitamins

Cattle obtain the majority of their vitamin requirements from the feed consumed, with the exception of Vitamin D, which is synthesized in the skin on exposure to the ultra violet light in sunlight. During periods when cattle are on pasture, vitamin deficiencies are generally rare. However, when fed fully prepared rations, attention must be paid to ensure that daily vitamin requirements are addressed.

Grains contain little or no vitamins, and conserved forages and silage contain highly variable levels of vitamins. When rations based on conserved forages and grain supplements are fed to cattle during winter, the addition of a vitamin supplement to the ration will address their daily requirement. Many common sources of vitamin supplements are available to assist in balancing the ration, and typically these will provide the key vitamins A, D and E.

3.3.5. Nutrient Balance

The balance of nutrients consumed by animals greatly affects their performance. In confined feeding situations where rations are prepared for animals on a daily basis, supplying and maintaining a balanced diet is a comparatively simple task. With the aid of feed tests to determine the nutrient content of the feed, and a ration formulating program such as Cowbytes®, Grazfeed™ or others, balanced diets that meet the physiological needs of cattle can be easily prepared.

However, in grazing situations the ideal balance of nutrients required to achieve maximum performance rarely occurs, and identifying the primary limiting nutrients and providing supplements can significantly improve productivity. However, this is not always economical or practical. In all circumstances, the health and welfare of the animal is the overriding consideration in meeting its nutrient requirements.

In ensuring that animals receive a balanced diet, producers should consider the hierarchy of supply and availability of the essential nutrients; energy, protein, macro minerals, micro minerals and vitamins. Substantive dietary deficiencies can then be addressed by basing management decisions such as supplementation on the most critical limiting nutrients first.

3.4. Water

Water is essential for animal survival. It comprises between 50% and 80% of the animal's liveweight. It provides the basis for all fluid in its body i.e. the blood supply, the digestive process (breakdown of nutrients, movement of feed through the digestive track, and in flushing the animal's body of waste), the production of milk, and has a role in regulating body temperature.

There are many factors influencing the quantity of water required by cattle:

- Air temperature and relative humidity. In hot weather, animals use more water for evaporative cooling, and consequently their water needs are greater as temperatures and relative humidity rise. Water intake doubles when daily temperatures increase from 21°C to 32°C.
- Class and size of animal. As a "rule of thumb", cattle drink at least the equivalent of 5% of their

bodyweight in water per day. On a fairly hot day, dry cows and bulls drink the equivalent of about 10% of their bodyweight, while growing cattle and lactating cows drink the equivalent of about 20% of their bodyweight. Providing insufficient or poor quality water to cattle can limit growth, production, and cause health and welfare problems.

- Water temperature and quality. A plentiful supply of fresh, cool water is important for cattle, as warm water reduces intake and will reduce weight gain and productivity. Generally, animals prefer water at or below body temperature, avoiding warmer water, and preferring cool water in hot conditions. Drinking water for beef cattle should contain less than 4,000mg/L (ppm) dissolved salts, and have a pH value between 6.5 (acid) and 8.5 (alkaline). Algae in troughs should be controlled, since they can produce unpleasant odours that will discourage stock from drinking. Livestock should never be forced to drink dirty or contaminated water. It is important to have at least two days' supply of water available in case of supply failure problems. Water supply should be monitored at least twice daily to ensure there are no problems.
- Toxicity/Contamination: Sites of potential contamination/pollution in the system include: the source (bore, well, spring, dam, waterways), storage container, and the trough itself, most commonly through feed or manure. Cattle should be prevented from drinking surface water in areas where the liver fluke parasite is present (Refer Section 4.5.2).
- Feed quality (level of dry matter intake). Stock on dry pasture consume more water in order to utilise the less digestible fodder. The extra water is used to maintain the movement of the coarse feed in the gut.
- Moisture content in feed. Good green pasture can supply a proportion of the animal's water needs.
- Level of activity. Active animals drink more water.
- Access to shade. Water intake is increased if no shade is available.



3.5. Feed Management

3.5.1. Feed Testing

Testing the quality of individual feedstuffs used to prepare rations for cattle is a fundamental requirement to being able to formulate efficient and cost effective rations for cattle, particularly during winter when energy requirements are critical to manage animal health and welfare.

Feeds vary considerably in the concentration of individual nutrients, both between and amongst the same feed types. For example, high quality pasture silage would be expected to contain in excess of 10.5 MJ of metabolisable energy per kg of dry matter, and at least 15% crude protein. However the same pasture cut for silage just a week later may look exactly the same, but only contain 8.5 MJ of energy and 10% protein.

In addition, excess moisture in hays, or too little in high dry matter silages - in excess of 45% dry matter, can result in heating which binds some proteins to sugars and turns them into a condensed but indigestible 'syrup'. Whilst cattle may eat heat damaged forages very readily because of this syrup effect, they perform very poorly due to the very low quality of the feed.

Low quality feed comes at a very high cost to both the business, in terms of lost energy and protein, and the animal eating the feed, in terms of lower growth and productivity.

The key nutrients to quantify in feed are metabolisable energy (ME – megajoules per kg), crude protein (CP - %, or g/kg), and neutral detergent fibre (NDF - %, or g/kg). With these three nutrient concentrations known in the feeds on hand, a balanced diet can be formulated to meet the weight and body condition targets set for the herd.

When the quality of the feed is known, several high quality computer programs can be used to help calculate balanced, least-cost rations, e.g. Cowbytes (Alberta Ag and Rural Development, Canada), and Grazfeed (CSIRO, Australia).

3.5.2. What to Feed

Grasses

Grasses, which comprise perennial and annual species as well as many of the human food plants like sugar cane and the cereal grains, are the most common source of

ruminant feed. The feeding value of temperate grasses is highest when the plants are young and leafy, and declines progressively as the plants mature. Consequently, while it is tempting to leave grass longer before cutting or grazing to allow maximum accumulation of forage, it is best, in terms of animal production, to use the grass before it becomes too mature, as this will only increase the percentage of indigestible fibrous stems and/or seed heads (Refer Fig 3.3).

Legumes

Legumes are a diverse group of plants ranging from low growing herbaceous species, through creeping and twining types, to shrubs and large trees. The one aspect they all have in common is that they all set their seeds in pods.

While there are three families of legumes, all the common temperate legumes belong to the family, Fabaceae, distinguished by a pea-shaped flower (Fig. 3.6).

Legumes generally have higher feeding value than grasses at a similar stage of growth, due largely to the fact that many legumes have the ability to extract nitrogen from the atmosphere and convert it to plant available nitrogen in nodules attached to their roots. This leads to plants having high crude protein levels in their leaves and stems. By contrast, grasses rely on soil availability of nitrogen to supply their protein requirements.

In mixed pastures, legumes perform as a valuable energy and protein supplement to grasses in the pasture sward that together provide the bulk of the animal's diet in a grazing situation. The extent of the impact of feeding legumes to cattle is related to the proportion of legume in the diet, the quality of both grass and legume, and the total amount of forage available to the animal.

When feeding poor quality grasses, even an additional 5% legume can produce a significant benefit to animal performance, although higher amounts will have greater impacts. Feeding pure legume diets is wasteful of protein, and in some cases may be detrimental to animal health and reduce animal performance, for example young, leafy alfalfa may cause bloating in cattle and eventual death if untreated.

In general, considerable benefit can be gained from feeding between about 30% and 50% legumes in the total forage diet, on a dry matter basis.



Alfalfa/Lucerne (*Medicago sativa*).



White clover (*Trifolium repens*).



Birdsfoot trefoil (*Lotus uliginosus*).

Figure 3.6. Examples of pea flowered forage legumes.

The value of feeding legumes increases with the onset of the dry season as grasses mature and their feeding value declines.

Crop Residues

Crop residues are commonly available sources of feed in mixed farming systems. They may be those parts of the plant remaining after a grain or pulse crop has been removed (e.g. cereal straw, maize stems, pea vines). Grain crop residues usually have very low feeding value and need to be supplemented with other forages to maintain animals or achieve higher production levels. This low quality results partly from the increase in lignin in the plant tissues with age, and partly from the fact that the plant mobilises nutrients from the vegetative part of the plant to concentrate them in the grain.

Crop By-products

Many extraction processes involving plant products result in the production of considerable amounts of by-

product (e.g. brewer's grains, potato waste). Many of these by-products can be used as livestock feeds, often constituting a concentrated source of one or more essential nutrients.

When using crop by-products, particularly those that have been through a post-harvest manufacturing process (e.g. potato skins) care needs to be taken to ensure that no chemical residues that may be harmful to animal or human health remain in the by-products when they are fed to animals.

Conserved Feeds

The basic principle in fodder conservation is to preserve feeds from a period of excess production to feed to animals at a time of feed shortage (Fig. 3.7). The most common methods of fodder conservation are drying (hay/straw) and ensiling (silage/haylage), and additional detail on forage conservation for beef cattle enterprises in cold climate countries is discussed in Section 8.

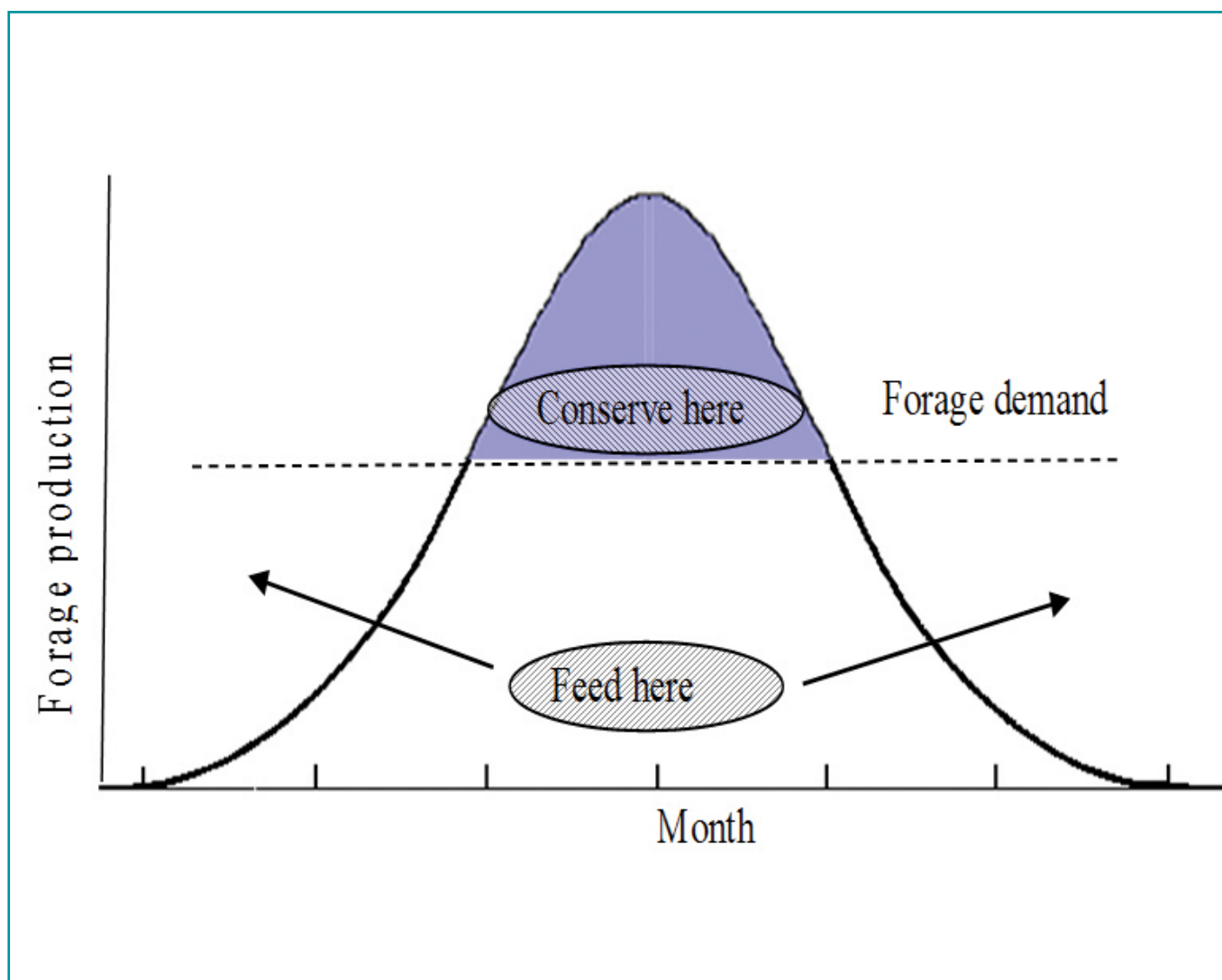


Figure 3.7. Principle of fodder conservation.

3.6. Moulds and Mouldy Feeds

During the conservation and storage of forages and grain, there is a risk that moulds will form on the feed and cause a number of problems for cattle to which it is subsequently fed. In general terms, the nutritional value of mouldy feed is reduced by their presence, as the moulds convert and utilize plant nutrients for their own growth.

Mouldy feeds can be very dusty due to the presence of mould organisms and spores. When the dust is inhaled, a type of fungal pneumonia may develop. This type of pneumonia is difficult to treat. Some spores may pass through lesions in the rumen wall and are carried by the bloodstream. The spores may settle in the pregnant uterus causing uterine infections and mycotic abortions.

Some moulds also produce toxins which can be extremely potent. These toxins can cause abortions or weak, deformed calves. Other symptoms include internal bleeding, vaginal and rectal prolapse, gangrene-like symptoms, and paralysis. Estrogenic compounds produced by some moulds may affect lactation and reproductive cycling.

Some toxins are extremely poisonous to cattle. Ideally, mouldy feeds should not be fed to pregnant or lactating cows. Diluting moulded feeds with good quality feeds may help reduce the potential for problems. An adequate supply of vitamin A should also be provided for cattle if mouldy feed is used.

3.7. Cold Weather Impacts on Feed Management

3.7.1. Ration formulation for Cold Weather

For most very cold winter climates, an assumed midday ambient temperature of -20°C should be the basis for determining the basal dietary energy requirement of the ration during the coldest winter months. Thereafter, the ration can be balanced for specific growth targets for different classes of animal, and pregnancy status of mated cows. When this temperature target is adopted, there is sufficient scope to manage sudden and dramatic drops in temperature by adjusting the energy concentration in the ration using increased quantities of grain. When practiced in conjunction with the use of 3 to 7 day weather forecasts, planning for the onset of poor weather conditions can be implemented, and can allow for the safe introduction of higher levels of grain in the diet.

Sudden drops in temperature during the winter months will cause cows to consume more feed as a physiological response to the cold conditions as the cows react and demand more energy. Feeding cattle low quality roughages in winter enables the animals to generate heat through the process of 'heat of digestion'. This heat alone is not sufficient to meet the animal's energy requirement, and therefore the energy component of the ration must be sufficient to enable the animals to meet their metabolic requirement and growth targets.

To meet their increased energy requirement in very cold weather, cattle fed poor quality feeds such as straw will attempt to consume more than they are able to digest and there is a risk that the rumen may become impacted and cease to function properly. This can lead to the death of the animal. Under these conditions, straw fed to cattle should not be processed through a mill or tub grinder, as this will encourage a greater intake of the straw and rumen impaction, particularly when sudden drops in temperatures occur.

Extremely cold temperatures are more adequately managed by adjusting the energy concentration in the diet by increasing the quantity of grain or pellets at a rate of 0.5kg per head per day for every -5°C drop in temperature below -20°C at midday. For example, if the afternoon air temperature is forecast to be -35°C , then an additional 1.5kg of grain per cow should be provided.

Extreme care is required with sudden increases in grains in the ration as the risk of acidosis (grain poisoning) increases substantially. It is a good practice to divide the grain over morning and night feeding to limit the chances of grain poisoning. If a cold snap is forecast, small extra amounts of grain should be fed for a couple of days before the weather change is expected.



4. Cattle Health and Welfare

4.1. Observational Skills

To assist in the detection of any abnormalities that will affect the animal's performance, producers must develop good observational skills. Experienced producers know the difference between normal and abnormal behaviour, and appearance. The behaviour or appearance of an animal is a good indication of how the animal feels, if it is well or sick, or if it needs more, or better quality feed.

4.1.1. Body Condition Scoring

The body fat reserves of beef cattle can be used as a visual indicator of their condition and are strongly correlated to performance throughout the breeding cycle (Fig. 4.1). Learning to assess the body condition of cattle is a basic management skill that producers can utilise to manage the productivity and profitability of the herd.

The objective of condition scoring is to obtain a reliable estimate of the body fat reserves of live animals. Body

Condition Score (BCS) provides an estimate of fat reserves that is independent of size and is a more reliable descriptor than liveweight alone.

With practice, "hands on" scoring of the herd takes only 10 to 15 seconds per animal. Condition scoring allows producers to monitor the results of feeding and management programs, and to make appropriate adjustments to their management in response. This is particularly important during winter when feed available must be sufficient for cattle to continue meeting production targets.

Condition scoring can be used on all classes of animals, including breeding, backgrounding and finishing. In breeding animals, assessment of body condition at critical stages of the production cycle identifies cows in need of nutritional management to reach target condition scores. For backgrounding and finishing animals, knowing their condition allows selection

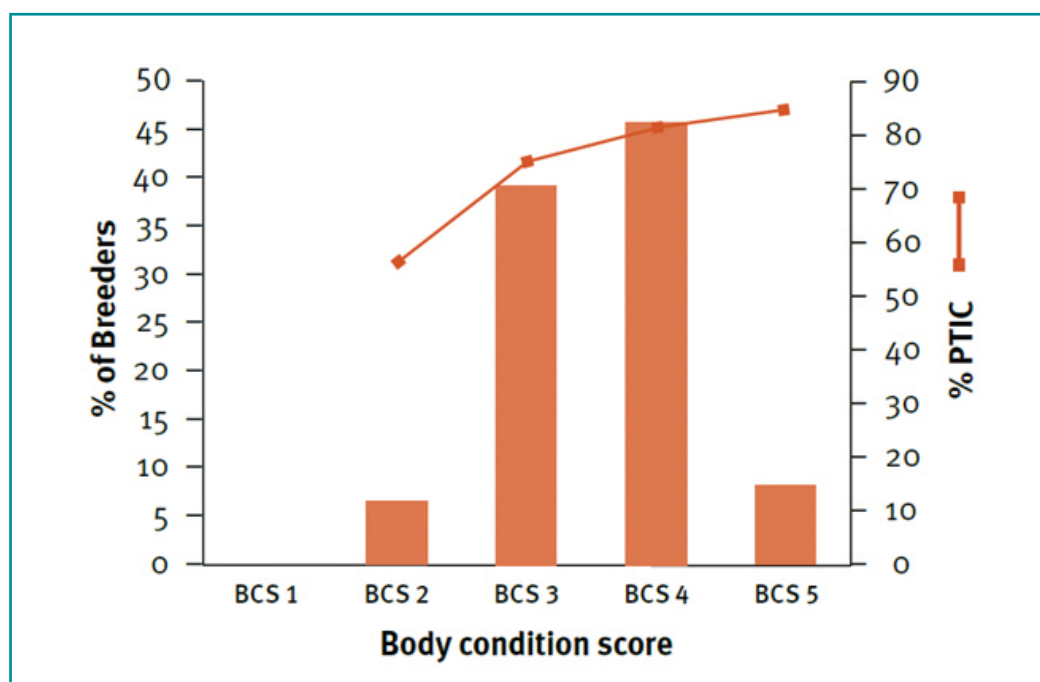


Figure 4.1. Relationship between body condition score at mating and pregnancy rate (PTIC). Cows in better body condition (BCS 3, 4 and 5) at mating have higher pregnancy rates. Source: Central Queensland Beef.

of those with the desired level of fat cover for target markets.

Both the beef and dairy cattle industries of a number of countries have adopted body condition scoring systems to assist producers to monitor their cattle. It should be noted that the number scales vary between countries and beef or dairy cattle; for example Australia uses a 0 to 5 scale for beef cattle, and a 1 to 8 scale for dairy cattle, the USA beef cattle scoring system is a 1 to 9 scale, and the Canadian beef industry uses a 1 to 5 scale.

Condition Scoring Techniques

Condition scoring is a subjective and reliable hands-on practice that involves palpating the short ribs (spinous processes), and the tail head to assess fat cover (Fig. 4.2).

The Short Ribs

The degree of prominence of the short ribs of the individual spinous processes is found by placing the fingers flat over the short ribs and pressing the thumb into the end of the short ribs (Fig. 4.3). A condition score is given according to the ease with which the individual short ribs can be felt with the thumb.

The Tail Head

The degree of fat cover around the tail head is assessed by using the fingers and thumb and should be done at the same time as assessing the short ribs. The appropriate score is given depending on the degree to which palpable fat can be felt.

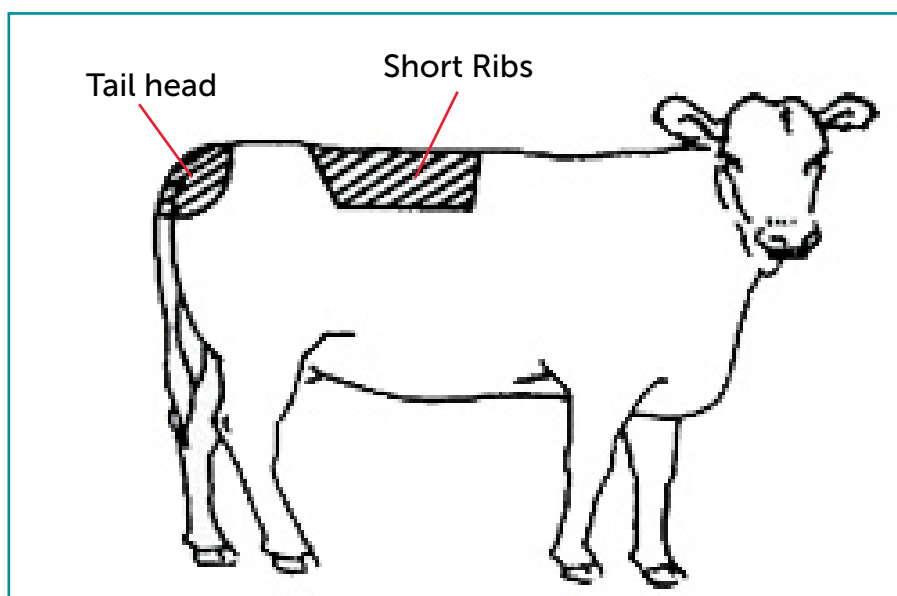


Figure 4.2. Condition scoring sites on beef cattle. Source: Department of Primary Industries, Victoria.

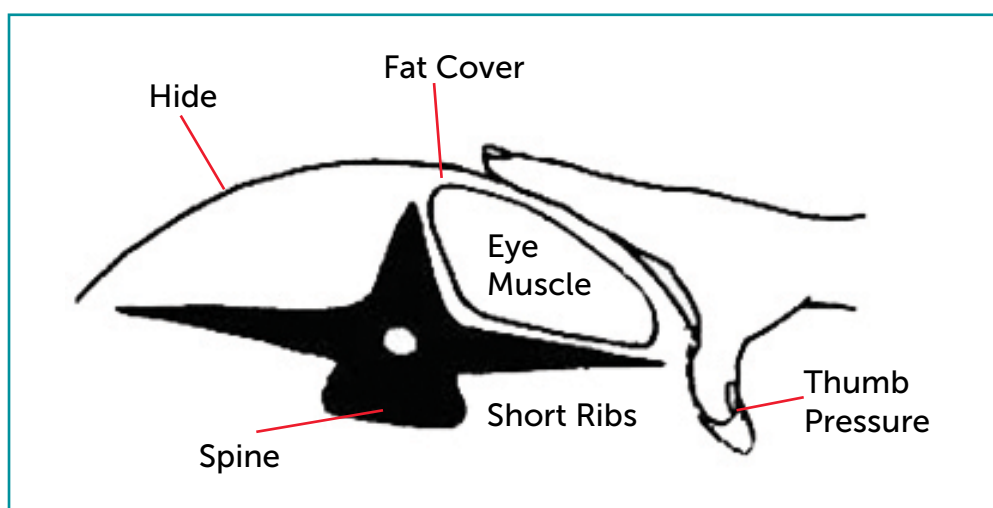


Figure 4.3. The degree of fat cover around the tail head and short ribs is assessed using the fingers and thumb. Source: Department of Primary Industries, Victoria.

Body Condition Score Classification

A body condition score of nil indicates a severely emaciated animal while a change to BCS of five is grossly obese. A difference of one BCS may reflect a liveweight difference of as much as 60kg. Descriptions of the BCS scale are as follows:

0. Short ribs very prominent and easy to see individually, muscle wastage obvious over whole body, tail bones easily felt, rump and leg muscles deeply concave, lacking energy and unresponsive
1. The individual processes are sharp to the touch, no fat at the head of the tail. Hip bones and ribs are prominent
2. The individual processes can be felt easily, but feel rounded rather than sharp. There is some tissue cover around the tail head. Individual ribs are no longer visually obvious
3. The short ribs can be felt only with firm thumb pressure. Areas either side of the tail head have fat cover which can be felt easily
4. The processes cannot be felt and fat cover around the tail head is easily seen as slight mounds, soft to touch. Folds of fat are beginning to develop over the ribs and thighs
5. The bone structure of the animal is no longer noticeable and the tail head is almost completely buried in fatty tissue.

These classifications are described in more detail and illustrated in *TECHNICAL NOTE 4 - Body Condition Scoring Beef Cattle*.

Welfare Implications of the Body Condition Score

Monitoring BCS throughout the year enables producers to gain an accurate picture of the nutrition and health of the herd as seasonal conditions, feed quality and availability, and animal physiology change. Importantly, body condition and body condition change should be used as a trigger for implementing different managements for either individual animals or mobs when required, based on current and past condition measurements.

In particular, cattle that fall within the low range of body condition, and those that sit at the highest condition score trigger additional concern when it comes to certain management activities (Table 4.1). Where animals in the herd are identified with scores in these ranges, the manager must initiate appropriate management responses to move the animals towards a better body condition.

Alternatively, and particularly for cattle with very low body condition, if mob-based feed and health management solutions are not readily available or able to be implemented, consideration must be given to remove the animals from the herd for individual management, or if in very poor condition, humane slaughter procedures should be implemented (see Section 4.2.6).

4.1.2. How to Recognise Sick Animals

It is important that producers quickly recognise animals that are showing signs that they are sick. Some of the common signs that animals are not well include; a disinterest in things happening around them, they stand alone with their heads down away from other animals, or are seen lying down and reluctant to rise. Other indicators include sunken eyes, rough coat, or a stiffness or lameness when trying to walk (Fig. 4.4).

Table 4.1. Welfare implications of cattle with varying body condition score.

Body Condition Score	Welfare	Management
0	High risk Weak with no body reserves	At risk of death from cold, wet weather or other stresses. Recovery dependent on high quality care and will be slow. Unable to be transported without prolonged intensive management.
1	At risk Significant muscle utilisation and may be weak	Able to recover for transport with adequate care. High level of management required. Unlikely can be transported without feeding and rest.
2	Of concern Lean but strong with evident muscle utilisation	Management intervention required. May be able to be transported if strong and dependent on journey and prevailing conditions. Limit on length of trip.
3	No concern	Ideal minimum target for females at calving.
4	No concern	Ideal maximum target for breeding.
5	At risk if travelling long distances	May be too fat for joining heifers and some cows. Can be transported if heat load is not excessive.

Source: A National Guide to Describing and Managing Beef Cattle in Low Body Condition, Meat and Livestock Australia (2013).



Figure 4.4. Recognise the signs of a sick or malnourished animal.

4.1.3. Healthy Animal Behaviour

Livestock producers and animal handlers are required to develop skills in understanding normal healthy animal behaviour. On a day to day basis, producers should look for the signs that indicate cattle are healthy. These include:

- ✓ **General Behaviour** - Are all the animals behaving normally? If some animals are standing on their own and look hollow or have their heads down in an unusual way, these are signs that something is wrong.
- ✓ **Eating** - The animal is not eating or is not eating enough. Is there something wrong with the feed or the animal?
- ✓ **Breathing** - Abnormal breathing may include short rapid breathing or heavy slow difficult breathing. This could be caused by heat stress, a fever, a disease or an internal infection.
- ✓ **Drinking** - Are all the animals getting enough water to drink? Do they look dehydrated (eyes appear sunken, the coat is dry and dull) and do they keep standing around the water trough? If so, is the water clean or is there something in the water they do not like?
- ✓ **Manure** - If the dung is very watery or dry and hard it is a good indication of a nutritional imbalance or deficiency, or a disease problem.
- ✓ **Discharges** - Discharges from the eyes, mouth, nose, vagina or anus generally indicate a disease or infection that needs to be treated.

- ✓ **Temperature** - If an animal has a higher than normal body temperature (38.6°C) then the cause needs to be investigated and treated.
- ✓ **Resting** - When the animals are resting do they appear to be relaxed and content? Are they ruminating (chewing their cud)?
- ✓ **Injuries & Wounds** - Signs of lameness or any wounds need to be investigated and treated as they could become infected.

All of the above are indicators to assess the health and wellbeing of animals, and animals should be observed daily. A checklist of these behaviours for day to day use is outlined in *TECHNICAL NOTE 3 - Healthy Animal Behaviour*.

Unfortunately, the symptoms of poor nutrition and disease often do not show up quickly. In cases such as this, the problem takes longer to resolve and cattle may have reduced growth rates, appear tired looking or have reduced calving percentages.

4.1.4. Reading Manure

Signs of disease and ill health can often be seen in the dung of cattle. Healthy dung pats are well formed, green in colour and do not have an offensive odour.

When the dung is hard, dry, in balls, or mounded in a heap (Fig. 4.5 - left) it is an indication that the feed is low in protein and energy and high in fibre. Such rations or feed are seen as being high in quantity and low in quality.

Very watery dung is an indication of a digestive upset or diarrhoea and the cause of this should be investigated immediately (Fig. 4.5 - right). Similarly the absence of any dung needs to be investigated closely as this is a highly reliable indication that the rumen is not functioning as it should.



Figure 4.5. Dry and mounded dung (left) could indicate poor feed or low protein, while sloppy dung with bubbles (right) could indicate Acidosis. Source: Livecorp, Meat and Livestock Australia - Manual for South-East Asian Cattle Feedlots.

4.1.5. Early Diagnosis and Treatment

Where disease is a major issue in a beef herd, the symptoms may not be immediately obvious. The producer may observe a number of symptoms in the animals which can be confusing as to what the actual cause of the problem may be. Some diseases often show the same symptoms and further investigation is required to ensure that the correct disease has been identified.

In most cases, experience and local knowledge will result in the correct diagnosis. Veterinary assistance should be considered if a disease issue becomes concerning or if it is an ongoing problem. Any abnormal behaviour requires immediate investigation as to the cause. Once the cause has been identified then the correct treatment of the problem should begin as soon as possible.

Beef producers should be aware of the more common diseases that occur in their area. They should also obtain information on the symptoms of these diseases so that the correct diagnosis can be made and treatment with the correct chemicals or drugs can start quickly. Passing this information onto other farm staff and neighbouring producers can also help with early detection and treatment to ensure that any loss of production is minimised.

4.1.6. Prevention Rather than Treatment

Optimal animal health is best achieved by preventing animals from contracting diseases and avoiding parasite infections. This is best done by ensuring that there is good farm biosecurity, that all animals have access to adequate amount of quality feed, and that they can get a good supply of clean cool water to drink. Fresh clean water also minimises the risk of the spread of diseases between animals.

It is more profitable to prevent diseases and parasites from occurring than to try to treat the cause after it has happened. To successfully treat animals a producer will have to purchase chemicals, vaccines and equipment to apply them. This additional expense, and the loss of production (reduced liveweight gain, or loss of a calf) associated with livestock disease has a negative impact on the profitability of the herd; often for more than one production season.

Where cattle graze on pasture, a system of rotational grazing should be practiced to help minimise the spread of diseases and parasites, particularly worms and ticks.

When vaccinations, antibiotics and other chemicals are used, the instructions and schedules must be followed. Any deviation from the recommended dosage rates,

timing, and number of applications will only result in an increase in the spread and severity of both diseases and parasites.

Whenever new cattle are brought onto the property, good biosecurity procedures entail quarantining the new animals for a period of up to four weeks, depending on their origin and the potential disease risk that they pose. This allows prophylactic treatments such as anthelmintics or vaccines to be administered, and the cattle can be observed closely for symptoms of ill-health before being released to join the existing herd. Adherence to a good biosecurity protocol will limit the introduction of diseases from outside sources and reduce the associated negative economic impact of such diseases.

4.1.7. Nutritional Stress

Maintaining normal rumen function is fundamental to help avoid nutritional stress in beef cattle. The animal needs to eat sufficient quantities of quality forage, and drink enough water to ensure there is a good balance of fibre and fluid in the stomach to allow for fermentation to take place. If fermentation does not happen, the digestive process of rumination that assists in the breakdown and absorption of nutrients will not occur. This fermentation process is necessary to assist the microbes in the stomach to extract the nutrients from the fibre (grass) ready to be absorbed in the small intestine. There needs to be sufficient numbers of the various types of microbes to ensure that fermentation continues and the animal functions normally.

Nutritional stress occurs when the animal is not getting enough feed and water, or the quality of the feed and/or water is poor. Where the animal is fed too much roughage (low quality forage, grass or straw), or feed with a high moisture content, the animal cannot extract enough nutrients to satisfy its needs for body maintenance, growth, or reproduction.

One of the first signs of nutritional stress is when an animal begins to lose weight. This will be followed by female animals having reduced fertility.

A sign of a lack of feed or poor quality feed is when animals stand around the feed trough looking for more to eat. They will often sort through the feed and eat the best parts first (the leaf and younger plant sections) and

leave the poor quality roughage or stalk until last. They may also be seen licking the walls of the empty trough to try and get as much nutrient as possible.

A similar thing will happen if water is in short supply. The cattle will wait around the water trough in the hope of getting a drink when they should be out eating grass or forage or resting and chewing their cud.

4.2. Safe, Low Stress Cattle Handling

4.2.1. Understanding the Animal Welfare Requirement

International standards for working with animals outlined by the World Organisation for Animal Health (OIE) concur that people working with and handling domestic livestock (cattle) are required to understand the following key points;

- Domestic livestock live in herds and follow a leader by instinct
- Animals have natural flight zones
- How animals use sight and sound influences their direction of movement
- Animals need to be handled in a balanced way to avoid harm, distress or injury
- Aids such as the 'cattle talker' can be used to encourage movement and direction of animals
- Unacceptable practices include creating noise that will agitate the animals, using implements that may cause pain or stress, hitting animals, and walking animals over the top of other animals.

Beef cattle are herding animals that like to be with and follow other animals in their group. The most important principles to understand are the animal's flight zone, its point of balance, the importance of handling smaller groups, and training cattle for handling procedures.

4.2.2. Features of Sight

Animals have panoramic vision (Fig. 4.6). Despite this, a zone exists directly behind them where they cannot see; known as the blind spot. The handler should never position themselves directly in their blind spot as the animal needs to be able to see and know where the handler is so that they feel comfortable, or can respond to their presence if they are uncomfortable.

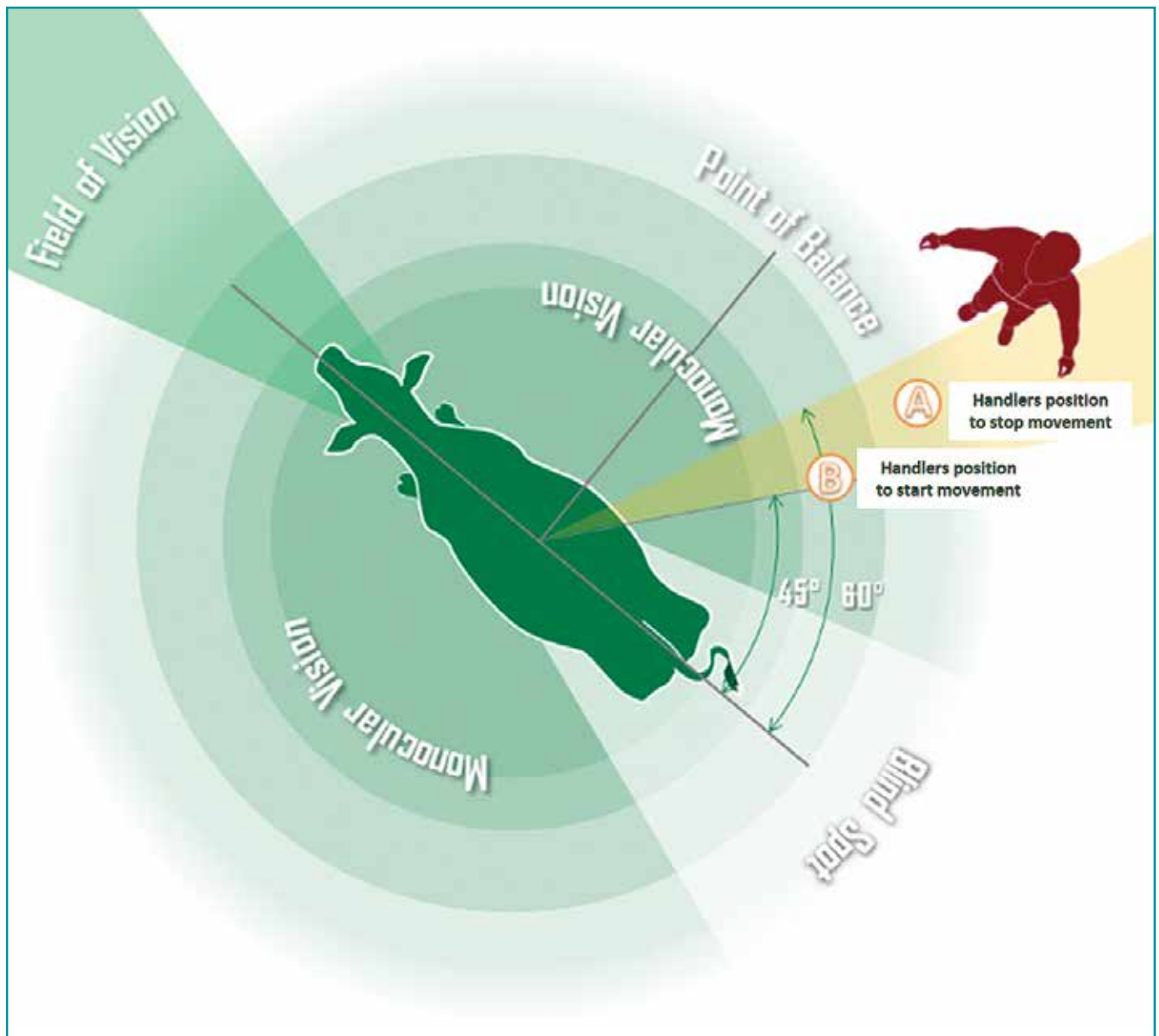


Figure 4.6. Cattle vision and their blind spot. Source: Grandin, T., Colorado State University, Proway Livestock Equipment.

The primary features of sight that influence the behaviour of cattle when handled include;

- **Depth perception** - many animals find it difficult to determine the distance of a stationary object, including people. Slight movement helps overcome this
- **Illumination** - stock like to move from dark to light areas. It is difficult to move animals into dark places
- **Colour** - animals can distinguish some colour such as the difference between red and blue or green.

Other livestock senses that need to be considered when working with animals are:

- **Sound** - excessive noise causes stress and should be avoided. Animals can be moved without noise
- **Smell** - for example cattle can become upset by strange smells, particularly the smell of blood.

4.2.3. Flight Zones

The Flight Zone is the area around the animal, within which the animal will be prompted to respond, by moving, if the area is invaded by a perceived threat to its safety (Fig. 4.7). In the case of cattle, a threat may include a person, an animal, or any other foreign object that can cause stress to the animal.

The boundary of the flight zone is the distance to which an animal will allow a handler to approach before moving away. The flight zone corresponds to the animal's safety or comfort zone, and understanding the size of this zone and how it can be manipulated are essential skills for animal handlers to master.

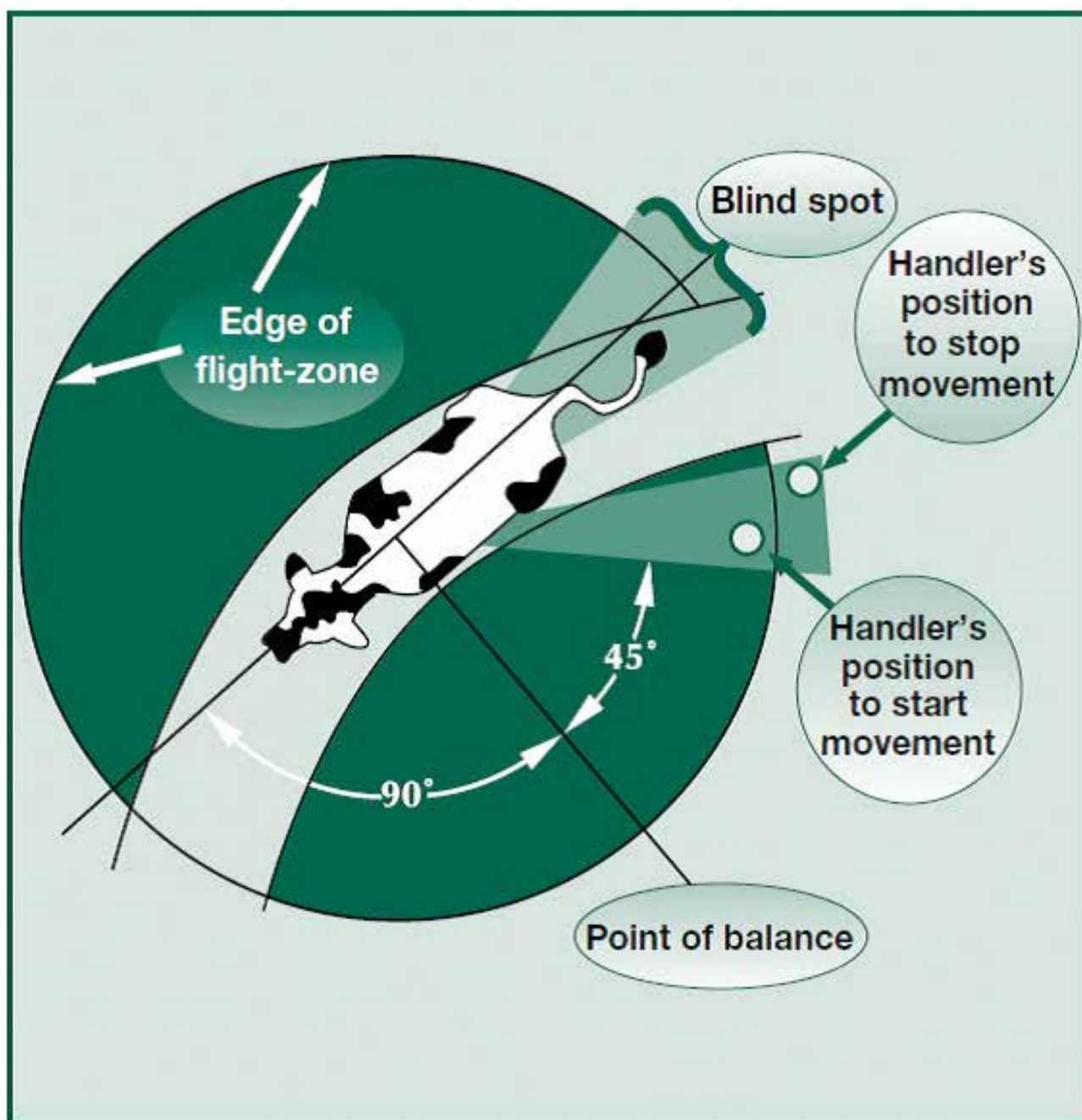


Figure 4.7. Flight zones of cattle. Source: Meat & Livestock Australia.

For example, tame cattle have no flight zone and will allow a handler to approach and touch them. However, cattle which are unaccustomed to people will turn and move away as a handler enters their flight zone, which may be some distance from the animal.

The flight zone size is determined by three factors:

- Genetics
- The amount of contact cattle have previously had with people
- The quality of that contact.

While some individuals are inherently nervous when in close contact with people, most cattle which have been properly handled and educated are calm and can be handled during husbandry procedures with minimum stress.

4.2.4. Education and Training

Education and handling of cattle through yards is an important management practice and it is essential that young cattle undergo a program of yard familiarity, and an introduction to handling by people. Weaning is an ideal time to begin this education.

Weaning cattle in yards provides an excellent opportunity to commence the handling and education process (Refer Section 6.2.1). When weaning in the yards, calves receive supplementary feeding for at least two weeks after weaning, and during this time they can be quietly handled through cattle yards and in any small adjoining paddocks. This period provides the opportunity to introduce the cattle to the various handling and management procedures normally used, and the types of concentrates and supplementary feeds they are likely to be fed during their lifetime.

4.2.5. Moving Animals

The most important aspect of communicating with animals is related to flight zones, mob structure and understanding their reaction to your position and movement.

Instinctively, animals want to;

- Move quietly without being rushed
- Follow other animals
- Be part of a mob and not to be isolated
- See what (or who) is pressuring them.

Vision is the most important animal sense when communicating with livestock. Cattle in a mob are always looking for a leader, which may be another animal or a person. The way the handler positions their body in relation to the animal's eye will influence its movement.

The four principles of communicating with livestock are:

- 1. POSITION** - where are you in relation to the animal's eye? By moving around within the animal's field of vision, the animal will move or turn in response to the handler's position and this movement can be used to position animals appropriately for subsequent movement
- 2. PRESSURE** - apply pressure to get the animals to move but then release it. By moving into, out of, or along the animal's flight zone, pressure can be exerted on the animal to initiate it to move in a direction that allows it to seek relief from that pressure (Fig. 4.8)
- 3. MOVEMENT** - move your body position so that the animal sees you. This also includes making appropriate rates of movement, as slower and more controlled movement by the handler generates more moderate responses by the animals compared to faster and more vigorous movements by the handler
- 4. COMMUNICATING** - let the animal communicate with other members of the mob while you communicate with your fellow workers.

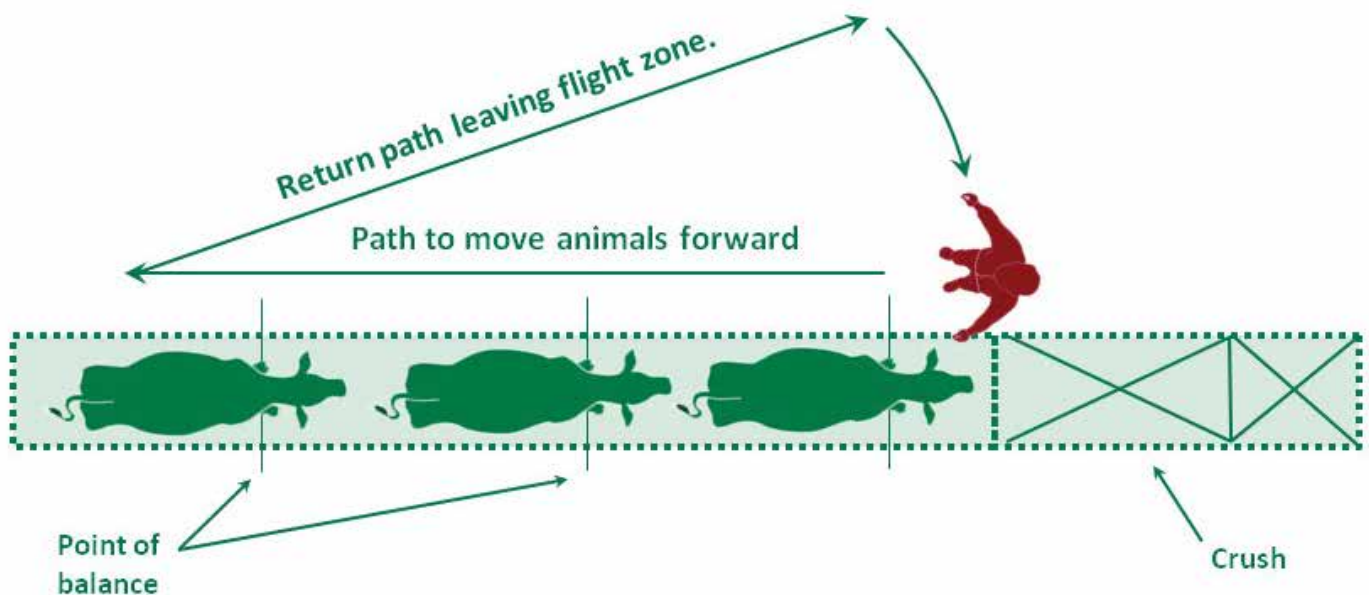


Figure 4.8. Walking alongside and in the opposite direction to the intended direction of movement of the cattle exerts pressure on them to move forward along the race, and pressure is released by moving diagonally out and away from the race. Source: Grandin, T. Colorado State University. Proway Livestock Equipment.

Tools that can be used to create movement responses by the animals include;

- Human body - moving your body is an effective way to create pressure and influence the direction of an animal (Fig. 4.9). Move your body by either walking towards an animal (in a zigzag manner) or moving your arms up and down (without noise) in the same position.
- Goads - the 'cattle talker' is a stick with a flapper on the end. Goads are seen as an extension of your body - they are NOT a tool to hit animals with.
- Once the cattle are moving, release the pressure.

Livestock prefer to move in a curve when going in and out of gateways and pens. Position yourself so the animals move around you, rather than blocking them.

Using the principles and methods above, it is simple to ensure that what you are asking livestock to do is made very clear to them. In working with livestock, particularly in confined situations such as yards it is critical for a handler to understand that;

- It is important to have cattle walking rather than trotting or running when you move them within a yard, pen or paddock.

- It is difficult to communicate with an animal that is frightened of the handler - their high levels of induced stress will often cause them to respond unexpectedly and vigorously.
- Do not penetrate the flight zone too deeply or too quickly when trying to create movement with frightened animals - this may also cause them to respond unexpectedly and vigorously.
- Cattle on their own can be dangerous and aggressive if they become frightened, and always be wary of cows with calves as they can be very protective.

Working Cattle in Yards

There are a range of training resources freely available on the internet that provide excellent demonstrations of the principles of moving and working with animals in yards. Examples such as this (<http://www.youtube.com/playlist?list=PL4OaBCdO34bBi3AxpqZLtlG-0qVZSnf8s>) can be used as the basis of a training program for farm staff.

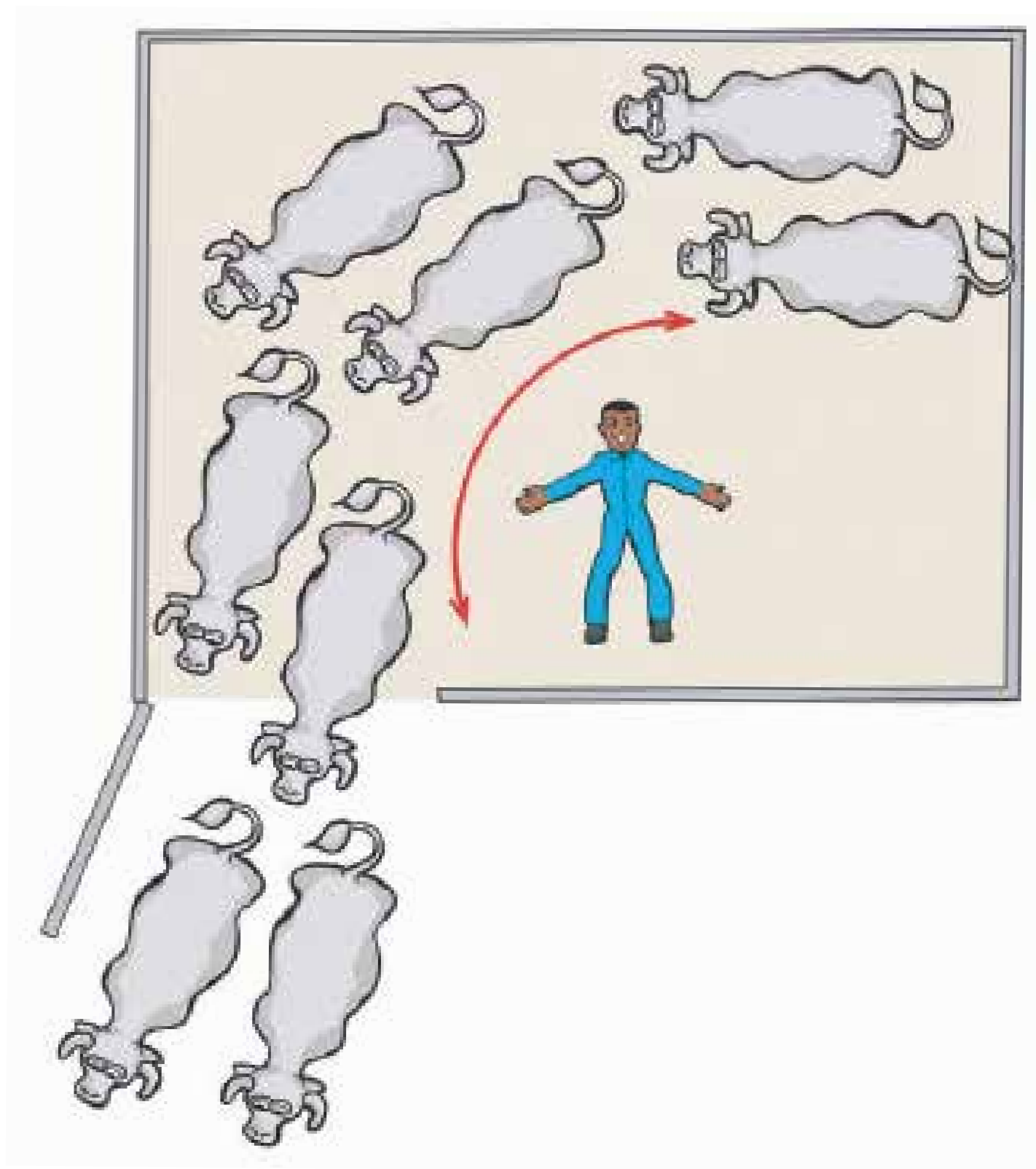


Figure 4.9. Position of the cattle handler in a yard to encourage cattle to move in a curve through the gate.
Source: Livecorp, Meat & Livestock Australia.

4.2.6. Euthanasia

There are likely to be occasions when it is necessary to euthanize an animal during the normal operation of a beef cattle enterprise. It is important to be aware how to safely and humanely euthanize an animal when it is found to be in pain or suffering, and where treatment is either not practical or not economically feasible. When done correctly, the animal feels no pain and it loses consciousness instantly.

Every farm should have access to personnel who are competent and readily available to undertake humane killing, and suitable equipment should be on hand and be maintained in good working condition. Where it is necessary to kill cattle, it must be done promptly, safely and humanely.

For beef producers without access to a veterinarian who is licensed to administer a lethal dose of a registered barbiturate to the animal, adult cattle may be effectively euthanized by shooting with a rifle with a calibre of at least .223, and for bulls at least .30 to ensure that the muzzle energy of the projectile is sufficient to reliably

euthanize the animal. For calves, a smaller calibre long rifle cartridge of at least .22 is required (Source: Dairy Australia).

Alternatively, a captive bolt pistol may be used where the operator is able to safely hold the captive bolt against the forehead of the animal without risk of injuring themselves during the process.

To produce instantaneous unconsciousness, the projectile must penetrate the brain with a high concussive impact. The correct positions for placement of the projectile are shown in Fig. 4.10. For cattle, the projectile must enter the middle of the forehead on an "X" formed between the eyes and the horns.

Immediately after administering a euthanizing treatment, the animal must be checked to ensure that the treatment has been successful. Indicators such as those in Table 4.2 must be observed. If euthanasia has been unsuccessful at the first attempt, due care and attention must be paid to readminister the treatment without undue delay and in an effective manner.

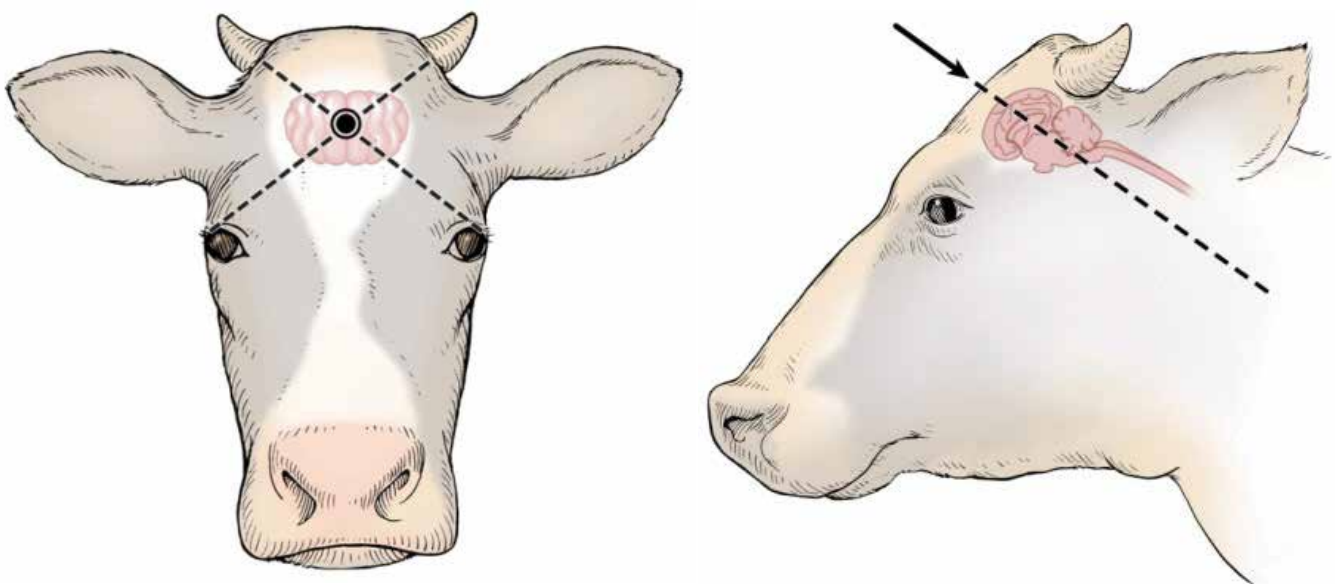


Figure 4.10. Correct location for shooting cattle with a firearm or a captive bolt pistol. Source: J. Shearer et al., 2013, Western Dairy Management Conference.

Table 4.2. Indicators of successful euthanasia.

Head	Must appear dead, hang straight and floppy
Tongue	Straight and limp
Back	Hanging straight, no righting reflex
Eyes	No natural blinking. Wide open, blank stare, no response to touch
Limbs	Uncoordinated kicking of hind legs acceptable. No righting reflex present
Vocalisation	None
Respiration	Absence of rhythmic breathing (ribs moving in and out at least twice). Agonal gasping not acceptable
Tail	Relaxes shortly after
Response to Pain	A pinch or pinprick may be applied to nose only and NO response should be observed

Source: T. Grandin, Colorado State University.

4.3. Transporting Cattle

Throughout the world, transportation by truck is a common and efficient means of moving cattle from one location to another. However, this form of transportation is also commonly associated with an increased risk of injury to the cattle involved. Much of this increased injury risk is due to inadequate loading and truck facilities, and poor cattle handling practices.

This section describes the requirements of a suitable cattle transport vehicle and outlines the means of ensuring that the health and welfare of the cattle is maintained during truck transportation, that production losses after transport that result from injury, sickness or death are minimised, and carcase quality of animals going for immediate slaughter is preserved.

4.3.1. Understanding the Animal Welfare Requirement

The overall objective when transporting cattle is to ensure the health and welfare of the stock whilst transporting, and minimise production losses through

injury, sickness or death, or reduced carcase quality if animals are going for immediate slaughter.

It is also imperative to understand that cattle must be in a suitable condition to be transported, and those that are not or are in doubt must not be transported. An animal is not fit for the journey if it;

- Is not strong enough to undertake the journey
- Cannot walk normally, or bear weight on all legs
- Is severely emaciated or visibly dehydrated
- Is suffering from severe visible distress or injury
- Is in a condition that could cause it increased pain or distress during transport
- Is blind in both eyes
- Is in late pregnancy.

To achieve this objective, proper preparation of the animals prior to transport, appropriate loading and trucking facilities, in-transit care, special considerations for extreme weather, and suitable recovery practices at the destination must all be addressed to minimise the negative impact of transportation on cattle. This also extends to obtaining and presenting any and all approvals for travel, health certificates, and transportation documents associated with moving the cattle.

4.3.2. Preventing Injury

Common causes of stress or injury to cattle during truck transportation include;

- Poor design and construction of loading and unloading ramps that cause injury to the animals, or encourage them to attempt escape
- Holes in the floor of the truck that cause injury as a result of the cattle stumbling or falling, or a slippery floor surface that can cause cattle to fall over
- Solid and sharp projections inside the truck that cause physical injury
- Low sides on the truck can allow agitated cattle to attempt to climb or jump over the sides
- Inappropriate ventilation that results in cattle suffering temperature extremes or receive poor quality breathing air
- Doors or gates coming open and cattle jumping or falling out
- Excessive speed on uneven roads, causing cattle to fall over
- Too many or too few cattle in a pen, also making it difficult for them to remain on their feet
- Already-sick, injured or frail cattle falling down and being trampled
- Cattle of different sizes being transported together in the same pen, resulting in trampling of the smaller animals
- Very long journeys without access to rest, food or water.

4.3.3. Features of Suitable Cattle Transport

Trucks and trailers are the primary means of moving cattle between locations, and if prepared and used

correctly, offer safe and effective means of transport. Essential features of suitable cattle transport vehicles include;

- Roadworthy and mechanically reliable vehicle
- Pen constructed from materials suitable to keep cattle safely confined (material strength and pen height)
- A solid, non-slip floor surface
- No protruding structures in the holding pen that may cause bruising or injury to the animals
- Adequate ventilation
- Adequate protection against temperature extremes.

Ideally, cattle being transported by trucks will stand for the duration of the journey, hence the surface of the floor of the pen on the truck must be of good quality and constructed so that it is non-slipping. When loaded at optimum loading densities in pens, cattle in the standing position are supported by others that surround them and are able to remain on their feet throughout the journey.

A variety of materials can be used to provide a non-slip surface on the pen floor. For example, Fig. 4.11 shows a 30cm by 30cm welded heavy cleat floor that is ideal for trucks transporting cattle. By contrast light steel mesh does not withstand the impact of cattle if the truck is used frequently for animal transport (Fig. 4.12).

Pens on trucks must be high enough to prevent cattle from attempting to climb or jump over the pen walls, and thus contain the cattle that will be transported. Trucks with pen sides that are lower than the height of the cattle are unsuitable for transporting cattle not used to close human contact as the low rail height would encourage nervous cattle to attempt jumping out (Fig. 4.13). This would certainly apply to beef breeding cattle imported from Australia. For cattle trucks with two decks, the space between decks should be sufficient for the cattle to stand in a natural position without contacting overhead structures.



Figure 4.11. Welded pipe cleats provide good footing and reduces slipping, injuries, and deaths. Source: LiveCorp & Meat & Livestock Australia.



Figure 4.12. Reinforcing mesh is too light for use as truck flooring and can break and cause injuries. Source: LiveCorp and Meat & Livestock Australia.



Figure 4.13. Sides of this truck are too low, and there is not a sufficient visual barrier to discourage animals from trying to escape. Source: Anon.

Whilst purpose-built cattle trailers provide an optimum transport solution, particularly those designed for moving cattle in cold climates (Fig. 4.14), good quality transport solutions can be implemented using retro-

engineered shipping containers (Fig. 4.15) where purpose-built trailers are unavailable, provided that the essential components of pen design are incorporated during re-engineering.



Figure 4.14. A purpose-built live cattle transport trailer providing both ventilation and, with side boards fitted to close off external vents in winter, protection against extreme temperatures. Source: International Agriculture for Development.



Figure 4.15. Live cattle transport trailers converted from shipping containers. Source: ExpoTrade.

4.3.4. Preparing Animals for Transport

Planning the transportation of cattle should begin well before the trucking date. Where possible, groups of cattle to be transported should be formed at least three weeks prior to transport to allow social order to be established. These groups should then be brought to the yards using low stress cattle handling techniques and allowed to settle prior to loading.

Animal welfare and meat quality standards are best met by providing access to dry feed and water to cattle right up to the point of loading, particularly if they are embarking on a long journey. In circumstances where transportation time is minimal, a four-hour period without access to feed and water before trucking helps empty out the cattle and keep excreta on the truck floor to a minimum.

4.3.5. Loading

Loading ramps need to be in good condition to allow cattle to load safely. Single file loading ramps work best

under most situations, and if possible they should have fully enclosed sides so that the cattle cannot see out.

After reversing the vehicle or lining up the side of the trailer to the ramp, there must not be any gap between the floor and sides of the truck and the ramp. This prevents any cattle from catching their feet as they move from the ramp into the truck during loading or unloading. If there is a gap, then a sheet of plate steel should be used to cover any gap present. Well-designed ramps will have a steel plate that folds down between the back of the truck/trailer and the ramp.

Cattle need to be loaded quietly and calmly. They also need to be loaded tightly enough to give each other support but not so tight as to result in suffocation, injury or trampling. Cattle of a similar size or weight should be loaded together in pens, and horned cattle should be transported in separate pens to cattle without horns.

Ensure gates or doors on the transport vehicle have been fastened securely before it leaves the ramp; this is

easily overlooked. Transportation should commence as soon as possible once the animals have been loaded.

4.3.6. Loading Density

Cattle should be loaded loosely enough that an animal can regain its feet if it falls down (Fig. 4.16, Fig. 4.17). The

appropriate density to achieve this is dependent on size, weight and horn status of the cattle involved. Horned, pregnant, or cattle in poor condition (but strong enough to travel) need to be given more space. Special care must be taken with cattle in late pregnancy. Pregnant cows must not be transported at all. Where cattle are loaded

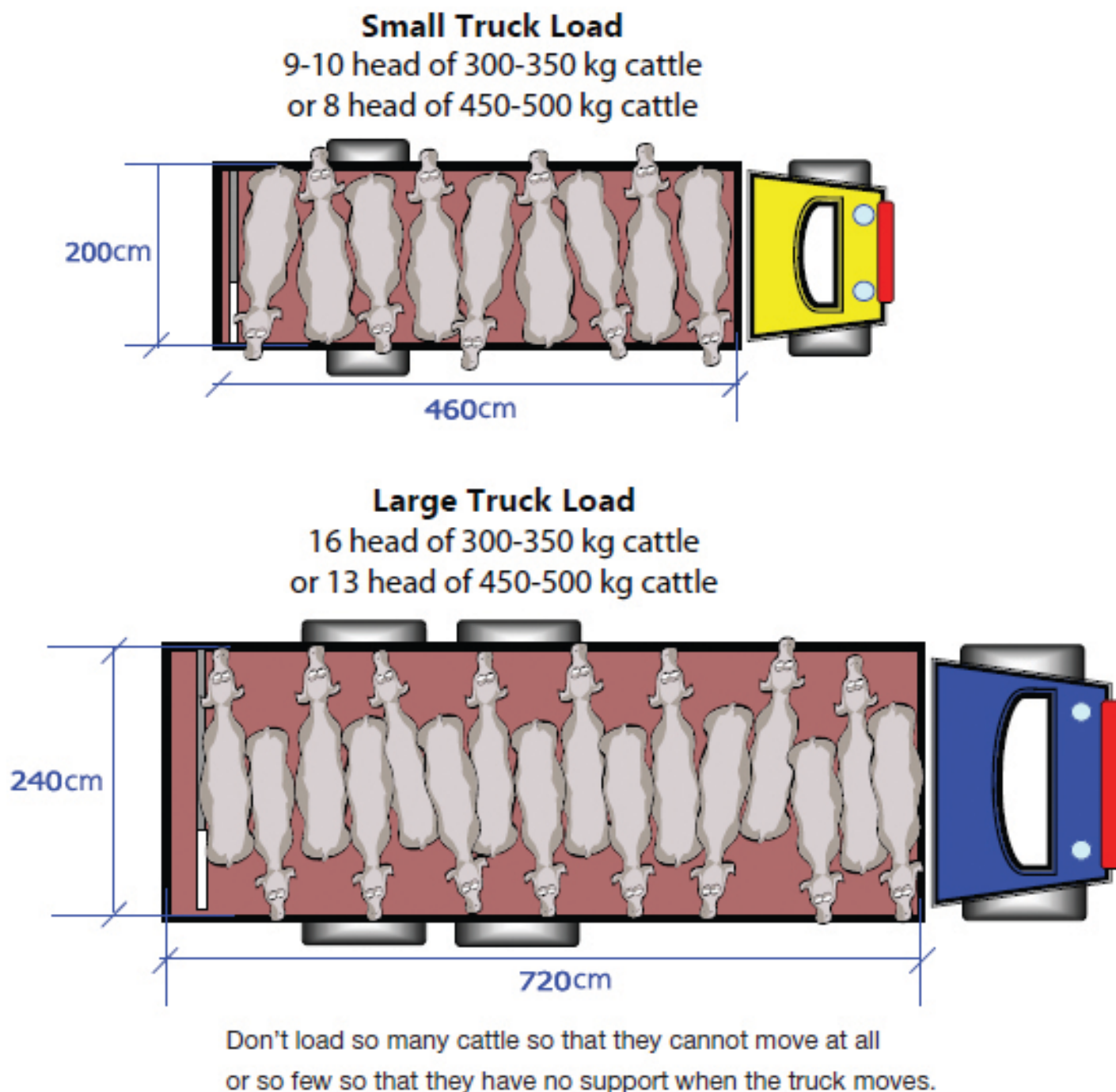


Figure 4.16. Loading densities for cattle on trucks. Source: LiveCorp and Meat & Livestock Australia - Manual for South-East Asian Cattle Feedlots.



Figure 4.17. Suitable loading density of trucks - they may appear loose but the density is ideal.
Source: LiveCorp and Meat & Livestock Australia.

too densely and an animal falls down and it cannot stand up, it can be trampled, leading to stress, injury and production losses. Where cattle are loaded too loosely, they may be injured by being thrown against the sides or onto the floor during transport.

Partitioning of large vehicles into smaller pens is essential to minimise risk of injury during travel.

Table 4.3 provides a practical guide on the space requirements per head for cattle of different weights, and the number of cattle that can be safely accommodated on semi-trailers with a 12.5m long deck and a width of 2.4m.

Mean Live weight (kg)	Floor area (m ² /head)	Number of Head per 12.25 m x 2.4 m deck (m ² /head)
100	0.31	94
150	0.42	70
200	0.53	55
250	0.77	38
300	0.86	34
350	0.98	30
400	1.05	28
450	1.13	26
500	1.23	24
550	1.34	22
600	1.47	20
650	1.63	18

Table 4.3. Recommended area of floor space required per animal for cattle of different live weights.
Source: Australian Animal Welfare Standards and Guidelines, Land Transport of Livestock, 2012.

4.3.7. In-Transit Care

Cattle should be inspected within the first 30 minutes of their journey to ensure their wellbeing, and about every three hours thereafter, or more often if the opportunity presents. When inspecting the cattle during transit, key things to be observant for include;

- All of the cattle are standing - any that are down should be assisted to regain their footing, or if necessary offloaded and treated for any injuries that have been incurred
- No animals are exhibiting signs of heat or cold stress
- Animals are breathing normally, and are not exhibiting abnormal behaviour in the pens.

Cattle should be unloaded, inspected, and rested during extended journeys according to their age and class (Table 4.4). During the rest and recovery period, they should be provided with water and hay up until recommencement of the journey. Cattle that are in poor condition, pregnant, or have calves at foot may need to be rested sooner.

Throughout the journey, the truck driver needs to be able to maintain contact with persons receiving the cattle, particularly if a change in arrival time is expected.

Table 4.4. Maximum travel time and minimum rest periods required for cattle when undertaking long journeys.

Class	Maximum time off water (hours)	Minimum rest duration (hours)
Cattle over 6 months old	48	36
Calves 30 days to 6 months old	24	12
Lactating cows with calves at foot	24	12
Calves 5–30 days old travelling without mothers	18	-
Cattle known to be more than 6 months pregnant, excluding the last 4 weeks	24	12

Source: Australian Animal Welfare Standards and Guidelines, Land Transport of Livestock, 2012.

4.3.8. Unloading

Cattle must be unloaded as soon as practically possible once they arrive at their destination. During unloading, the animals should be given the opportunity to walk quietly off the truck. Thereafter, cattle should be placed onto feed and water as soon as possible if not destined for immediate slaughter. For cattle that have been off feed for some time, good quality palatable hay is desirable.

Once the cattle have been unloaded from the vehicle, it should be washed clean after each load to maintain good hygiene and biosecurity procedures.

4.3.9. Transporting in Extreme Weather

Wherever possible, cattle should not be transported in extreme hot, cold, wet, or windy weather. It is particularly

important to avoid transporting wet cattle during very cold weather. Water on the coat of the animal reduces its insulating qualities, and in extreme cold can lead to ice formation on the coat that extends to the skin and the onset of hypothermia and subsequent death.

When the air temperature falls below 10°C, adding bedding material such as straw to the floor of the pens provides good insulation against the cold, particularly if any cattle go down during the journey (Fig. 4.18) and helps the animals keep dry.

For trailers with adjustable vents, these may be selectively closed off while travelling to reduce the effect of wind chill in the trailer. However adequate ventilation needs to be maintained at all times to prevent development of respiratory issues.



Figure 4.18. Bedding material is required in very cold conditions to provide insulation, particularly if animals go down during the trip. Source: Unknown.

Correct livestock loading density reduces the risks of heat stress on hot days, and frostbite on cold days by allowing individual animals experiencing extreme temperature to reposition themselves away from the source of discomfort. Provision of high nutritional value forage to cattle after prolonged exposure to the cold during transport will assist with recovery.

4.4. Australian Health Status

Australia enjoys an enviable animal health status amongst the world's livestock producing countries. Comparatively, Australia has few diseases of concern to livestock importing countries, and as a result Australian beef cattle suppliers enjoy access to significant live animal export markets. Substantial and effective quarantine procedures and frameworks are maintained by the Australian Government to preserve the country's livestock health status, and ensure that Australia's livestock exports continue to develop the world's livestock resources.

4.5. Common Cattle Diseases

It is essential that livestock producers know what diseases and parasites are normally present in their region, when they are more likely to occur (seasonally after rain etc.), and how to recognise the symptoms. Some diseases and parasites result in similar symptoms, so being able to tell the difference is important to ensure the correct diagnosis is made and the correct treatment started as soon as possible.

The longer that diseases or parasite infestations go undetected, the worse they get, and they will affect the long term health and wellbeing of the livestock.

4.5.1. External Parasites

External parasites are generally blood sucking insects such as lice and ticks. These parasites may also spread blood borne diseases, cause irritation, or skin infections.

Lice

Lice irritate cattle, causing the cattle to bite, scratch and rub. This constant irritation results in noticeable loss of weight and can become a welfare issue. Lousy cattle can cause damage to fences, yards or trees which the cattle use as rubbing posts. The coats of lousy cattle take on a rough scruffy appearance, and, at times, areas of skin are rubbed raw, this will reduce hide value at slaughter (Fig. 4.19). There are two types of cattle lice; biting lice and sucking lice.

Biting lice

Biting lice feed on skin debris and can cause severe irritation. The cattle biting louse (*Bovicola bovis*) is a reddish-brown louse about 2mm long with a brown head and eight dark cross bands on its abdomen (Fig. 4.20). It is mostly found on the neck, shoulders, back and rump.



Figure 4.19. Example of the coat effects of lice infestation in cattle. Source: International Agriculture for Development.



Figure 4.20. The cattle biting louse (*Bovicola bovis*). Source: The Merck Veterinary Manual.



Figure 4.21. Short-nosed cattle louse (*Haematopinus eurysternus*). Source: The Merck Veterinary Manual.

Sucking Lice

Sucking lice pierce the skin and suck blood. In large numbers they can cause anaemia (reduced blood volume).

- The short-nosed cattle louse (*Haematopinus eurysternus*) is dark-grey (Fig. 4.21). The female is 3.5-5mm long. The male is smaller. It is mostly found around the cattle's eyes and in the long hair around the neck and tail, but in heavy infestations it can occur anywhere in the hair coat. In summer it is often found in and around the ears and under the tail.
- The long-nosed or blue cattle louse (*Linognathus vituli*) is bluish-black and about 2.5mm long (Fig. 4.22 - Bottom). Like the short-nosed cattle louse it may be found anywhere in the hair coat including the neck, dewlap, inner thigh and scrotum.
- The tubercle-bearing louse (*Solenopotes capillatus*) is the smallest louse (Fig. 4.22 - Top). At only 1.2mm long, it has a brown head and a bluish abdomen. It is usually found around the head and neck in distinct dark clusters.

The life cycles of all species are similar. Eggs are laid by the female and glued to hair shafts, and take 8 to 19 days to hatch as nymphs. The nymphs undergo

three moults on the beast, and develop into adults. The entire life cycle takes 3–6 weeks.

Lice are spread entirely by animal to animal contact. The lice and their eggs survive for only a few days if removed from cattle. Cattle lice cannot live on other species of farm animals.

Lice populations are highest in winter and lowest in summer. Cooler skin temperatures are associated with heavier lice infestations. The denser winter coat and cooler weather favours survival of lice. It appears that well-fed healthy cattle do not develop heavy lice infestations and that those lice present do not adversely affect performance, but they can still spread to other animals when physical contact occurs. The number of lice tends to increase as nutrition for the cattle becomes poorer. It is usually when cold weather is coupled with poorer nutrition in winter that heavy lice infestations occur.

There are many commercially available insecticides registered for control of cattle lice. All must be used strictly in accordance with manufacturers' directions.

Read the label thoroughly. Pay particular attention to the withholding periods required for meat and milk production, and to compatibility of use with other chemical treatments such as drenches.

Ticks

British breeds of cattle are susceptible to ticks. In many countries with cold winter climates in Europe and Asia, ticks are widespread and cattle often carry ticks, particularly in the late spring and summer months.

Large tick infestations on animals can impact on productivity. However they are also implicated in transmission of the zoonotic disease Tick-borne Encephalitis (TBE) to humans during a multi-host lifecycle that arises following infection with Tick-borne Encephalitis Virus (TBEV, Fig. 4.23). In countries such as Russia and China, cattle can act as an intermediate host in the lifecycle of Ixodid ticks (*Ixodes ricinus* - Sheep Tick, and *Ixodes persulcatus* - Taiga Tick) carrying TBEV (Fig. 4.24).



Figure 4.22. Tubercle-bearing louse (*Solenopotes capillatus* - Top), and the long-nosed or blue cattle louse (*Linognathus vituli* - Bottom). Source: The Merck Veterinary Manual.

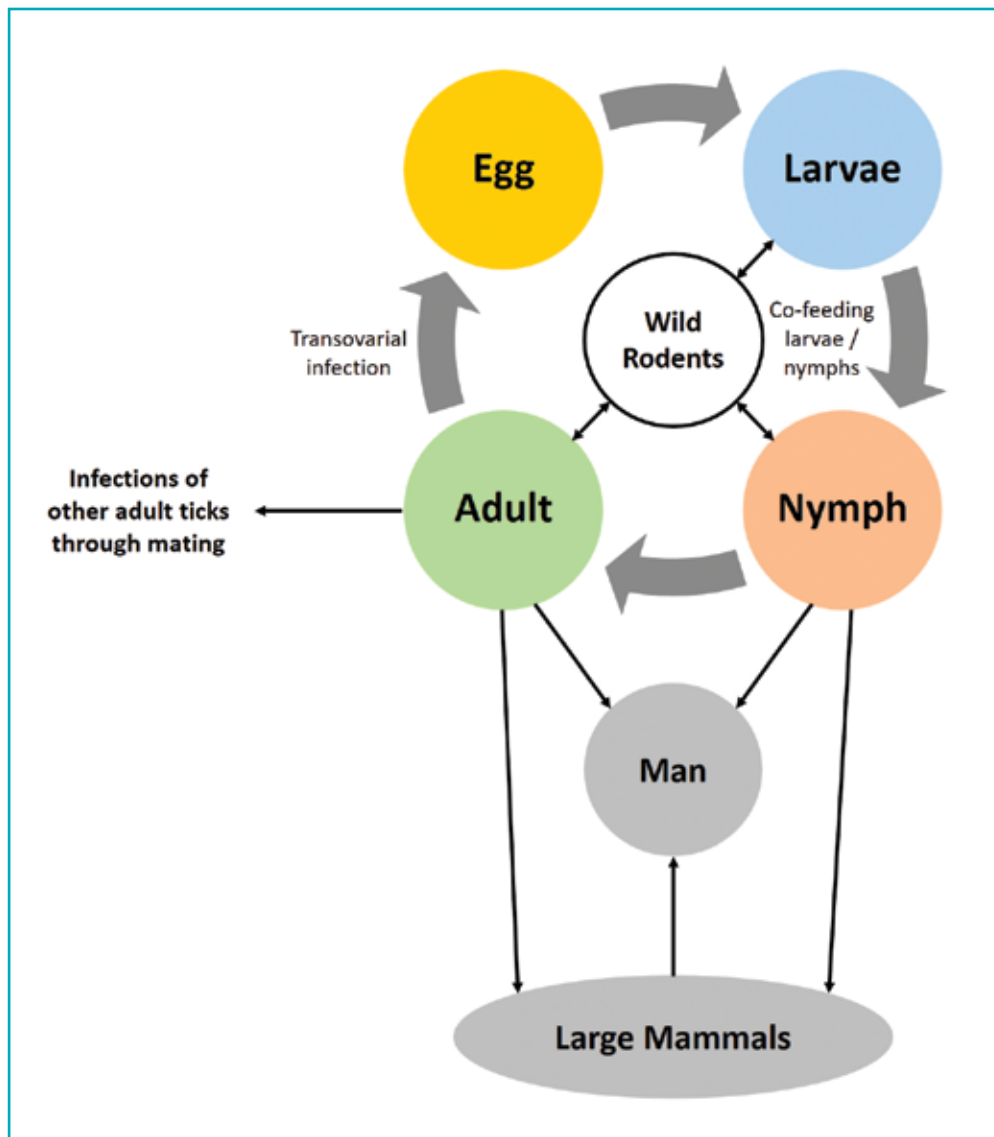


Figure 4.23. Transmission of tick-borne encephalitis virus within the life cycle of *Ixodes ricinus* ticks (tick stages are highlighted with grey shading). Source: Mansfield, K. et al. (2009) Journal of General Virology, 90, 1781-94.



Figure 4.24. *Ixodes ricinus* in engorged (left) and starved (right) states. Source: R. Bartz (left), J.K. Lindsey (right).

A range of chemical treatments are available to prevent tick infestation and to treat cattle with ticks. Pour-on insecticides such as Butox (active ingredient - deltamethrin) are convenient to apply using good

handling facilities, are widely used in Russia to prevent attack from midges and mosquitoes (see next page), and offer extended protection against ticks.

Midges, Mosquitoes and Biting Flies

In June and July in some regions, particularly Siberia, mosquitoes and midges have significant impacts on cattle productivity. Persistent irritation caused by the biting insects to the face, body and udder, and the energy required by the animal to 'defend' itself, by tail flicking for example, have notable effects on productivity. Producers in the region also report occasional blinding of cattle as a result of mosquitoes, and fly-strike to open wounds, for example following the application of ear tags.

Local experience in Russia indicates that cattle with dense hair coats are better defended against these biting insects, are better able to resist attack and do not suffer to the same extent as cattle with less hairy coats, and cattle with thicker hides.

The two primary treatments in Russia and Kazakhstan used to mitigate the impact of these pests include Bayofly (Bayer Animal Health) and Butox. Bayofly (active ingredient - cyfluthrin) and Butox (active ingredient - deltamethrin) are both pour-on insecticides applied

along the backline of cattle, and both offer extended protection of cattle against flies, midges and mosquitoes. Periodic reapplication may be required during the risk period, depending on weather conditions and the type of insect causing problems to the cattle.

At present, there is interest in Siberia to evaluate cross-breeding with cattle derived from *Bos indicus* breeds, for example Santa Gertrudis, to confer greater resistance to cattle to these insect pests (Dr. Bazarbai Inerbaev, Siberian Institute of Livestock, Pers. comm.).

Chemical Treatment for External Parasites

There are a number of ways that chemical treatments can be applied. One method is by spraying the cattle with the chemical using a spray race. Most chemical treatments for external parasites have also been formulated to be applied by administering a concentrated dose of a chemical along the backline to the coat of the animals (Fig. 4.25). This method can also be used to apply specially formulated anthelmintics to control internal parasites.



Figure 4.25. Spray race for applying veterinary treatments for control of external parasites (Left), Source: Tal-Tec, and applying a pour-on insecticide to a beef animal restrained in a cattle crush (Right), Source: International Agriculture for Development.



Figure 4.26. Ringworm on the head and neck of a Friesian heifer. Source: Meat and Livestock Australia.

Some of these insecticides may cause temporary irritation to the animals, and it is essential that the producer always reads the label of the product carefully to determine the method of treatment, potential side effects to the animal and operator, and mandatory withholding periods and export slaughter intervals. Moreover, records of all animal treatments must be kept by the producer that includes this information, and also the batch number and date of application of the treatment.

Ringworm

This is a highly infectious fungal disease and affects the outer layers of the skin. It occurs mainly in young animals and once infected, the animal develops immunity and will not be re-infected (Fig. 4.26). Signs of the disease include crusty skin lesions that start as small scaly patches and slowly enlarge. It is most often seen on the head and neck - lesions persist for several months then heal completely, and in very thin or diseased animals the ringworm scabs may persist longer. Ringworm can also be present at the same time as a lice infestation as both thrive under the same conditions.

Treatment of cattle for ringworm involves isolating the infected animals as they will pass the disease onto others. The affected areas can be treated by scrubbing with soap and water and then bathing the area with a 1% solution of tincture of iodine for 3 to 7 days. It should be remembered that this disease can be passed onto humans, thus protective clothing such as gloves should be worn while treating and handling affected animals.

4.5.2. Internal Parasites

These parasites can generally be grouped into two main types; round worms or flat worms. Some of these parasites may spend their entire life cycle in the cattle while others spend a part of their life cycle in other hosts (for example, snails in the case of the liver fluke).

Young animals, and animals in poor condition or poor health are particularly vulnerable to any parasite or disease as their natural immune system is not fully effective to resist the disease challenge. Conversely, adult animals in good condition and on good feed can tolerate higher parasitic infestations than poorer conditioned animals or calves.



Figure 4.27. Infective third stage larvae of nematodes suspended on grass in a drop of dew. Source: Merial Australia.

Most internal parasites are spread by cattle depositing the eggs on the ground in their dung. The eggs then hatch and contaminate the pasture or feed (Fig. 4.27).

With some worm types the eggs have to be eaten and they then hatch inside the animal. Generally most worm eggs hatch on the pasture. This is then eaten by

the cattle foraging for food. Any feed that is harvested for cattle should be fed in a trough off the ground to reduce the spread of worms.

Life cycles of Liver Fluke and gastro-intestinal round worms are shown in Fig. 4.28 and 4.29.

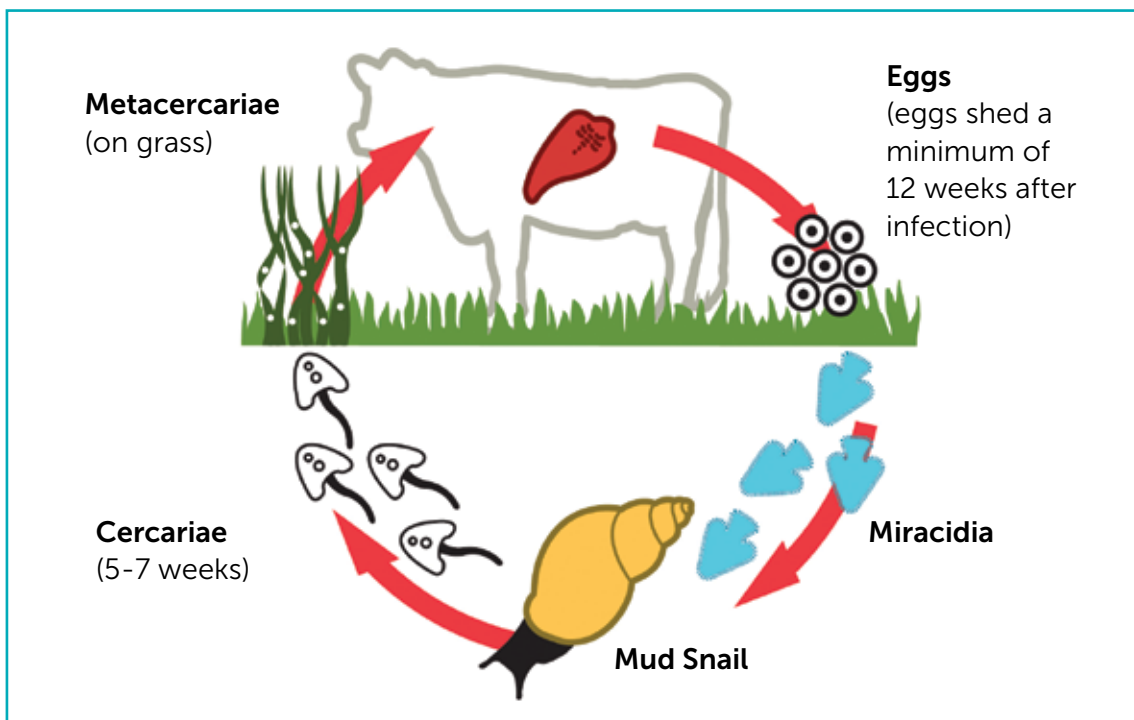


Figure 4.28. Life cycle of Liver Fluke. Source: Pfizer Animal Health.

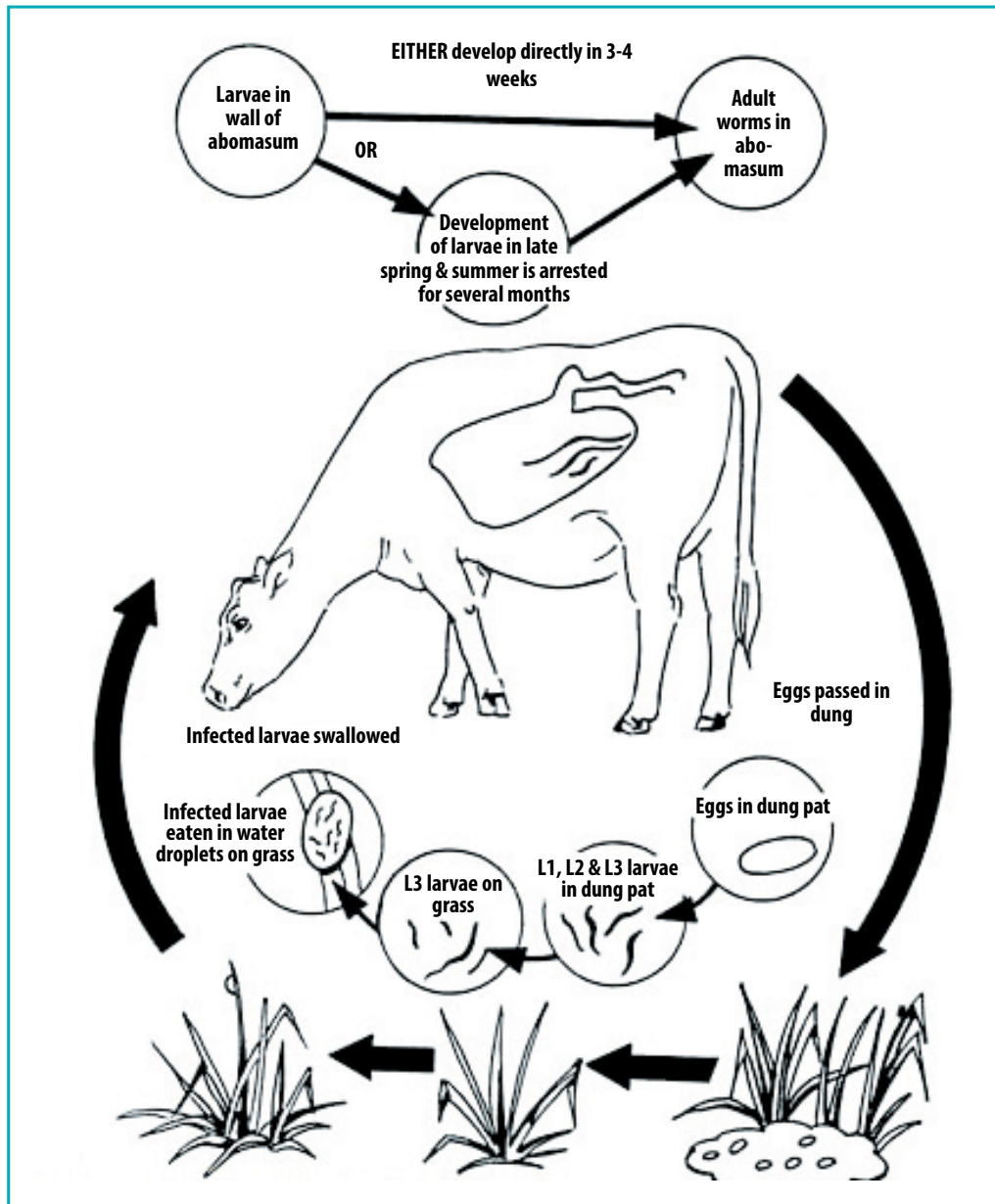


Figure 4.29. Life cycle of gastro-intestinal roundworms.

Symptoms

Symptoms may not become evident until the worm infestations become heavy. Signs to look for are:

- Poor or skinny animals - or loss of weight
- Rough or dry coat (the hair becomes harsh to touch and stands up)
- Diarrhoea which may be foul smelling
- Bottle jaw - swelling under the jaw caused by fluid build up
- Eggs in the dung
- Death in acute cases.

Treatment

Treatment for internal parasites is generally by drenching with chemicals or by pouring a chemical along the back of the animals.

Insecticidal pour-on is easy to apply and will last for up to three weeks for both internal and external parasites. It is essential that the producer has the type and extent of the parasitic burden identified so that the correct treatment can be given.

Incorrect treatment will only lead to increased levels of infestation and resistance to chemicals, which will make it more difficult to control them in the future.

Where drugs or chemicals are to be used to treat parasites, a disease, or an infection, it is important that the label describing how it should be used is properly read, and the instructions followed. The label will have instructions on when and how to use the product and the recommended dose rate. There will possibly be warnings on when not to use it, such as on lactating cows, and the recommended methods of storage and disposal, and an expiry date. As with external parasites, records of all animal treatments must be kept by the producer which includes the batch number and date of application of the treatment.

Liver Fluke

Liver fluke can have a major effect on the performance of cattle. Current estimates suggest that fluke can reduce the market value per finished animal by 10 to 15%. Taking action to control the damage caused by liver fluke will help reduce liver condemnations in abattoirs and improve the performance of the animal.

Liver fluke (*Fasciola hepatica*) is a flat leaf-like parasite found in the tissue and bile ducts of the liver (Fig. 4.30). Adult flukes only measure 2-3cm but cause severe damage to the cattle they infect (Fig. 4.31). To reduce



Figure 4.30. Liver Fluke. Source: Hybu Cig Cymru.



Figure 4.31. Damage caused to the liver from Fluke. Source: The Merck Veterinary Manual.

the spread of live fluke cattle should only have access to water in troughs and be kept away from any surface water that may have the host snail present.

Roundworms

Parasitic roundworms, or nematodes, are found year-round in cattle in most areas of the world. These parasites live in many sites including:

- Lungs
- Body cavity
- Tear or lacrimal ducts
- Beneath the skin
- Gastro-intestinal tract.

Each area is occupied by roundworms specific to those sites. Cattle producers should be aware of the more important worms that can live in their cattle.

Cattle can host over 14 different species of gastro-intestinal roundworms. Different species live in different locations in the intestine. As there are usually just a few of these roundworms present, the harm they cause is not always apparent and can be difficult to assess.

An effective way to detect the prevalence of roundworms and to determine if an anthelmintic treatment is required to improve health and production is through a faecal egg test. Using fresh faeces, an estimate of the number of nematode eggs can be derived, and if the number of eggs is high then treatments can be implemented.

4.5.3. Diseases Affecting Reproductive Performance

Leptospirosis

Leptospirosis is a bacterial infection of cattle that can also adversely affect human health when cattle handlers come into contact with infected materials originating from cattle (for example urine, and urine contaminated pasture or drinking water).

It may also be contracted from contact with materials contaminated with urine from mice and rats. It is caused by bacteria of the genus *Leptospira*, and in humans, it can cause a wide range of symptoms, some of which may be mistaken for other diseases.

Some infected persons may have no symptoms at all. Without treatment, Leptospirosis can lead to kidney damage, meningitis (inflammation of the membrane around the brain and spinal cord), liver failure, respiratory distress, and even death.

There are many different strains of Leptospirosis, of which *Lepto pomona* is the most common. It is often found in wet areas such as waterholes and soaks, rivers, lakes, sewerages, and also in the sea.

Calves affected with Lepto will exhibit a yellowish discoloration of the visible mucous membranes coupled with blood tinged urine. Loss of appetite, fever and anaemia may also be observed. In older cattle symptoms vary greatly making diagnosis difficult. Abortion is common and there can be a sharp drop in milk production. The milk may be thick, yellow and blood tinged, without any sign of udder inflammation.

Leptospirosis is a preventable disease with specific vaccination.

Brucellosis

Brucellosis is a contagious disease caused by bacteria that causes abortion. It can also be passed onto humans. Importantly, Brucellosis is not present in Australian beef cattle. However, it is a disease of concern in many of the destination countries that receive Australian beef cattle and must therefore be managed to avoid the negative consequences associated with the disease.

Pregnant females that are infected with Brucellosis will abort a foetus at about 3 to 6 months following conception. Infected animals spread the disease through the urine, an aborted foetus, onto pasture, or into drinking water. Infected animals should be culled to prevent the spread of the disease.

Currently there is no known cure for Brucellosis. However, it is a preventable disease with specific vaccination. Inoculation of heifer calves between 6 to 8 months with the live vaccine is the best known preventative measure. Adult cattle can also be vaccinated to control the spread of the disease.

Where Australian cattle are imported to regions with a known prevalence of Brucellosis in beef cattle, the Australian cattle should be provided with an appropriate and specific vaccination immediately upon arrival in quarantine so that they are protected from subsequent infection.

Vibriosis

Vibriosis is a bacterial infection which causes temporary infertility in cattle. The most obvious sign of Vibriosis is when females, particularly heifers, keep returning to the bull for mating or have an irregular oestrus cycle. Only about 5% of an affected herd will abort, and this is often associated with a retained placenta.

The disease mainly affects heifers having their first calf, as the animal will develop immunity following Vibriosis infection. Even though females develop immunity to the disease, they can still spread the disease to bulls and other females in the herd for a number of years. Bulls remain infected for life once they contract Vibriosis.

Vibriosis is a preventable disease with specific vaccination. Once the Vibriosis has been diagnosed in the herd, all animals should be vaccinated. All heifers should be vaccinated at about 10 to 12 months of age. They only need to be vaccinated once. Bulls should be vaccinated each year in the spring. Other preventative measures include routinely culling bulls at eight years of age and keeping young bulls separate from older bulls.

Infectious Bovine Rhinotracheitis (IBR)

IBR, also known as Red Nose, is an infectious disease of cattle caused by Bovine herpesvirus-1 (Fig. 4.32). The disease can manifest itself in two ways;

- 1) Through upper respiratory tract infections, or
- 2) By venereal infection.

Animals rarely die from this disease, however secondary bacterial infections can occur which impact on the performance of the animal, with a 10-30% drop in live weight gain. The main sources of infection are;

- Droplet infection from nasal discharge
- Genital secretions
- Foetal fluids
- Semen.

The incubation period ranges from 7 to 20 days, and the severity of symptoms will depend on the strain of the virus and the susceptibility of cattle.

Respiratory symptoms include;

- Sudden onset of fever (temperature up to 42°C)

- Animal is off its feed
- Severe inflammation of nasal mucosa (Red nose - irregular scabs)
- Serous discharge from the nose and the eyes
- Conjunctivitis
- Hyper salivation
- Dramatic drop in milk yield, particularly in dairy cattle
- In some cases sudden coughing
- Recovery can take about two weeks.

Venereal symptoms include:

- If disease occurs in last trimester of pregnancy, foetus may be aborted and could be mummified. If a live calf is born it will be weak
- Infected females will show signs of frequent urination, an elevated tail, a vaginal discharge, swollen vulva showing small fluid like pustules on the surface



Figure 4.32. Infectious Bovine Rhinotracheitis. Source: Calfology.com.

- Infected bulls will have small fluid like pustules present on the surface of the penis and sheath.

Once introduced it is difficult and expensive to eradicate IBR. Animals tend to become unapparent carriers. Systematic testing and elimination of positives has been successful in some countries. Different types of inactivated vaccines are available. Officially free countries restrict the use of these vaccines.

4.5.4. Clostridial Diseases

Clostridial organisms of various types are found in the soil where they can survive for a long time. Most clostridial organisms can also occur quite naturally in the gut of healthy animals. They live there causing no trouble, pass out in the manure of animals, and consequently contaminate the soil. When conditions are favourable for the uncontrolled growth of clostridial organisms they produce powerful toxins that are usually fatal. Not all species of clostridia cause disease, but those that do are usually fatal. The major clostridial diseases in cattle are Blackleg, Tetanus and Botulism.

Blackleg

Blackleg is a preventable infectious bacterial disease that usually affects younger animals between 6 to 24 months of age. It is a fatal disease that produces an acute local infection that leads to blood poisoning and rapid death. Marked lameness and pronounced swelling over the shoulders and thighs caused by the formation of gas in the subcutaneous tissues are the primary symptoms of Blackleg.

When pressure is applied to the swelling a peculiar crackling sound can be heard. Infected animals have foul smelling yellowish white faeces and the hindquarters are dirty. Calves become dull and weak, lose weight, the eyes appear sunken, breathing is rapid, and body temperature drops below normal.

The disease is almost always fatal within 12 to 36 hours. Post-mortem inspection of diseased muscles typically shows dark tissue with a dry or bubbly appearance (Fig. 4.33).

Blackleg is a preventable disease by specific vaccination and is the most practical method of combating this disease. Vaccination is normally carried out at weaning.



Figure 4.33. Blackleg post-mortem examination reveals extensive necrosis of the leg musculature with a blackish-red discoloration with a "bubbly" appearance. Source: infograph.venngage.com/p/91280/black-leg.



Figure 4.34. A calf with tetanus following castration. Note the neck and head are extended. Source: National Animal Disease Information Service, United Kingdom.

Tetanus

Tetanus is a preventable disease caused by toxins produced from the *Clostridium tetani* bacteria. The bacterial spores are commonly found in soil and animal faeces. They persist for many years and are resistant to environmental effects.

The usual method of entry of the bacteria is through deep puncture wounds on the body or feet, or as a result of entry through exposed surgical wounds such as castration. Bacterial spores can remain inactive for some time and when conditions are right they multiply rapidly in the body, producing toxins that affect the nervous system of the animal. The incubation period can be from 5 days - 3 weeks.

The disease can last for up to 10 days and is nearly always fatal. Animals are characterised by increased muscle stiffness and muscle tremors, with the head, neck and tail held stiffly, and restricted jaw movement - referred to as 'lockjaw' (Fig. 4.34). The animal eventually cannot stand and may fall over showing muscle spasms with outstretched limbs. Raised temperatures up to 42°C are common, and death is due to muscular spasms coupled with paralysis of the respiratory muscles.

Tetanus is a preventable disease with specific vaccination. Calves should be vaccinated twice at an early age (according to manufacturer's recommendations) to generate immunity, and animals retained for breeding should be vaccinated again on an annual basis.

For breeding cows, vaccination should take place at least six weeks before calving to ensure post-calving immunity is passed to the calf for the period until the vaccine is administered to the calf to confer long term immunity. Good hygiene practices such as the prompt treatment of all surgical wounds is also a preventative against tetanus infection.

Botulism

Botulism is a preventable disease that is caused by the ingestion of toxins (poisons), which are produced by *Clostridium botulinum* bacteria commonly found in soil or on dead and decaying carcasses, decaying plant matter, or feedstuffs contaminated with dead animals. There are several distinct types or strains of botulism commonly referred to as types A, B, C, D and E.

The condition is often associated with cattle experiencing a phosphorus and/or protein deficiency. To try and



Figure 4.35. An advanced case of botulism with the head turned back and tucked into their flank. Source: afrivet.co.za.

overcome this deficiency they begin to chew bones of dead animals where the toxins of the bacteria are found.

In other cases animals grazing on the edges of water courses where decaying plant matter is found can also pick up toxins. These toxins have a major effect on the nervous system of cattle.

Often the first sign is the discovery of dead animals. Any sick animals may show signs of unsteady gait, with a progressive paralysis starting in the back legs and advancing to the front legs through to the jaw and throat. In advanced cases where the animals generally do not recover, you will see the animal lying down in an upright position with the head turned back and tucked into their flank (Figure 4.35) or head and neck outstretched on the ground. Generally if you pull the tongue out the animal cannot retract the tongue as the muscles of the throat are paralysed. Sometimes the animal may be found on its side moving their legs in a slow paddling motion unable to get up.

Botulism is a preventable disease with specific vaccination. All calves should be vaccinated with the bi-

valent Botulism Vaccine. This covers the most common types; A and D. Some companies make a one shot vaccine that provides up to three years protection.

If an unvaccinated animal is infected there are no specific treatments to remedy the infection. Destroy dead animals/carcasses by either burning or deep burial to ensure other animals cannot gain access to them.

4.5.5. Other Important Diseases

Anthrax

Anthrax causes sudden death in cattle and is a disease that affects humans as well. In all cases of sudden death without any forewarning symptoms of illness, anthrax should be suspected. Finding a dead animal is commonly the first sign of the presence of this disease. If anthrax is suspected do not post mortem the animal as this increases the risk of contaminating people and pastures.

Anthrax symptoms can include a black tar like blood running out of all body orifices, particularly the anus,

vulva and nostrils (Fig. 4.36). Prompt vaccination of all other animals in the herd is recommended to prevent the disease from spreading if it is identified in the herd. All infected carcasses must be burned or buried deeply in a pit lined with lime.

Foot and Mouth Disease (FMD)

This is a highly contagious viral disease that affects all cloven hoofed animals such as cattle, buffalo, sheep, goats and pigs. Foot and Mouth Disease (FMD) occurs periodically through parts of central Asia and Russia, and is endemic throughout most tropical regions of the world. By contrast FMD is not present in Australia.

The disease is characterised by the appearance of blisters on the mucous membranes of the tongue (Fig. 4.37), lips, palate, cheeks, on the skin and around the dewclaws of the feet (Fig. 4.38), and on the teats and udder. The presence of blisters in the mouth stimulates a profuse flow of saliva that hangs in strings from the mouth of the infected animals.

If animals with FMD symptoms are observed, the responsible Government Agency and veterinary Authority must be notified immediately.

If the disease is suspected, the farm must be quarantined and the area thoroughly disinfected with a strong solution of sodium hydroxide or formalin. All infected animals showing clinical signs must be treated with alum and gentian violet or sodium hypochlorite.

In most countries infected animals and other cloven hoofed species on the same farm, e.g. sheep, deer, goats, and pigs, are all destroyed to contain the spread of the disease.

This is an effective but expensive way of minimising the spread of the disease. However, the disease can be controlled by vaccination, and some countries adopt this approach both to manage the disease, and to implement regional and national disease eradication programs.



Figure 4.36. A cow that has died from anthrax. Note blood dripping from eyes, nostrils and mouth. Source: NSW Department of Primary Industries, North West Local Land Services.



Figure 4.37. Foot and mouth disease (FMD) lesions on tongue and mouth. Source: Department of Agriculture, Australia.



Figure 4.38. FMD lesion on the back of the foot. Source: Department of Agriculture, Australia.

Hemorrhagic Septicaemia (HS)

Hemorrhagic septicaemia is an important disease in Asia, Africa, some countries in southern Europe, and the Middle East. It does not occur in Australia.

Hemorrhagic septicaemia is a fatal disease of cattle caused by the bacterium *Pasteurella multocida*. Also known as Bollinger's Disease, it is transmitted by direct contact with infected animals and on infected objects and materials. Cattle become infected when they ingest or inhale the causative organism, which probably originates in the nasopharynx of infected animals. In endemic areas, up to 5% of cattle may normally be carriers. The carrier rate can increase to more than 20% for a few weeks after an outbreak.

The worst epidemics occur in animals in poor physical condition. Stresses such as a poor food supply are thought to increase susceptibility to infection, and close herding and wet conditions seem to contribute to the spread of the disease. *P. multocida* can survive for hours and possibly days in damp soil or water. Viable organisms are not found in the soil or pastures after 2 to 3 weeks.

A fever, dullness, and reluctance to move are the first symptoms. Salivation and a serous nasal discharge develop, and oedematous swellings become apparent in the pharyngeal region. These swellings spread to the ventral cervical region and brisket. The mucous membranes are congested. Respiratory distress occurs, and the animal usually collapses and dies 6 to 24 hours after the first symptoms are seen.

Animals with clinical signs, particularly buffalo, rarely recover. Mortality is nearly 100% unless the animal is treated very early in the disease; few animals survive once they develop clinical signs.

The disease is preventable with specific vaccination. Antibiotic treatment is effective if started very early. Various vaccines can provide protection for 6 to 12 months.

Bovine Tuberculosis

Bovine Tuberculosis is a bacterial respiratory disease that is not present in Australia. Specific symptoms are difficult to detect in live animals. In advanced cases, the coat may be rough and dry and the animal will have a run-down appearance. These symptoms are also similar to a number of other diseases and cannot be seen as conclusive.

The most reliable test is the Tuberculin Test, normally given in the caudal fold under the butt of the tail, which will cause a characteristic swelling under the skin within 72 hours.

There is no economic method of treating animals for tuberculosis. Infected animals must be destroyed to prevent its spread to other animals and humans.

Johne's Disease

Bovine Johne's disease is caused by *Mycobacterium paratuberculosis* (bacteria) and is a condition that is rarely seen in cattle under two years old. However, infection normally starts from a young age.

The bacterium is commonly found in the gut and is passed in faeces. Animals become infected by eating contaminated pasture, water and other food containing the bacteria.

The animal can appear normal and healthy during the incubation period and routinely pass bacteria in faeces

without showing signs of illness. Animals in housed areas or confinement are most at risk due to their exposure to faecal material.

The disease is characterised by progressive emaciation, along with the development of Bottle Jaw; fluid swelling around the lower cheeks down to the lower jaw (Fig. 4.39). Cattle may also exhibit diarrhoea and excessive thirst.

No vaccine or treatment is available for Bovine Johne's. Animals that are tested and confirmed positive for the disease need to be slaughtered and disposed of by burning or deep burial. Routine testing and slaughter of animals that test positive (blood test) to the disease need to be considered in order to eradicate this disease.



Figure 4.39. Bottle Jaw can be a sign of worms or Johne's Disease.
Source: Johne's Information Center, University of Wisconsin.

Calf Scours and Diarrhoea

Scours, or diarrhoea, is caused by an interaction between the environment, the health of the calf and the presence of disease causing agents (pathogens), which include bacteria, viruses and protozoa.

Common pathogens which cause calf scours include;

- Cryptosporidia
- Rotavirus
- Bovine coronavirus
- *E. coli*
- Salmonella.

These pathogens are shed in low numbers in the manure of cows around the time of calving. They are also shed in much greater numbers in the manure of scouring calves, and also by unaffected calves up to six months of age. Affected animals have liquid faeces that

may be discoloured. The hindquarters and tail are dirty and covered in faecal material.

Calves affected by scours should be allowed to drink as much milk containing colostrum as possible. The colostrum contains antibodies that assist the calf to build resistance to these diseases. It is also very important that fluid balance is maintained so water with electrolyte replacements should be administered. The use of sulphur drugs and broad spectrum antibiotics are effective in controlling these diseases and are best given orally.

Pinkeye

Infectious bovine kerato-conjunctivitis (IBK) is commonly referred to as pinkeye in cattle. It is a contagious bacterial infection of the eye that causes inflammation. In very severe cases pinkeye can lead to temporary or permanent blindness in the affected eye.

In the first two days of the infection, the membranes of the eye are red and swollen (hence the name 'pinkeye') with a watery discharge causing tear staining and a closed eye. It should be noted that a weeping discharge from the eye, otherwise known as conjunctivitis, is not always associated with pinkeye. Cattle may periodically 'weep' as a result of minor irritations caused by dust, insects and grass seeds and other foreign bodies. It is important to differentiate between these various causes of conjunctivitis as the treatment and prevention for each differs significantly.

In the case of pinkeye, one or both eyes may be infected. The cornea then becomes cloudy or bluish and a small whitish spot appears in the centre. In the majority of cases, the infection then starts to resolve, leaving little or no permanent damage.

In more severe infections, the spot in the centre of the eye continues to enlarge to form an ulcer that spreads and swells, with most of the eye changing from white to yellow and then to red (Fig. 4.40). Treatment should be given before the disease is this severe. If ulceration is severe, the cornea may rupture and the cornea will be permanently damaged.

As recovery progresses, the blood vessels start to recede and the eye becomes a cloudy blue colour, then begins to clear. Recovery is usually complete 3 to 5 weeks

after the initial infection, and most affected eyes heal completely.

Pinkeye has a number of predisposing factors that include dusty conditions, flies, bright sunlight, and physical irritation, and outbreaks are most frequent in summer and autumn when ultraviolet radiation is high. Consequently, controlling dust and flies in situations where animals are confined together can be effective strategies to avoid outbreaks of pinkeye in the herd.

Cattle with unpigmented eyelids and protruding eyes that are susceptible to damage are more prone to pinkeye, whereas hooded eye conformation, which offers some protection from sunlight and physical damage, may reduce susceptibility to pinkeye.

Pinkeye persists in a herd in the eyes of carrier cattle that do not show any signs of disease. Eye irritation from dust, bright sunlight, and long grass can then cause tear production which attracts flies. The flies feed on infected secretions and move from animal to animal, spreading the bacteria. Carriers may also carry infection in the nose and vagina, so that discharges from these areas are also a source of infection.

The most practical and effective treatment for pinkeye is the use of a long-acting antibiotic (penicillin) ointment applied in the conjunctival sac; in the space between the eyelid and the eye.



Figure 4.40. Progressions of pinkeye from the yellow/red stage (left) to blue (right) as the eye recovers. Source: International Agriculture for Development.

4.5.6. Acidosis - Grain Poisoning

Acidosis, or grain poisoning, is a debilitating nutritional condition that results from the accumulation of large quantities of lactic acid arising from the fermentation of grains that are high in rapidly fermentable carbohydrates. Wheat, triticale, rye, barley and oats are (in that order) the most likely grains to cause acidosis. It can also occur in high quality diets that are low in effective fibre.

Although it is not strictly a disease, it can have significant impacts on the herd, particularly where breeding cows and weaner cattle are fed grain diets during winter, calves are fed grain as a weaning supplement, or cattle are fed finishing diets with very high levels of grain.

Acidosis commonly occurs when cattle that are not adapted to grain diets are first given access to the grain. During the fermentation of grain by rumen microorganisms, lactic acid is produced. An excess of lactic acid affects the animal by;

- Decreasing the numbers of useful bacteria in the rumen and increasing the amount of acid-producing bacteria (causing further build-up of acid in the rumen)
- Causing rumen contractions to cease
- Causing dehydration by drawing fluid into the rumen from the tissues and blood
- Causing the blood to become more acidic, resulting in heart failure, kidney failure and death
- Damaging the rumen wall and enabling fungal or bacterial invasion of the body. This can result in peritonitis or liver abscess even up to a week after grain poisoning
- Laminitis; a painful inflammation of the hoof, may occur, resulting in severe lameness.

Fortunately, some species of bacteria that are normally resident in the rumen are able to utilise lactic acid and prevent excess lactic acid build-up, but unless grain is present in the diet, they remain only a minor component of the rumen micro-flora. Consequently, grain needs to be introduced gradually over a period of time to allow the lactic acid utilising bacteria to build up in numbers to a level where they can cope with the rapid production of lactic acid by other microbes in the rumen.

Other instances where acidosis may occur include when a sudden increase in the quantity of grain is fed and excessive quantities are consumed, where a change in grain type or concentrate is fed, and as a result of an inadequate consumption of effective fibre. It has also been observed where animals have had accidental access to grain storage areas, or split grains.

Cattle may suffer either of two forms of acidosis; acute (rapid onset) and chronic (Table 4.5). Where cattle suffer acute acidosis, unless intervention is applied immediately upon observing affected animals, they will die from the effects of the condition. Chronic (sub-acute) acidosis may persist for an extended period, and although may not cause the death of the animals, they will suffer production losses by going 'off-feed' for periods of time when they are affected.

Prevention

Prevention of acidosis requires a multi-factorial approach to manage the inherent risk of high grain, low-fibre diets.

1. The gradual introduction of high risk feeds to cattle over a period of at least 14 days or longer is the most effective way to ensure that the rumen microorganisms adapt to the grain in the diet
2. Supplementary feeding with neutralising agents (rumen buffers) can also be used to further reduce the risk of acidosis. However, using buffers alone and without other preventative measures is not an effective way to prevent the condition. Commonly used rumen buffers include;
 - Sodium bicarbonate (at 0.75 to 1.5% w/w)
 - Magnesium oxide (at 0.5 to 0.975% w/w) plus sodium bicarbonate
 - Calcium carbonate (at 1-2% w/w), barley or triticale (or 3% w/w wheat)
3. Adding fibre to the diet to promote rumination and saliva/bicarbonate production by the animal
4. Feeding cattle on a daily basis, or twice daily particularly during very cold weather (see Section 3.7.1) will help cattle perform better than those fed irregularly, as it further limits the chances of grain poisoning

5. Total mixed rations can assist in the prevention of acidosis by providing a balanced ration containing fibre and grain.

Faecal consistency should be monitored daily to identify potential problems as they develop.

Treatment

Cattle affected by grain poisoning should be removed from the herd and placed on a 'recovery' diet. This involves removing access to grain and providing good

quality hay until the animal recovers and is usually effective for animals with mild cases.

Feedlot animals that are scouring can be temporarily changed to a ration 20%–25% lower in grain content for 2 to 3 days to see if their condition improves.

In severe cases, where the animals are unable to stand and have abnormal body temperature, urgent veterinary assistance should be sought, and if unavailable, consideration should be given to humane destruction of the individual (see Section 4.2.6).

Table 4.5. Symptoms of cattle with acidosis (grain poisoning).

Acute Acidosis	Chronic Acidosis
Rumen contents become acidic, falling below 5.0	Reduction in rumen pH, and motility
Excessive fluid build-up within rumen and intestinal contents lead to a distension of the abdomen	Faeces may appear as diarrhea (Fig. 4.5), foamy, with gas bubbles, and contain undigested fibre or grain
Loss of appetite, depression, isolation, panting, dehydration	Reduction in rumination (cud chewing)
Laminitis (lameness)	Reduced feed efficiency
Diarrhea	Daily variation in feed intake is high
Death	Reduction in average daily growth rates

4.5.7. Bloat

Bloat is another nutrition disease that can have a significant economic impact on cattle grazing pastures and forages. It tends to be a seasonal condition that is usually caused by the rapid consumption of lush legume pasture species, and some forages and grasses containing high levels of soluble proteins in spring, summer and autumn.

Bloat is caused by an increase in the gas pressure within the rumen as these feeds are fermented. The gas cannot be belched up normally and death results from the pressure; causing heart and lung failure. The gas is often trapped in the form of a stable foam.

Bloat is often triggered by cattle gorging themselves with legume rich pasture. Hungry cattle should not be allowed access to these areas. Feeding out grass hay a few hours before the cattle are moved into a new paddock will reduce their appetite. If faced with a choice of grazing fresh young forages or mature forages, the cattle should be introduced into more mature pastures. An increase in the height of legumes will generally decrease the risk of bloat. Legumes in flower are safer to graze than the less mature stages.

Cattle will learn to moderate their pasture intake to control the extent of bloating and discomfort. This occurs over several weeks. Older cattle are better at adapting their grazing behaviour than younger animals.



Figure 4.41. Cattle displaying signs of bloat, with the abdomen distended outwards and upwards on the left side. Source: University of Nebraska, Lincoln.

Cattle with bloat may display the following signs:

- No longer grazing
- A reluctance to move
- Distended left abdomen (Fig. 4.41)
- Appear distressed - vocalise, eyes bulging
- Strain to urinate and defecate
- Rapid breathing - mouth may be open with tongue protruding; staggering.

The animal will go down in advanced cases. Death is rapid at this stage, and is due to the swollen rumen compressing the lungs; interfering with breathing and obstructing blood flow.

Treatment

Early/mild cases of bloat can be treated orally with an anti-bloat preparation. After dosing, keep the animal moving to encourage the preparation to mix with the frothy rumen contents.

Moderately affected stock that are bloated and starting to show signs of distress need veterinary attention. A stomach tube can be used to relieve the gas build-up, and anti-foaming agents can be delivered directly into the rumen. Moving the animal around after treatment is important.

In severe cases, bloated and distressed animals will need veterinary attention and rapid relief. This is usually done by inserting a wide-bore trochar and cannula into the rumen high on the left flank (where the swelling is greatest). After gas and froth is released, an anti-bloat preparation may be poured through the cannula into the rumen to help break down remaining froth/foam (dose according to label instructions). In emergency situations, vegetable oil (250 to 500mL) or paraffin oil (100 to 200mL) has traditionally been used.

Prevention via Management

Fast growing, legume dominant pastures should be avoided until the pasture matures further and bloat risk declines. Mature pastures with less than 30% legume content pose little risk of bloat. Dew on the grass is also believed to increase the incidence of bloat. Cattle selectively graze succulent grasses and legumes which makes assessing the risk of a pasture difficult, hence pasture management should not be solely relied on to control bloat.

Increasing fibre intake will reduce bloating. Feeding grass hay daily can help to reduce the intake of pasture with a high bloat risk. However, some animals will eat pasture in preference to the hay.

Prevention via Medication

There are several labour saving methods for the administration of anti-foaming agents to beef cattle. However none are 100% effective. They are usually used in conjunction with other management strategies to minimise losses from bloat.

- Sustained Release Anti-bloat Capsules - Each capsule is approximately 150mm in length and is administered as a large plastic pellet down the throat and into the rumen. They provide a continuous supply of ingredient for 80 to 100 days and must be given one week prior to the cattle being introduced onto 'bloaty' pasture. A second capsule is required if the bloat season extends beyond 100 days or if bloating occurs in your area during other times of the year. The capsules have been found to reduce bloat deaths by about 80%
- Bloat Blocks - Bloat blocks or licks place minimal demands on management and are popular. Several types are on the market and contain a specific detergent. Bloat control relies on each animal consuming an adequate daily dose of the block. Cattle can be encouraged to use the blocks by placing them close to stock camps and watering points. Alternative control methods are required for those animals which do not use the blocks
- Water Trough Treatments - Medication of the cattle through their water supply is another alternative. The addition of chemical makes the water less palatable so all other water sources must be fenced off. The daily dose that each animal receives depends on the amount of water consumed and the concentration of the chemical in the water. The water consumption of individuals can vary substantially depending on the water content of the pasture and the weather. The chemical in the trough will be diluted when fresh water is released from the ball cock. This problem can be overcome by shutting off the refilling mechanism and replenishing the trough with chemical and water daily. Otherwise a metering device which releases chemical with the water will be required.

5. Beef Cattle Breeding

THE SUCCESS OF BEEF CATTLE HERDS is dependent on the producer being able to implement a successful breeding program for the herd.

This extends from the conceptual process of establishing breeding objectives for the herd and determining the genetic pathway to produce cattle that satisfy target markets, through to the very practical outcome of producing healthy calves on the ground. Understanding these processes and principles will underpin the long term success of beef cattle genetics imported from overseas countries, and Australia in particular.

To assist with the planning and running of the range of activities that are required to be successfully implemented, an annual Calendar of Operations has been developed that is based on the combined experience of commercially successful beef cattle production systems in countries with cold winter climates such as Canada, northern USA, Russia and Kazakhstan (TECHNICAL NOTE 1 - Calendar of Operations for Beef Cattle Production in Cold Climates). These activities are outlined in the following sections of this Manual.

5.1. Developing a Breeding Objective

It is essential that all beef breeding enterprises have a clearly defined breeding objective. This objective provides the basis for decisions such as which sires to use and which females to retain as potential breeders. The breeding objective is most simply expressed as the 'ideal' animal the enterprise aims to produce. It is specific to the intended market, the production system, management environment and the current level of herd performance.

For enterprises in cold climate countries receiving imported Australian breeding cattle, it is likely that the primary objective will be to establish a foundation herd from which to build up breeder numbers until a stable herd size is reached, while producing surplus

offspring suited for local consumption. Accordingly, an appropriate breeding objective for these enterprises will incorporate elements such as:

- Maximising the number of live calves born unassisted
- Maximising the proportion of female calves born that are suitable for selection as potential breeders
- Maximising the proportion of male and cull female progeny that meet production targets as feeder animals destined for local consumption
- Minimising the number of existing breeders that leave the herd each year.

Once herd build-up is complete and a stable size herd has been reached, greater selection pressure can be applied to females kept as replacements as fewer are required each year. At this point, the breeding objective will most likely change, and selection of breeding cattle (both bulls and cows) with greater emphasis on traits such as growth rate, muscling and improved body confirmation becomes possible.

There are two components to achieving a breeding objective:

- The genetic merit of animals (both bulls and cows) in the herd
- The environment under which the animals live (includes climatic and managerial effects).

Genetics define the production potential of cattle. Using the most suitable genetics available allows producers to improve productivity and subsequent enterprise profit. However, significant genetic improvement, while permanent and cumulative, is a long-term process that takes generations to achieve.

The **Environment** in which cattle are raised also has a considerable impact on the performance of individual animals, and the herd overall. 'Environment'

encompasses both the physical environment (for example, prevailing climate, soils, forage species) and the management environment (for example, timing of breeding cycle, supplementary nutrition, health, husbandry practices). In contrast to the long-term nature of genetic change, management decisions affecting the animal or herd's current environment can have an immediate impact on productivity.

A sound understanding of the actions available to beef managers to address any preventable environmental limitations is therefore essential in challenging environments such as the cold winter climates of the northern hemisphere.

Inherent genetic traits and the overall living environment ultimately interact in very complex ways to determine the physical appearance and production of beef cattle. A successful beef breeding enterprise must understand, and where possible influence these interactions in order to produce their 'ideal' animal.

5.2. The Role of Genetics

Genetics affect the ability of the beef enterprise to achieve its defined production goals. For breeding enterprises, important production traits are fertility, calving ease and milk supply. For steer production, important production traits include growth rate, muscling and carcass quality. As little genetic information is available for most commercial females, it is through the selection and use of appropriate bulls that most deliberate genetic gain is made in a breeding herd.

Over its working life, a single sire has a much greater influence than a single cow on the rate of herd genetic improvement. For example a cow might produce 7 to 9 calves in her lifetime while a bull may produce more than 100 calves over his life.

An important consideration when selecting sires for use in a breeding program is that introduced bulls or semen be unrelated, or very distantly related, to current and previously used sires in the herd.

Inbreeding can lead to reduced animal performance and an increased susceptibility to some genetic disorders. This is most likely to occur with widespread and continued use of a limited number of sires in an artificial insemination program. This situation is not uncommon in central Asia, and enterprises importing Australian heifers will need to ensure they use sires that

provide genetic diversity to the herd as the herd age structure matures.

5.2.1. Selecting the Most Appropriate Breed

Many beef cattle breeds exist throughout the world, each with particular characteristics that make it successful in its place of origin. While considerable genetic diversity exists within all breeds, the general characteristics of each breed as a whole provide a base for determining what breed or combination of breeds might be best suited to any individual enterprise. Put simply, the environment the animals live in and the market to be supplied are the major determinants of the most appropriate breed of cattle to use. The basic characteristics of the most common beef breeds are:

- British breed cattle (e.g. Angus, Hereford, Shorthorn) are best adapted to temperate, Mediterranean and Continental environments, and are early maturing, perform well on moderate nutrition, have high fertility and good eating quality carcasses
- European breeds (e.g. Charolais, Limousin, beef Simmental) grow faster, have more muscle and mature at a later age. They require more feed than British breeds to lay down adequate fat
- Bos indicus breeds (e.g. Brahman, Santa Gertrudis) are best adapted to tropical environments, and have high survivability under poor nutrition, and excellent parasite resistance
- Dairy breeds (e.g. Holstein, dairy Simmental) can be crossbred with British breeds to produce specialist vealer producing cows and these require good nutrition to achieve their production potential
- Composite breeds are a combination of two or more breeds bred together until they reach a stable biological type. The breeds used will determine the biological type, its potential productivity, and nutritional requirements to achieve it
- Crossbreeding within a herd can make better use of breed selection by combining breeds with different strengths (e.g. fertility of British breeds combined with muscling and growth of European breeds or with the environmental adaptation of local breeds). The progeny from these animals will also exhibit hybrid vigour, significantly lifting performance further.

Most young beef heifers imported from Australia to cold climate countries will be British breeds. These breeds are well adapted to the central Asian climate, produce high eating quality beef, and there is a large international herd from which to select pedigree animals. Imported heifers will most likely form the foundation of purebred herds, but some may become part of a crossbreeding program with local breeds (commonly dual-purpose dairy and beef animals).

5.2.2. Crossbreeding

An opportunity exists to introduce a second beef breed into purebred herds and develop structured crossbreeding programs. Cross-breeding offers significant commercial advantages over pure breeding in enterprises where the focus is on producing fast growing slaughter cattle that meet market specifications.

These advantages are due to the expression of hybrid vigour; a widely recognised phenomenon that results in productivity benefits in the progeny of animals mated to a breed different from their own. In beef cattle, these benefits are typically measured in terms of higher growth rates of the progeny, therefore leading to reduced feeding costs to reach the same slaughter weight. Fertility in crossbred females kept as replacement breeders is also improved by hybrid vigour.

A number of breeds would be well suited to crossbreeding with Angus in countries with cold winter climates, and they include Hereford, Limousin, and Simmental. Others may also be suitable in the long term as terminal sires in a three-way cross (for example Charolais).

5.2.3. With Local Breeds - Beef and Dairy

In order to improve cash flow and rapidly increase the size of the breeding herd, an opportunity lies in mating local dairy or dual purpose (dairy and beef) cows to imported beef bulls.

Local cows may offer some intangible benefits such as existing adaptation to the local environment. Cows selected for entry into a local beef crossbreeding herd would need to be selected with some reference to body type and conformation, i.e. exhibiting beef characteristics. The female progeny from the local crossbred cows can undergo further selection with suitable heifers retained for future breeding as half-bred beef

cows. If mated to beef bulls, within three generations the resultant females would be 88% beef breed, and well established as an adapted local beef hybrid.

Although ongoing advantages can be achieved by implementing a planned crossbreeding program, the potential disadvantages also need careful consideration:

- Additional herd management and associated costs with crossbreeding
- Any discounts that might be experienced when selling crossbred animals particularly when sold through the livestock exchange (saleyard) system
- Time and cost required to bring the herd into genetic equilibrium if developing a stabilised crossbreed is the breeding objective.

Crossbreeding is best suited to large herds producing big lines of cattle for sale.

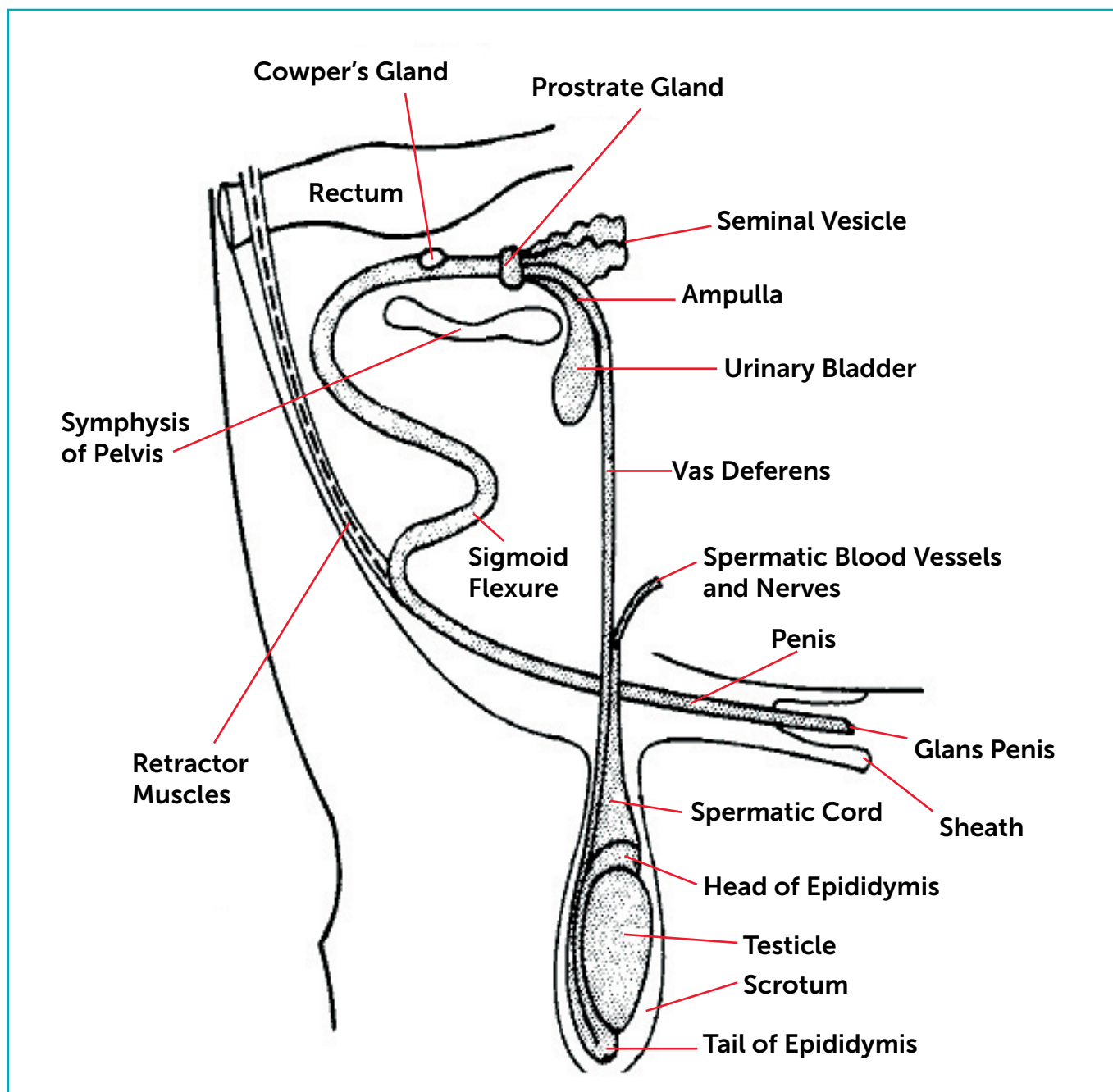


Figure 5.1. The reproductive system of the bull. Source: http://www.iowabeefcenter.org/Beef%20Cattle%20Handbook/Reproductive_Anatomy-Bull.pdf.

5.3. Bulls

5.3.1. Reproductive System of the Bull

The reproductive system of the bull consists of the testicles which manufacture sperm, and the secondary sex organs that transport the sperm from the testicle and deposits them in the female reproductive tract. These secondary sex organs are the epididymis, vas deferens and penis, plus three accessory glands; the seminal

vesicles, prostate, and Cowper's gland. This basic anatomy of a bull's reproductive system is illustrated in Fig. 5.1.

The role of bulls in a herd is to produce calves - as many as possible for as long as possible. A sound bull is capable of siring about 40 calves per year, for about 4 to 6 years - a potential of over 200 calves in his lifetime, yet many bulls do not sire anywhere near this many offspring.

Typically;

- About 10% of bulls break down in the first few weeks of mating
- The average working life of a bull is around three years
- After five years of age the breakdown rate is about 35% per year.

The main reasons why bulls are culled include:

Arthritis - about 50% of bulls are culled because of loss of mobility due to arthritis. Arthritis is caused by poor leg and joint structure. Grain feeding of bulls as yearlings accelerates the onset of arthritis and joint problems.

Injury - caused through fighting, accounts for about 10% of bull wastage.

Broken penis - (15%). This problem is usually found in bulls in their first season, or in older bulls as arthritis begins to affect serving ability. Poor serving ability caused by structural problems (particularly straight hind legs) is the major cause of a broken penis.

Corkscrew penis - (15%). The penis corkscrews as the bull mounts, making service difficult if not impossible. This condition often only appears when a bull is 3-4 years of age, and gets worse as the bull gets older.

Sheath problems - prepuce or sheath infections account for about 5% of bulls culled. Pendulous sheaths contribute to sheath problems.

Overgrown feet - (5%). Feet defects such as scissor claw and uneven toes are inherited feet problems - overgrown feet is generally a sign of poor leg structure.

Clearly, structural soundness of bulls is a critical issue. As conformational traits are of medium inheritance, introducing a bull with a structural problem is likely to pass that problem on to his progeny. Bulls should be structurally sound in legs, feet, joints and all components of the reproductive tract.

5.3.2. Physical Evaluation of Bulls

Evaluating bulls intended for use in a breeding program is an essential part of the breeding process. To determine how well bulls are equipped to be successful breeding animals, an assessment of four major factors is required. Each of these factors influences the fertility of an individual bull. The four main factors are:

- Physical or structural soundness of the animal
- Scrotal circumference and tone
- Semen quality
- Ability and desire to mate.

For a bull to successfully pass an evaluation the bull must:

- Pass a physical examination of the important structural components (legs, feet, penis and sheath (prepuce))
- Meet minimum requirements for scrotal circumference (refer Section 5.3.5.) and have a firm tone (not soft or hard)
- Semen testing must show at least 30% of sperm are motile (moving) and sperm cell morphology must exceed 50% normal for natural mating in multiple sire groups, and exceed 70% normal for single sire mating or if intended for use in an artificial insemination (AI) program
- Show both the desire (libido) and ability to physically mount and mate with a cow.

A bull must meet these minimum criteria in all categories to pass an evaluation. These criteria are relatively easy to test as outlined in 5.3.3 - Structural Soundness and Body Conformation.

5.3.3. Structural Soundness and Body Conformation

Bulls need to be able to withstand the physical demands of reproduction in order to have a long and productive life in the breeding herd. Correct structure and conformation is essential to ensure that bulls can walk, forage, successfully mate with many cows during a restricted period, and their calves are born without difficulty. Bulls that exhibit undesirable body conformation traits should not be considered for use in a breeding program as many such traits are heritable, and are likely to be passed on to their progeny.

Sound body conformation is based around the animal's limbs.

Shoulders

The shoulders and front leg structure of the bull are shown in Fig. 5.2. Ideally the shoulders should slope forward about 45–60 degrees. This angle applies even

pressure on all leg joints and provides good shock-absorbing ability during mounting and dismounting cows at mating.

A bull with less angle at the shoulder joint and elbow joint has straighter front legs with less shock-absorbing ability. These straight-shouldered bulls tend to walk with a short choppy gait and may have difficulty raising his head much above his backline. Quite often the tip of the shoulder blade is prominent above the backline. Usually, a bull that is straight in the shoulder will also be straight in the hind leg.

These bulls are particularly prone to early breakdown through the wearing of the leg joints, and the onset of arthritis. While many straight-shouldered bulls will break down in the hind leg, they are also more susceptible to arthritis in the pasterns and knees of the front leg. Straight-shouldered bulls may also be straight in the pasterns, causing rapid wearing of the front of the hooves.

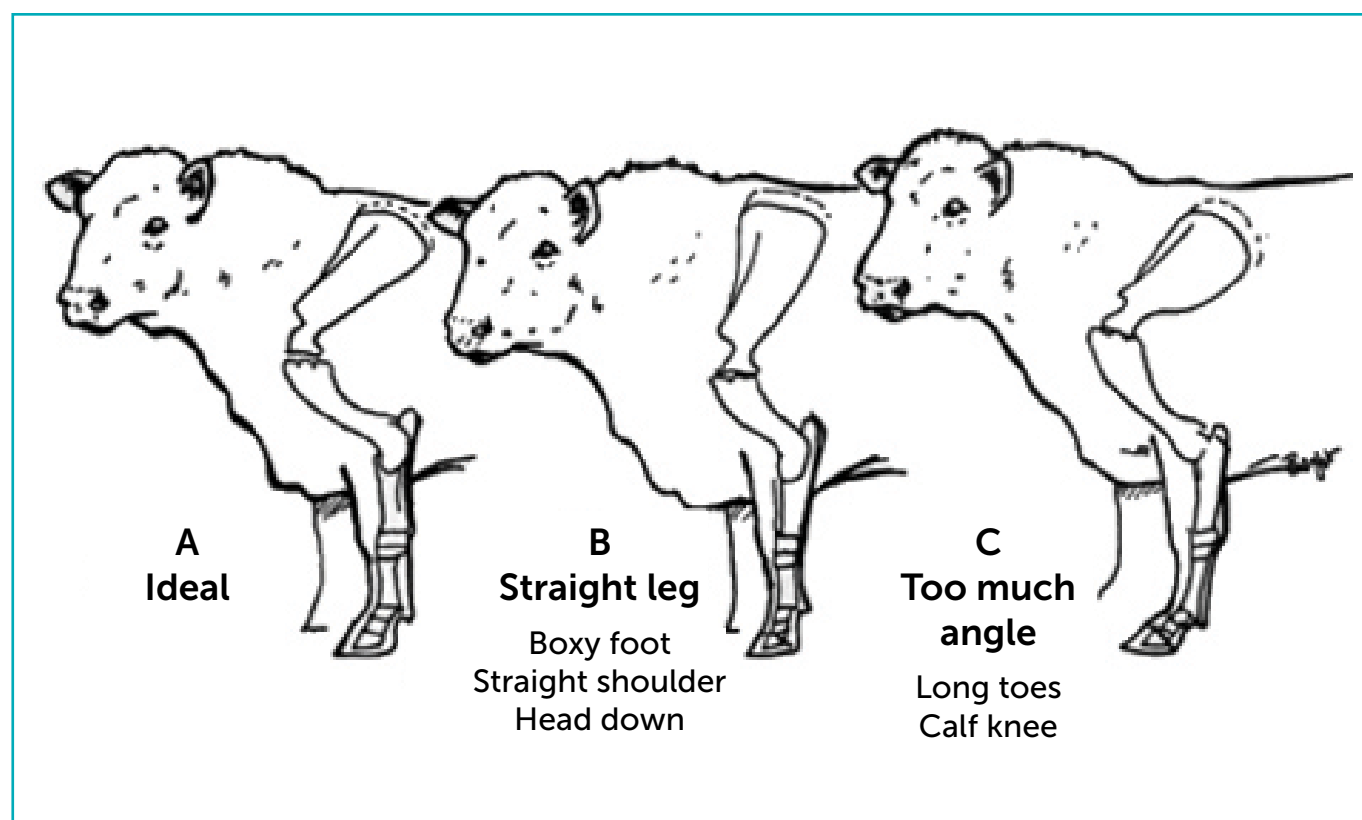


Figure 5.2. Front leg and shoulder structure of the bull. Source: NSW DPI.

The shoulder should be smooth against the rib cage. Bulls whose shoulders are wide at the point of the shoulder (the base of the neck) or wide between the shoulder blades (when observed from above) may throw heavily shouldered calves, increasing the chance of calving problems (Fig. 5.3).

Front Legs

The front legs of the bull should be straight when viewed from in front. On a structurally sound animal, a vertical line may be drawn from the point of the shoulder to the middle of the claw. This line should intersect the knee

(Fig. 5.4). As the knee joints carry more than half the bull's body weight, deviations from this line may cause excessive wearing of these joints.

A 'knock-kneed' bull may have turned-out front feet (up to 10 degrees is considered normal). A bull is considered 'knock-kneed' when the knee joints lie inside this line, which may eventually lead to overgrown outside claws. A bull that is wide at the knees (bow-legged) presents a more serious problem. These animals are often narrow in their stance and may roll their feet as they walk. They can also be wide in their shoulders.

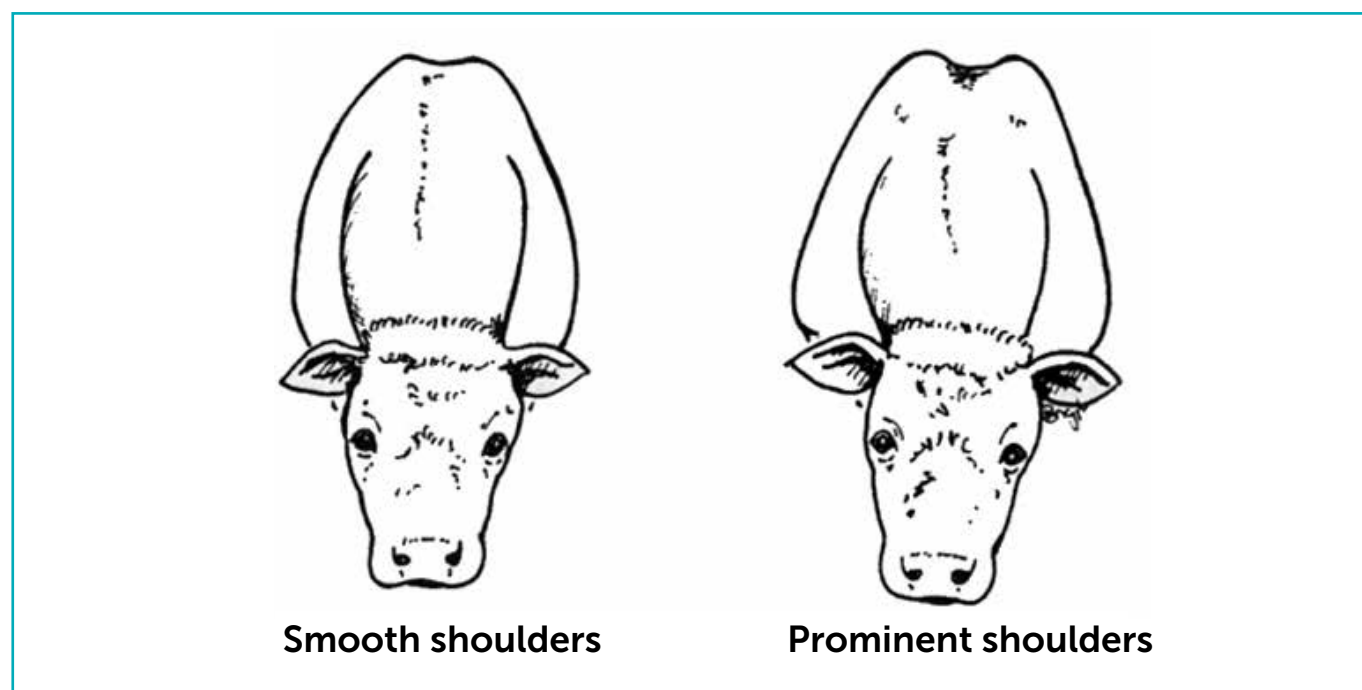


Figure 5.3. Front view of shoulder conformation. Source: NSW DPI.

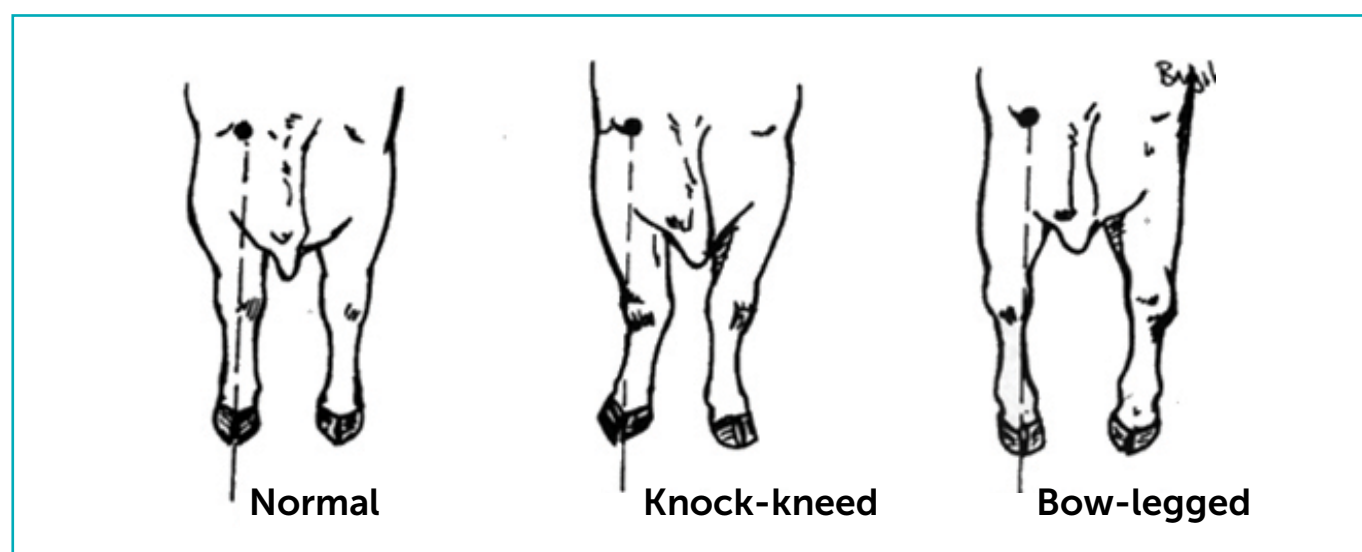


Figure 5.4. Front view of normal and undesirable front leg structures. Source: NSW DPI.

From the side, the forearm and cannon bones should be in a straight line. A knee joint forward of this line (buck-kneed) can be associated with steep shoulders and pasterns, and may be a serious fault. A knee joint set back of this line (calf-kneed) may be associated with sloping shoulders and has little impact on function.

Hind Legs

The structure of the hind legs is similar to that of the front legs. Again there are well-defined angles in the joints at the hip, stifle, hock and pastern joints. The angles are critical, particularly during mating when large amounts of stress are placed on these joints. Deviations from the correct angles (Fig. 5.5) will cause excessive wear and

tear on the joints, leading to early breakdown. More bulls seem to break down from problems associated with the hind leg than from any other reason.

Too much angle in the leg joints (straight-legged) is a serious structural fault. These cattle don't have the flexing and shock-absorbing effect of the structurally sound animal, and they are prone to severe wearing of the hip joint, leading to arthritis. Bulls with arthritic problems are reluctant to serve many cows, as the condition can be quite painful. Straightness in the hind leg can also be seen in the hock and pastern joints, and these cattle will wear the front of the claws, resulting in short upright hooves.

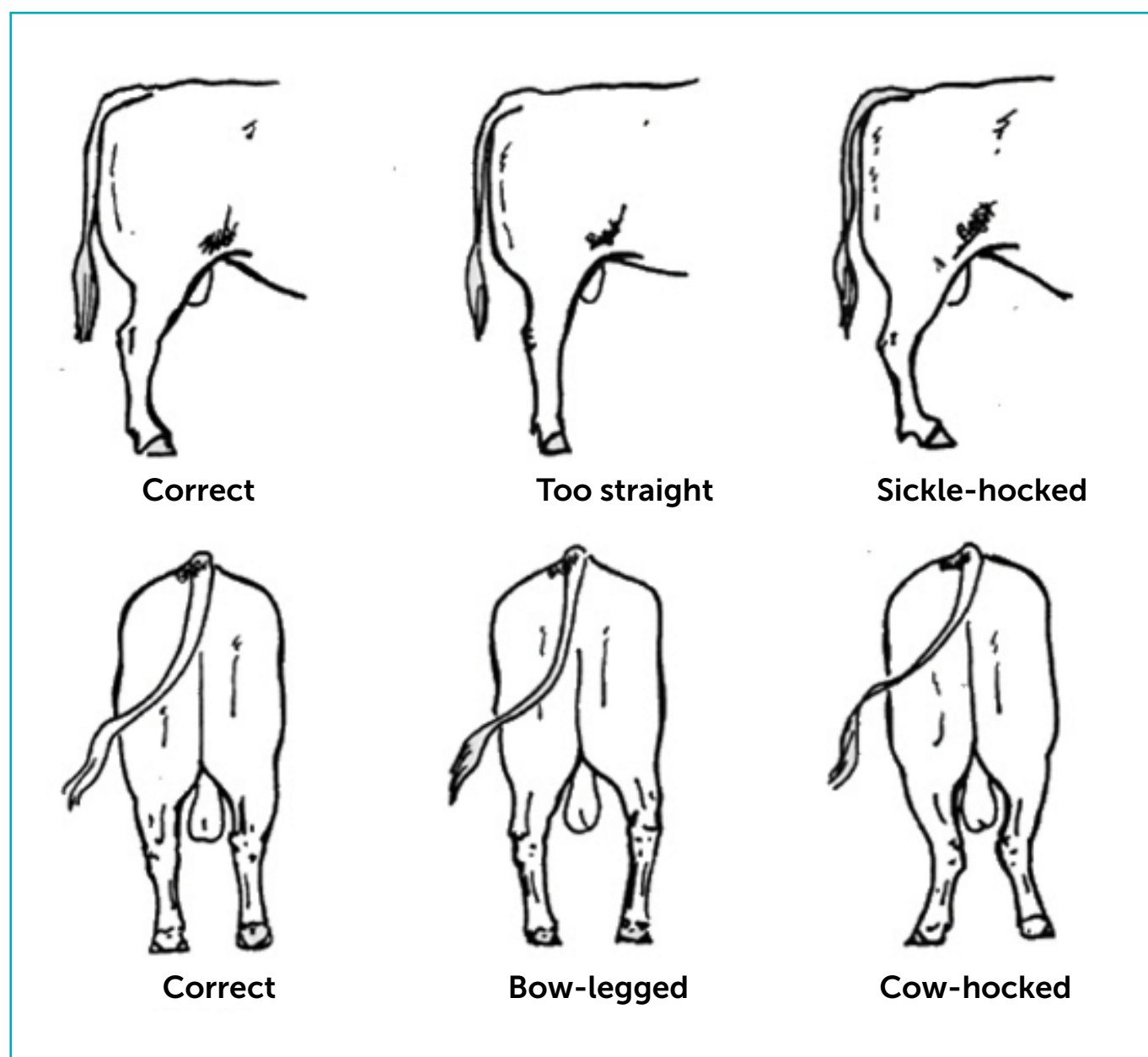


Figure 5.5. Normal bull hind leg structure and common structural faults. Source: NSW DPI.

If the degree of the angle in the leg joints is less than ideal, 'sickle hocked' condition may exist. This is less of a problem than straight legs, but in extreme cases may cause strained ligaments (pastern and hocks) and long claw growth, increasing the chance of injury, and affecting serving ability. Sickle-hocked bulls may overstep the mark of the front feet as they walk out.

Viewed from behind, the leg and hock joint should be in a straight line. A bull is 'bow legged' when the legs are turned outwards at the hocks, but the hooves are turned in. This can be a serious problem if the extra strain placed on the ligaments leads to lameness. These animals should not be considered for use in a breeding program.

Less of a problem are 'cow hocked' animals when the hocks are rotated inwards and the hooves rotated outwards. This is only a problem in extreme cases where uneven pressure on the claws may cause the outside claw to grow long.

Feet

The way the claws of the feet grow often indicates structural problems higher up the legs. Long or excessively short even claws may indicate too much or not enough pastern angle, causing both claws of the hoof to grow or wear excessively. Overgrown claws affect the mobility and performance of the animal. Fig. 5.6 indicates the correct angle of the pastern joint.

Uneven wearing of the two claws, where one grows longer than the other, is often due to a problem in the leg structure. It is caused by an uneven distribution of weight through the foot. Avoid overgrown, scissor or curved claws (Fig. 5.7). Mild curling is normal, although it can be exaggerated by heavy feeding and soft soils. Overgrown, uneven claws are usually indications of poor limb structure or early signs of hip arthritis. Avoid extremely short feet, which are often associated with over-straight legs.

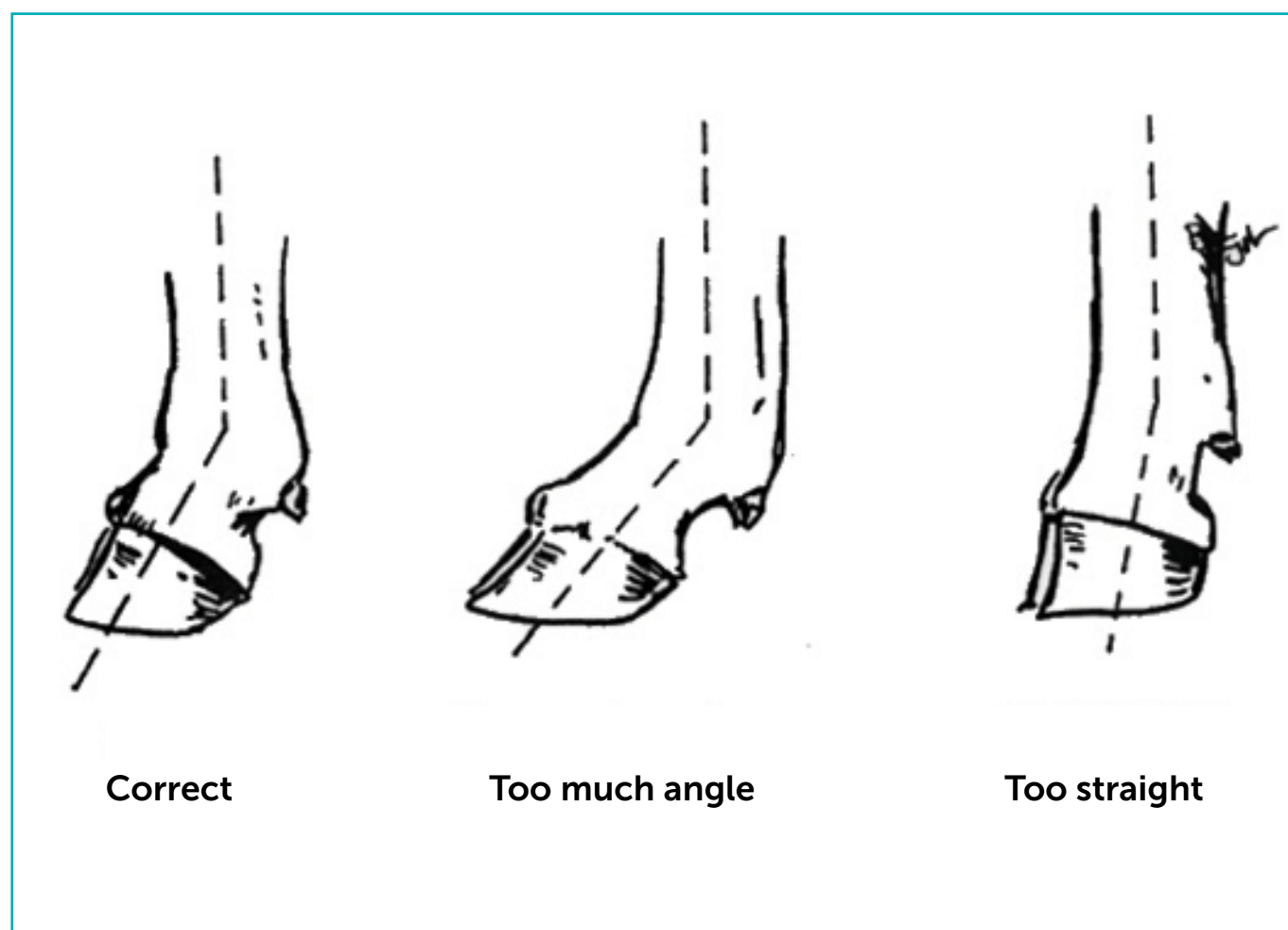


Figure 5.6. Normal pastern and hoof structure, and examples of common faults. Source: NSW DPI.

Walk

A structurally correct bull, when walking, will place his hind foot in exactly the mark left by his front foot. If he is lame, or not moving freely, or if he is straight in his leg structure, he will short-step and not reach his mark. Likewise, if he is suffering arthritis in one leg he may tend to short-step or drag his leg on that side. Problems such as these will affect the serving ability of the bull.

5.3.4. Penis and Prepuce

The sheath and penis should be examined for abnormality or malfunction. The sheath should be trim and close

to the body. Loose and pendulous sheaths should be avoided and are often associated with increased risk of injury or infection which can affect the functionality of the bull at mating (Fig. 5.8).

Some bulls may show prepuce protruding below the end of the sheath. Although such bulls often have a normal working life, they will be at increased risk of injury. A pendulous prepuce usually is indicative of a weak retractor muscle.

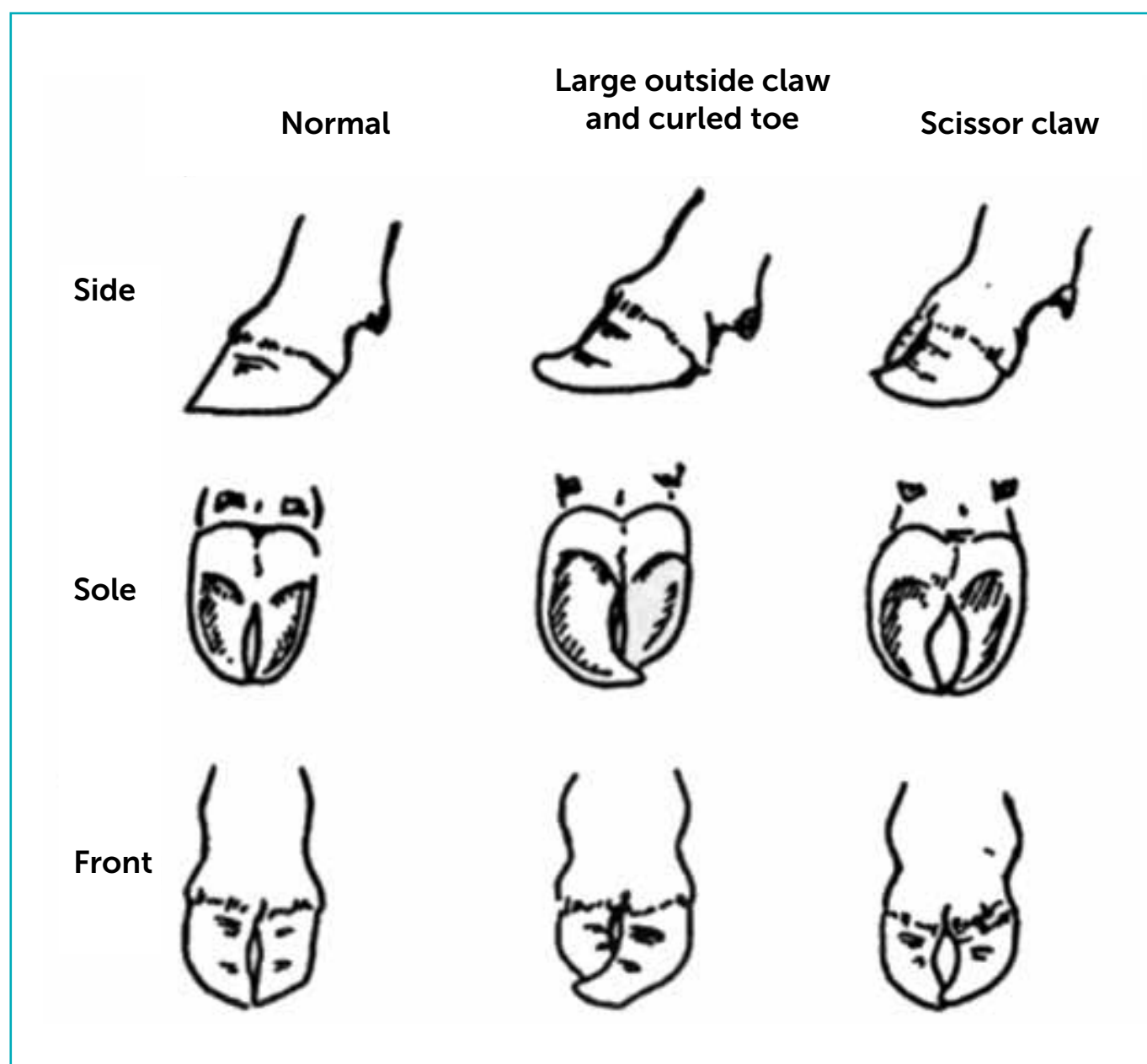


Figure 5.7. Normal claw structure and examples of common faults. Source: NSW DPI.

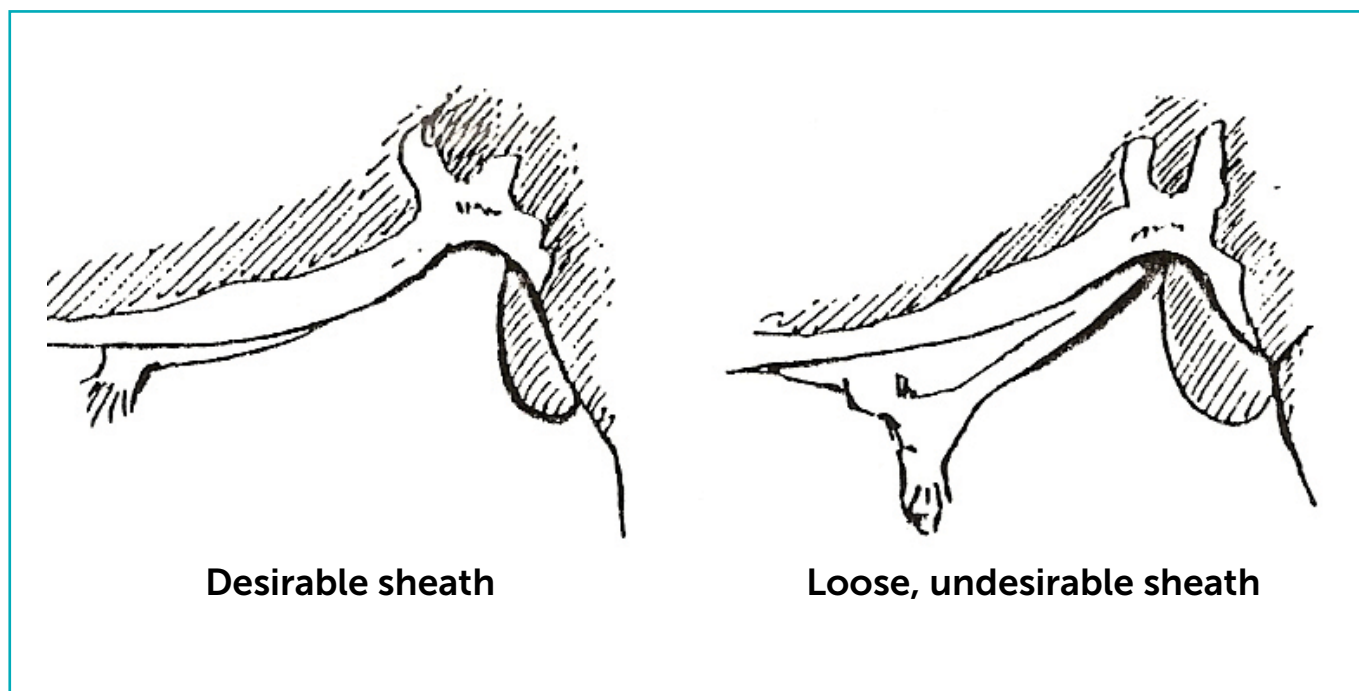


Figure 5.8. Illustrations of a desirable sheath (tight against the body - left image) and an undesirable sheath (loosely hanging - right image). Source: NSW DPI.

5.3.5. Scrotum and Testicles

Scrotal circumference is highly correlated to total sperm output and moderately correlated to normal sperm morphology. Bulls with larger testes will produce increased daily and total sperm production. Testes size (and scrotal circumference) is highly heritable. This means it is an easy trait to select for and rapid progress can be made in selecting bulls that will also influence age of puberty of his daughter. Bulls with genetically larger scrotal circumference will produce daughters that reach puberty at a younger age. These females tend to have better fertility throughout life. Thus, selecting bulls with genetically larger testes has positive benefits for both the ability of the bull to sire calves, and the ability of his daughters to conceive and reproduce. The physical scrotal size increases with improved nutrition and the bull's age.

The testicles should be uniform, well-developed and properly balanced in relation to the age and size of the bull. As bulls grow and mature their scrotum and testicles should be of a minimum size depending on their level of nutrition (Table 5.1). Bulls with scrotal circumferences smaller than the minimum will have reduced sperm

production and should not be considered for use in a breeding program.

Table 5.1. Minimum scrotal size for young, growing bulls to be considered for use in a breeding program.

Source: Coulter et al. (1987). *Theriogenology*. 27, 485-91.

Age (months)	Minimal Scrotal Size (cm)
12-14	32
15-20	34
21-30	35
>30	36

Scrotal measurements are made by holding the neck of the scrotum with one hand, gently forcing the testicles into the bottom of the scrotum, then placing a measuring tape around the widest point of the scrotum (Fig. 5.9).

There are variations in both normal and abnormal scrotal conformation. The testes and epididymis should be palpated for size, tone, and symmetry and to make sure that there are no lesions on the epididymis. The testes should be firm but not too soft or too hard. A symmetrical testes shape is normal and preferred. Any deviation in size, shape, and/or position should be viewed with suspicion.

Common scrotal faults include;

- Extremely pendulous, soft or swollen testes
- Degenerative testes, penis and prepuce
- Scrotum held in a tucked-up position
- “Tied” scrotum - where the attachment of the scrotum at the rear tends to hold it more horizontally to the body.

A bull exhibiting any of these problems should not be used in a breeding program.

5.3.6. Semen Sample

A semen sample should be examined for the percentage of motile (moving) sperm, with 30% motile the minimum, and for the percentage of normally structured sperm, with 50-70% normal being acceptable for multiple sire

mating, and >70% normal acceptable for single sire mating and artificial breeding.

The two most common techniques of collecting semen samples are:

- Electro-ejaculation (for semen quality testing); and
- Artificial vaginas (AV's, for collecting semen for artificial breeding).

The electro-ejaculator technique is one of a gradual build-up of electrical stimulation until the bull has an erection, protrusion of the penis and ejaculation. It requires a skilled operator to stimulate ejaculation without unnecessary or excessive discomfort to the bull during the procedure. Some bulls do not respond well to electro-ejaculation (failure to get an erection or to ejaculate, or unable to remain standing during the procedure), and in these circumstances an alternative method is required. Manual massage of the prostate, ampullae, and seminal vesicles can also produce an ejaculation, and this is a good alternative for bulls that do not respond to electro-ejaculation.

The collected semen sample is then examined (usually on-site in the yards) using a microscope to determine sperm motility.



Figure 5.9: Measuring scrotal circumference on a young bull. Source: Future Beef.

Sperm quality can vary from one test to another, even in healthy bulls. Nutrition, temperature, illness, time since last ejaculation, bull age, and the proficiency of semen collection can all influence the results of a semen quality test. Bulls with low semen quality results should be tested a second time at a later date before being permanently excluded from the breeding program.

5.3.7. Ability to Mate (Serving Capacity)

A bull must have both the physical ability and the desire to mate with cows in order to be useful in a breeding program. All bulls being considered for use must demonstrate the ability to mount, position themselves, direct their penis into the cow, and ejaculate. Observing a bull while in the company of a cycling cow will quickly reveal if he has any basic interest in mating, and whether he is capable of successfully mating.

Most bulls naturally exhibit a strong desire to mate with cows that are cycling, so it is usually the ability to mate that is of most importance in a serving capacity test. The most common problem likely to be observed is failure to align the penis with the vagina. Deviation ('corkscrewing') of the penis, or a loose, swinging sheath may make alignment difficult, and bulls with these characteristics should not be considered for use in a breeding program.

5.3.8. Bull Management and Preparation for Mating

Bulls should be assessed for general health and body condition score (BCS) at least two months prior to joining. Ideally bulls should be a BCS of 3.0 to 3.5 during mating so provision of adequate nutrition in the months prior to joining is essential to achieve this. Over-fat bulls (above condition score four) are prone to heat stress, which can impact on fertility. Supplementary protein in the diet leading up to mating will improve testicular development and sperm production.

Bulls intended for use in the same mob should be put together (if not already) at least two months prior to joining to allow social hierarchy to be established before mating begins. This reduces the chances of fighting and injury during the joining period.

During the joining period, bulls should be observed weekly to ensure they are actively working and are not injured. Bulls should also be vaccinated annually against diseases that affect reproduction (Refer Section 4.5.3).

When managed correctly, bulls may be used for breeding as yearlings. Yearling bulls are capable of successfully breeding with heifers and adult cows, provided they are sufficiently grown and meet the minimum bull evaluation criteria. Yearling bulls can be used in multi-bull groups, but only with other yearlings. Mixing them with older, bigger bulls increases their risk of injury during the joining period. Once they have been removed from a mating group, young bulls should receive highly nutritious feed to help them regain body condition and to continue their growth and development.

5.3.9. Bull to Cow Ratio

Bulls should be joined with 30 to 50 cows each, with 40 being the optimum number. Joining bulls to less than 30 cows is an inefficient use of bulls and increases overall bull purchase costs. In multi-bull herds with less than 30 cows per bull, increased competition for the few receptive females also often results in fighting and injury to both bulls and cows. Single sire mating reduces bull injuries from fighting, but increases the potential for poor conception rates if the bull becomes infertile or incapable of mating through injury or illness.

Young (yearling) bulls should not be joined with more than 30 cows each.

Reserve bulls are essential to replace any of the main working bulls that are injured or otherwise unable to mate as soon as they have been identified. A guide to the number of reserve bulls required is about 10% to 20% of the number of working bulls, with the cost of having extra bulls being compared with the risk of production losses, if not enough reserve bulls were available when required.

5.4. Cows

A breeding cow's productivity is dependent on her ability to cycle, conceive, carry a pregnancy, calve unassisted, provide adequate milk for her calf, and return to cycle while still lactating. The environmental conditions under which a cow lives (i.e. access to sufficient nutrition, protection from extreme climatic conditions, protection from pests, diseases and predators, exposure to fertile bulls, etc.) combine with her genetic potential to determine the actual level of productivity achieved.

The objective of a profitable breeding enterprise is to have all cows calving on or about the same date each year (known as a 365-day calving interval). Achieving such a high level of herd productivity requires careful management of all females throughout the annual breeding cycle. Cows that do not calve every year are a cost to the enterprise, and eliminating these from the herd should be the primary focus for all beef breeding enterprise managers. A sound understanding of the basics of a cow's reproductive system and how to manage it assists managers to reduce the number of cows that do not calve every year.

5.4.1. Reproductive Organs

The ovaries are the primary reproductive organs of the cow and have two important functions:

- Production of the female reproductive cell, the egg or ovum
- Production of two hormones, oestrogen and progesterone.

The secondary sex organs are a series of tubes which receive the semen from the bull, transport the sperm to the egg so it can be fertilised, nourish the fertilised egg (embryo), and expel the offspring. These organs include the vagina, cervix, uterus, uterine horns, and oviducts (also called Fallopian tubes) (Fig. 5.10).

The ovary produces eggs by a process called oogenesis. In contrast to sperm production in bulls, which is continuous, oogenesis in the female is cyclic. This cycle, called the oestrus cycle, is of a characteristic length and consists of a definite sequence of events, both of a physiological and a behavioural nature. These are described below.

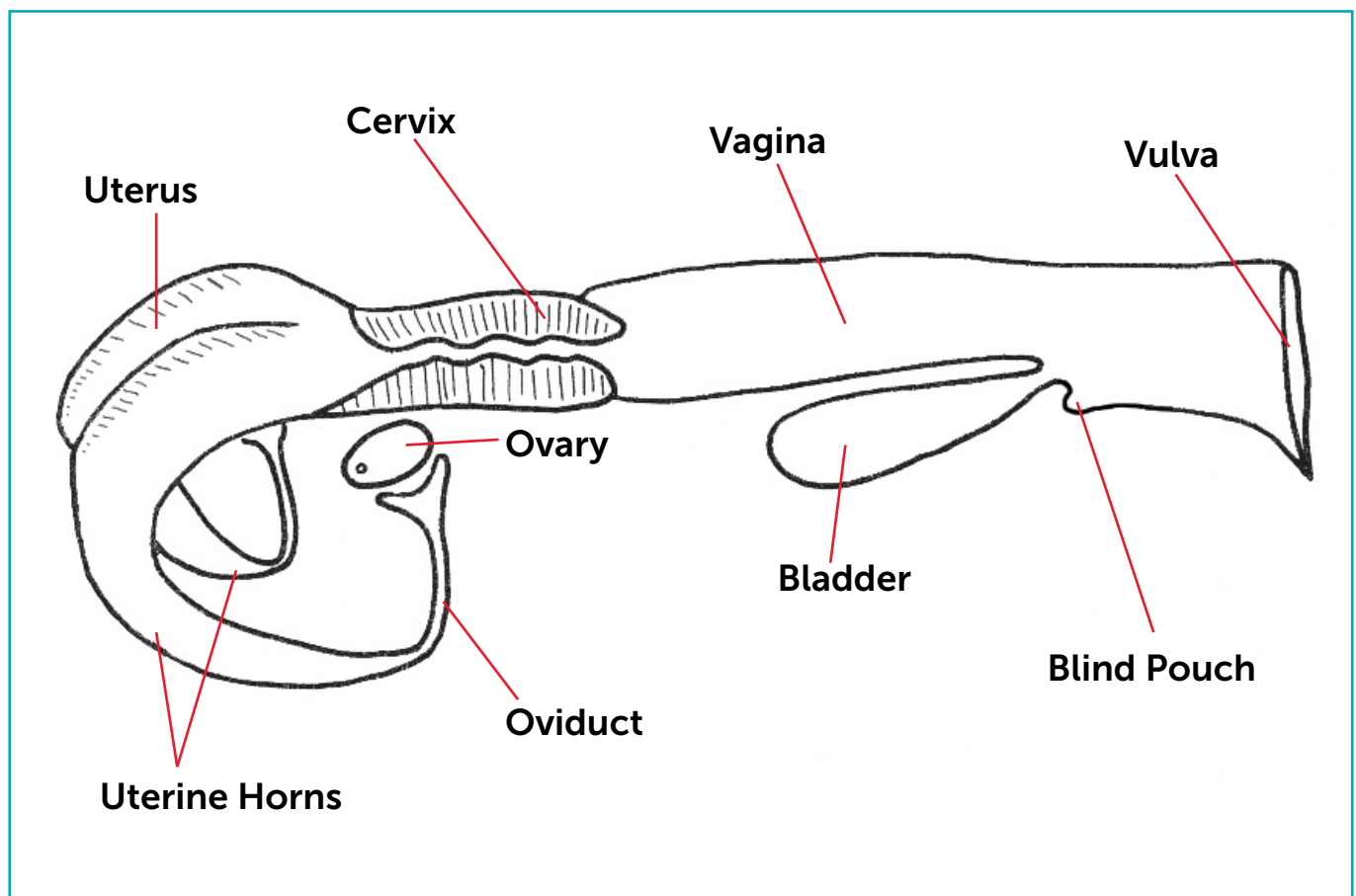


Figure 5.10. The reproductive tract of a cow. Source: http://www.iowabeefcenter.org/Beef%20Cattle%20Handbook/Reproductive_Anatomy-Cow.pdf.

5.4.2. Oestrus Cycle and Heat Detection

The oestrus cycle in cows first occurs during puberty and normally continues at regular intervals until conception. The oestrus cycle begins when the British breed heifer is between 6 and 11 months of age, but weight is a more significant factor than age in triggering puberty in young cattle. For young British breed heifers, cycling will generally commence when they reach about 285kg.

The average interval between heat periods, i.e. the period of time where the cow is receptive to the bull, is

21 days, but this may range from 18 to 24 days. It tends to be shorter in heifers than in older cows.

The most reliable sign a cow is in heat is standing to be mounted by bulls (if present) or by other cows (Fig. 5.11). Each stand lasts only 4 to 6 seconds. Cows are in heat for only 6 to 8 hours, a little more than a third of a day and only spend a total of 3 to 5 minutes actually standing to be mounted on each occasion.

Under natural mating conditions, bulls detect and serve the cows when they come into heat and no input by



Figure 5.11. Standing heat. Source: Irish Farmers Journal.



Figure 5.12. Signs of heat including (left) clear mucous discharge, and (right) sniffing. Source: Livecorp & Meat and Livestock Australia, Cattle Breeding Guide - A guide to the management for breeding cattle in South-East Asia.

people is required. However, in an artificial breeding program, cows must be observed for oestrus to determine the ideal time for insemination. Apart from exhibiting the desire to stand while being mounted, other signs of heat include:

- Clear mucous discharge from the vagina (Fig. 5.12 left)
- Rubbed patches over the pin-bones and tail area resulting from having being mounted
- Swollen red vulva, frequent urination
- Ruffled flanks and tail head
- Bawling, restlessness, sniffing behaviour (Fig. 5.12 right).

5.4.3. Joining

Cows should be joined on a rising plane of nutrition as this promotes cycling in the cow and increases fertility and her chances of getting pregnant. For re-breeding heifers that have had their first calf and have a calf at foot, a minimum body condition score of 3.0 should be achieved by joining, and mature cows should be joined at no less than condition score 2.5. In both cases, aim

to not exceed condition score 4.0 at mating, as over-fat cows at calving are at higher risk of calving problems.

Drafting females into groups based on condition score will enable their nutritional requirements to be managed according to their actual and target body conditions and weights, by increasing or decreasing the quantity and quality of the forages grazed, or provided as supplements or fully hand-fed rations. Heifers may require supplementation with a protein source to reach target growth rates and frame scores if pasture quality is inadequate.

If the body condition of any lactating cows falls below 2.0, the calves should be weaned from these animals, and the cows provided with good quality pasture and/or supplementary feed to regain condition and to support her next pregnancy. Alternatively, low condition score cows may be culled prior to rebreeding if they are in poor condition for reasons other than poor environmental conditions or poor management.

It is common practice in well-managed breeding enterprises to restrict the exposure of cows to bulls, or artificial breeding, to a short period in order to achieve

a similarly-restricted calving period. A restricted calving period has considerable advantages over long or continuous calving, such as:

- Minimising the period of calving supervision
- Ease of management - all calves can be processed at one time, minimising labour requirements
- Marketing of larger groups of similar animals - producing larger groups of similar sized weaners improves marketing options and efficiency
- Identification of sub-fertile breeders - cows that repeatedly have extended periods between calving and conceiving again (i.e. longer than three months) are more easily identified and removed from the breeding herd if desired.

Timing and duration of the joining period are two of the most critical factors affecting beef breeding enterprises. The time of the year when calves are born influences many subsequent actions and decisions relating to the management and operation of the enterprise.

The long gestation period for cattle (about 285 days) and necessary period of recovery before being able to conceive again make calving at the same time every year a challenging but readily achievable feat in well managed herds. Changing the time of year when calves are born is, however, not easy and/or comes at a considerable production cost. Therefore, careful consideration is required when deciding the date to begin the joining period; considerations such as:

- Likely prevailing weather conditions during resulting calving period
- Feed requirements for cow and calf (and the eventual weaner)
- Availability of forage to supply the animal's requirements.

Calving inside sheds during winter is not uncommon on traditional dairy farms in Russia. However, costs associated with shedding, supervision, and supplementary feeding make this a less desirable practice in a modern beef enterprise focussed on lowering the cost of production. Ideally, beef cows should calve when temperatures are mild and nutritious green feed is available or soon will be.

An optimal time for beef cows to begin calving is around mid-April to early May. Cows require high levels of nutrition early in their lactation to provide their calves with sufficient milk, while maintaining sufficient body condition themselves to maximise their chances of conceiving again within three months of giving birth. Calving from mid-April onwards would result in peak nutritional demand from the majority of cows by about the end of May. It is expected that sufficient new pasture growth will have occurred by this time in most years to support the high demand for feed.

The bulls should be with the cows for a minimum of 42 days (six weeks) to cover two oestrus cycles and no longer than 63 days (nine weeks) covering three cycles. Any longer than this results in calving being spread over a long period and later calves will require separate management.

REPRODUCTION TARGETS

- ✓ at least 80% of cows exposed to the bull should conceive by the end of the second heat cycle
- ✓ 95% of cows should be in calf after a nine week mating period
- ✓ calving distribution should result in about 65% of calves born in the first three weeks, 25% in weeks 4 to 6 and 10% in weeks 6 to 9.



If more than 20% of cows are conceiving in the third cycle, further investigation is needed to rectify the issue. BCS of breeders at the beginning of mating is a key factor in the resultant calving pattern, with cows in BCS 3.0 or higher more likely to conceive during their first cycle than cows in BCS 2.5 or less.

For both bulls and cows, checklists have been developed to ensure that all of the premating and mating requirements of these animal can be met leading up to and during joining. These are provided in *TECHNICAL NOTE 10 - Preparations for Breeding*.

5.4.4. Mating After Calving

The period between a cow calving and her return to oestrus cycling ranges from 30-72 days. For a cow to calve on the same date each year, she must conceive again within 80 to 85 days of calving. Therefore there is only a narrow window of opportunity between return to oestrus and the desired conception date to achieve a 365-day calving interval. Management of the breeding cow's body condition score throughout the calving and re-mating period is essential to achieve high conception rates in lactating cows. Ideally, cows should have a BCS of at least 2.5 and preferably 3.0 at the time of re-mating. This also means that their BCS should be at least 3.0 when they calved. Cows with a BCS falling to 2.0 or below following calving have a significantly reduced chance of conceiving again within the desired mating period.

5.4.5. Using Artificial Insemination in the Reproductive Cycle

Artificial insemination (AI) provides a breeding enterprise with access to industry-leading genetics that would not otherwise be available to most herds. AI is also an effective means of widening the genetic base within

herds that rely heavily on bulls bred in the local area from a limited gene pool. However, a high level of management is required if the enterprise is going to capitalise on the higher costs of calf production from artificial breeding.

AI is most commonly used with heifers, as they:

- Are usually in ideal body condition at joining because they are not lactating
- Are the most genetically advanced generation in the herd
- Managers can select from a wide range of sires with desirable traits (such as ease of calving).

5.4.6. Pregnancy Detection

Two common methods of pregnancy detection are manual palpation (Fig. 5.13), and ultrasound. Manual palpation involves an operator manually feeling the uterus, via the rectum, for evidence of a pregnancy, while ultrasound machines use either an external or internal probe to provide an image of the uterus for the operator to examine for signs of pregnancy. Pregnancy status can also be determined through measuring the progesterone levels in blood or milk.

Heifers can be pregnancy tested by manual palpation from six weeks (42 days) after the last day of mating, while older cows should wait eight weeks (56 days). All females can be diagnosed using ultrasound from one month (30 days) after the last day of mating.

Check for multiple births when pregnancy testing so these females can be managed accordingly. Multiple births are very risky for cattle and close supervision is required to minimise calving difficulties.

More practical details on pregnancy detection are provided in *TECHNICAL NOTE 11 - Pregnancy Testing*.

5.5. Calving Management

With adequate planning and preparation, the aim of good calving management is to ensure that calves are born successfully, and that cows and heifers are maintained in good health. Successful management of calving ensures a more profitable cow operation. British breed cows typically calve between 285 and 295 days post conception, averaging 290 days after the service date.

5.5.1. Preparations for Calving

Cows and heifers should be calved down on clean areas with adequate quality and quantity of feed available, and ideally kept close to cattle handling and restraint facilities in case calving difficulties occur.

As calving can commence up to two weeks prior to the calculated date, cows in late pregnancy should be in

calving areas at least three weeks prior to the expected calving date, and observations for calving should commence at the same time.

Cows and heifers should be observed a minimum of twice daily. If needed, early assistance is crucial to the survival of the calf and reducing incidence of uterine prolapse and calving paralysis. When checking cows and heifers they should be disturbed as little as possible.

Birth

When a cow begins to calve, she will lose two lots of fluid from the vulva, the second thicker than the first. The calf's two front legs should be presented within two hours of the cow losing her second fluid sac. If this is the case, the birth is proceeding normally and the cow should not be disturbed and allowed to calve naturally. Check the cow about every 30 minutes during the

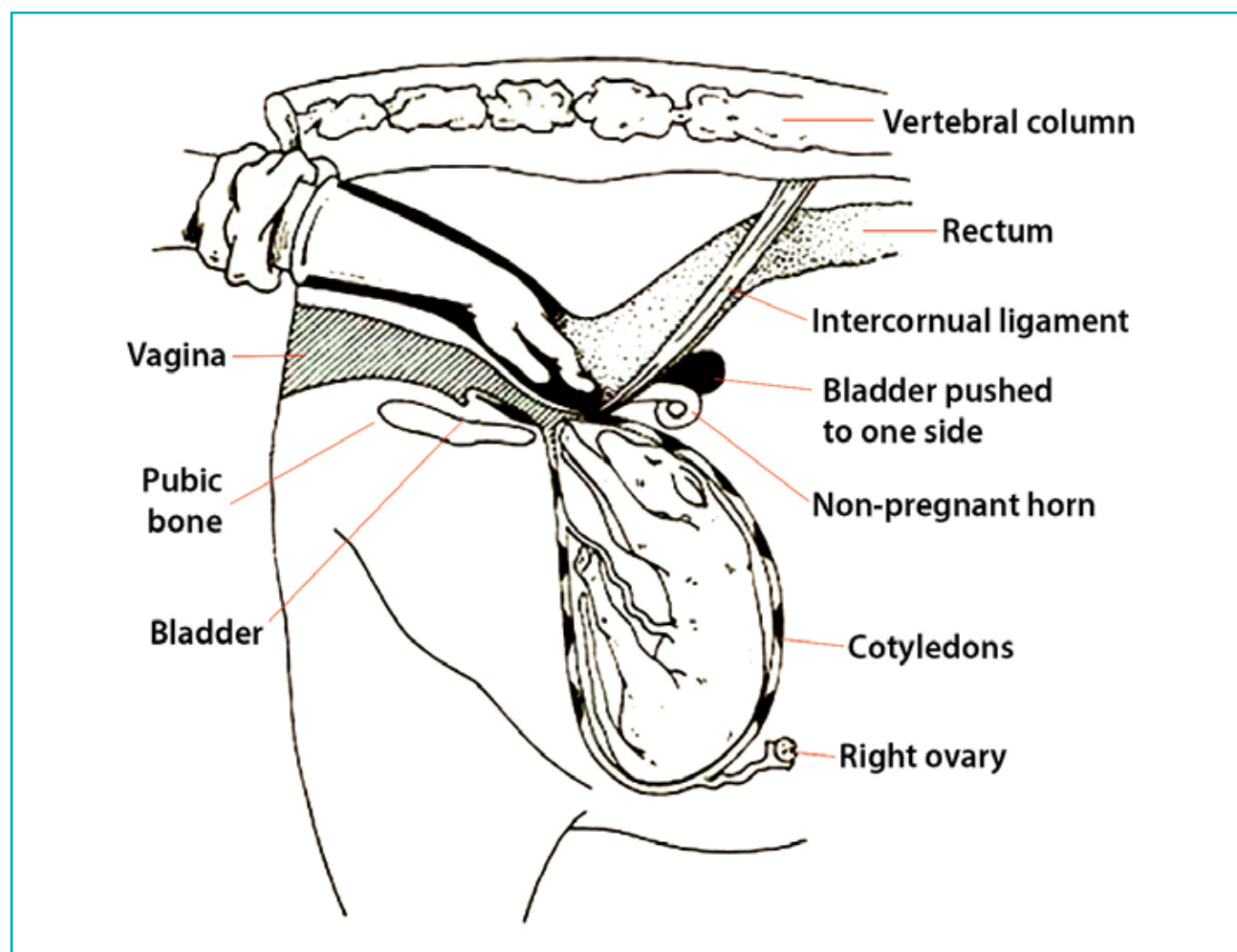


Figure 5.13. The rectal palpation method of pregnancy detection.

calving. Only intervene if there is no progress for some hours.

Once the calf is born it should be left alone for the first 12 to 24 hours to establish the cow-calf bond. Following a short recovery period immediately after calving, the cow will lick the calf clean and allow the calf to suckle her.

Placenta (Afterbirth)

When the calf is born the placenta normally detaches within a few hours and is expelled. In almost all situations, the placenta is expelled within 12 hours of the birth of the calf. If the placenta does not come away naturally, leave it alone (Fig. 5.14). Do not pull it out. If the afterbirth is pulled by force, you could cause a haemorrhage and the cow could bleed to death. Check 12-24 hours later, and if necessary, leave for another day

and then seek veterinary assistance if it is still retained.

A retained placenta usually causes the cow to have an increased time from calving to the conception of the next calf. It is not uncommon for a cow with a retained placenta to delay the next pregnancy for 2-6 months, meaning she has a high chance of being non-pregnant at the next pregnancy diagnosis in a restricted mating system.

5.5.2. Abnormal Calving

The majority of cows calve without trouble. However, a cow that has not calved within two hours of the appearance of a fluid sac needs to be brought in and examined. On inspection, any cows or heifers that have a calf that is mal-presented should be assisted immediately. Similarly, a cow or heifer that is weak or exhausted should also be assisted immediately.



Figure 5.14. Example of a retained placenta in a cow following calving. Source: Livecorp and Meat & Livestock Australia, Cattle Breeding Guide - A guide to the management for breeding cattle in South-East Asia.

If the cervix is fully dilated and three essential parts of the calf (two forefeet and head, or two hind feet and tail) can be felt in proper position, the problem may be due to the uterus not contracting properly. If this is the case then attempts can be made to pull the calf out. However, prolonged calving can cause the uterus to tire and stop contracting and if this is the case there is the danger of the uterus rupturing. A veterinary surgeon should be called immediately if assistance is unsuccessful and the calf cannot be safely delivered. Some abnormal calving presentations are shown below (Fig. 5.15).

Once the calf has been born, allow the mother to clean her calf. If the mother is too weak the calf should be handled and cleaned up. In these circumstances, it

may be necessary to clean mucus from the nostrils and attempt to start the calf breathing.

If a cow or heifer has been assisted in calving she should be kept confined in a yard until she has accepted her calf and allowed it to suckle. After a difficult calving, heifers in particular will often abandon their calves. In these instances it may be necessary to place the mother in a crush to allow the calf to drink.

Where a cow has twin calves, a maximum of four hours should be allowed after the waters have broken for the first calf to be born, and a maximum of two hours allowed after the first calf has been born for the second calf to be delivered.

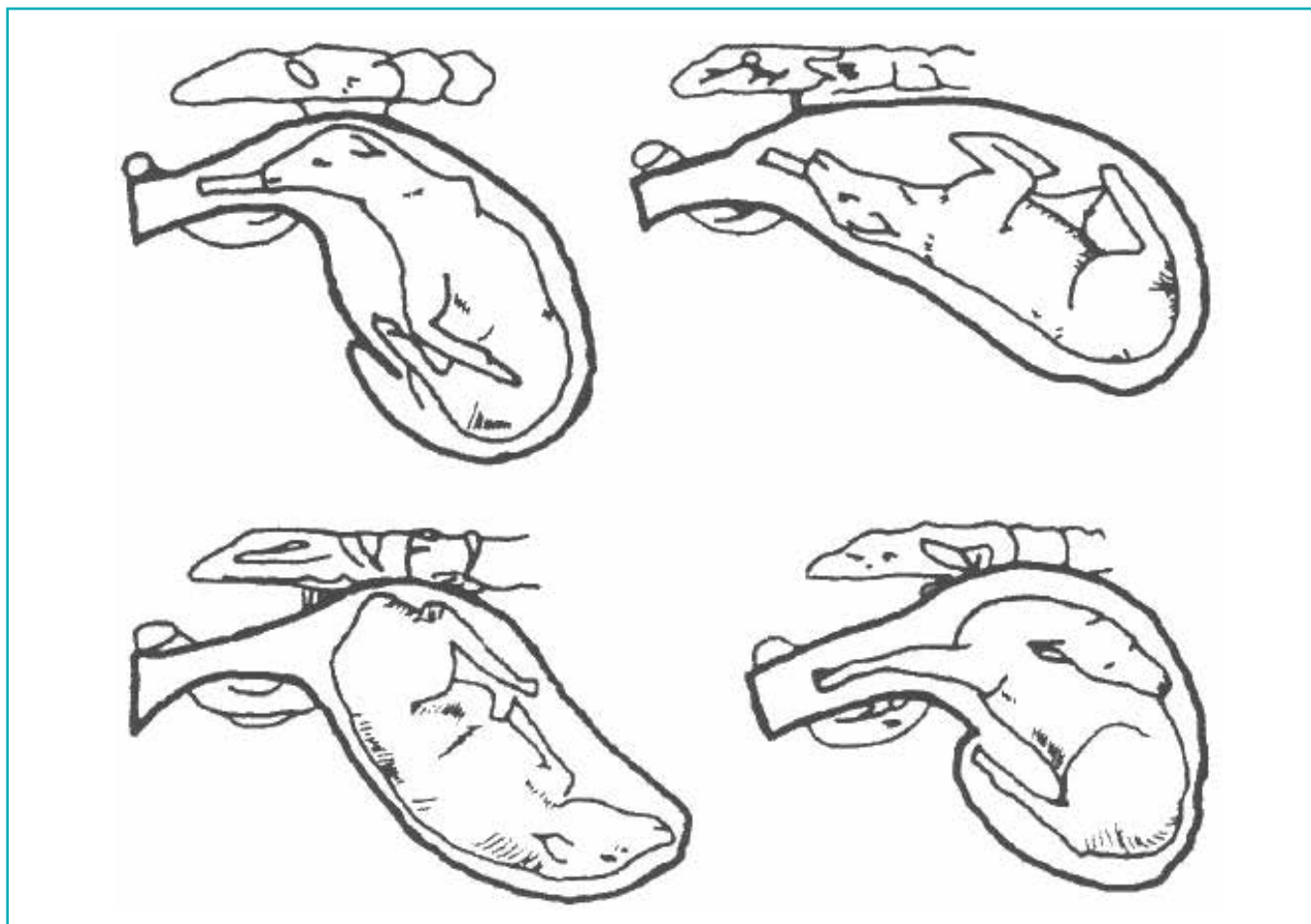


Figure 5.15. Abnormal Presentations. Top Left - One foreleg back. If necessary, push the head back into uterus, then bring both forefeet into the normal delivery position. Top Right - One foreleg back and upside down. This position will require the calf to be rotated and both forefeet brought to the normal delivery position. Bottom Left - Upside down breech presentation (hind legs forward). Carefully push the calf forward, rotate, and bring the hind legs into the birth canal. Bottom Right - Head turned sideways. If necessary, push the calf back into uterus, then bring the head and forelegs into the normal delivery position. Source: University of Nebraska, Lincoln.



Figure 5.16. Prolapsed uterus. Source: Iturreria M (2009), The Drost Project (www.drostproject.org).

5.5.3. Prolapse

In the hours immediately after calving, some cows may suffer the condition known as prolapse (Fig. 5.16). The condition occurs when the cervix or uterus protrudes from the vagina and has a number of predisposing causes that include;

- Cows with 'relaxed' sacral ligaments, and cows that strain during calving tend to have increased risk of prolapse
- Almost always occurs at calving or soon after calving when the cervix and uterus are open and lack muscle tone
- Cattle transported in the third trimester of pregnancy have an increased risk of prolapse
- Risk is increased if heavy cows stand with their hind quarters lower than forequarters.

There are two forms of prolapse, i.e. prolapse of vagina and cervix, or prolapse of uterus, and they both require the same treatment. In the case of prolapse of the vagina, the animal generally recovers and no further problems occur. However, if the uterus prolapses,

veterinary assistance is strongly advised. In both cases, treatment involves the following;

- (a) If possible get the animal to stand
- (b) Wash the prolapsed organs with clean water and disinfect with a slightly salty solution
- (c) After cleaning the prolapsed organs apply gentle pressure and begin to push them back in place. Additional support can be given by sutures in the vulva or a slight tourniquet around the prolapsed reproductive tract
- (d) If this is difficult try to stretch the hind legs out behind the animal, or stand the female on an incline with her hind legs on the high side of the incline
- (e) To avoid infection treat with a long acting antibiotic.

Persons undertaking these procedures should wear protective equipment such as surgical gloves.

5.6. Culling Unproductive Cattle from the Herd

Successful beef breeding enterprises rely on an efficient and productive breeding herd. To achieve this, the cows contributing least productivity to the enterprise need to be identified and removed. This practice is called 'culling'.

Low or lost productivity during a cow's breeding lifetime can be summarised as:

- Failure to conceive
- Failure to produce a live calf
- Failure to rear that calf to become a healthy weaner.

In cases where the causes of these failures are management-related rather than genetic, culling affected animals will have limited impact on future herd productivity. Therefore, sound principles must be applied before the decision to remove a cow from the breeding herd is made.

5.6.1. Failure to Conceive

In efficient and well-managed beef enterprises, most cows that are identified as non-pregnant after being exposed to the bull for a reasonable period are culled from the herd. This ensures any infertile or genetically sub-fertile individuals are removed from the herd, and the head manager can make the most efficient use of the pasture available.

However, for a cow that has successfully raised a calf previously, failure to conceive may well be due to an unfavourable environment rather than undesirable genetics, and culling her from the herd would achieve little in reducing the likelihood of future failures to conceive, if nothing is done to correct the overriding environmental constraint.

Assuming fertile and physically sound bulls, cattle can fail to conceive for a number of reasons:

Freemartinism:

An infertile heifer as a result of sharing the womb with a male twin. She must be culled once identified, often only as a non-pregnant heifer at pregnancy diagnosis

Other Physiological Problems:

Any other inherent problem that may impact negatively on conception or pregnancy. Culling non-pregnant heifers will remove these animals from the herd

Infection Inhibiting Conception or Causing Abortion:

Individuals known to have been affected by reproductive diseases or bacterial infections should be considered for culling from the herd as their reproductive ability may have been compromised by the infection, or they may be a source of future infection of others

Nutritional Anoestrus:

When cattle body condition score drops to 1.5 or less, the oestrus cycle often ceases, a situation most common in first calvers or during periods of severe nutritional stress such as drought. Improving nutrition will overcome this issue and culling affected animals will not benefit the herd (Fig. 5.17).

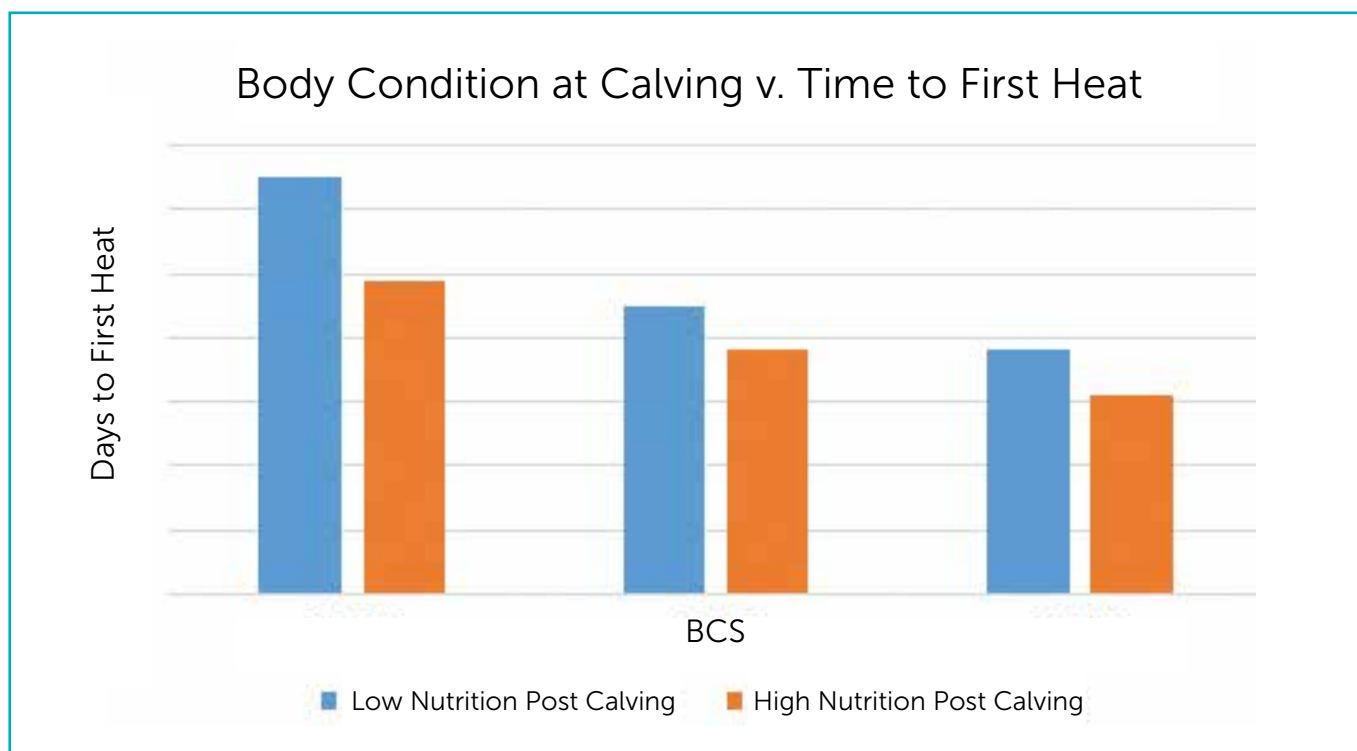


Figure 5.17. Relationship between body condition score of cattle at calving and the time taken to return to heat. Cows in poorer condition take longer to cycle after calving, and the effect can be partially overcome by improving nutrition post-calving. Source: Graham, J. (1982) Proc. Aust. Soc. Anim. Prod. 14, 309-12.

5.6.2. Failure to Produce a Live Calf

Calf mortality at birth can be a major production loss in beef breeding enterprises. Calves that die at, or soon after birth can easily reach 10% of all calves born, particularly in heifers. Common causes of calf mortality at birth are:

- Small or low BCS heifers being unable to fully push the calf out
- High birth weight or broad shouldered calves becoming stuck in the pelvis
- Mis-presentation of calf during birth (one or more feet back, breech, etc.)
- Genetic disorders
- Failure of mother to accept and suckle the newborn.

In many cases, difficult calving can have a significant detrimental effect on the cow such as paralysis, uterine prolapse, infection, and in the worst cases, death.

Animals affected by this condition are obvious choices for removal from the breeding herd.

If necessary to maintain breeder numbers, cows who lost a calf through mis-presentation and are in good health at joining time can be retained, as they are no more likely than any other cow to have a mis-presentation in the future.

Selection of bulls with desirable genetics for calving ease will help reduce calf mortality at birth.

5.6.3. Failure to Raise a Calf to a Healthy Weaner

There are a range of factors that can lead to a cow not raising a healthy calf. These include;

- Failing to suckle the calf sufficiently. This is often associated with poor teat or udder conformation or breakdown and is a reason to consider culling the cow
- Low milk supply failing to provide sufficient nutrition

to the calf. Often the cow is healthy and fat but the calf is poor, and this is a reason to consider culling the cow

- Death or injury to calf by misadventure. Like mis-presentation at birth, misadventure has no genetic basis and herd productivity will not be improved by removing affected cows. Under these circumstances, the cow can be retained if sufficient pasture is available to support her for a year before she breeds again
- Structural breakdown of the cow, reducing her ability to forage and maintain a productive body condition score, and consequently being unable to supply sufficient milk for her calf. These cows may be culled.

Determining when to cull a cow because of udder faults is dependent on the impact the fault is having on production (Fig. 5.18). Collapsed udders with ballooned teats make drinking sufficient milk difficult for the calf, and its growth may be affected. In such cases, the cow should be culled.

Less significant udder faults may not have immediate production affects but udder and teat conformation are moderately heritable, so by selecting replacement heifers only from dams with good teats and udders, the proportion of cows in the herd with well-structured and productive udders increases substantially over successive generations. Cows with undesirably shaped but functioning udders may be kept for producing feeder animals only. Otherwise, such animals should be culled if adequate replacement breeders are available.

5.6.4. Cast-for-Age

Using data from commercial beef herds in the northern border region of the United States of America (USA), economic analysis suggests that beef cows managed in a cold climate are most economically culled after weaning their 7th calf, at about 8.5 to 9 years of age, if first mated at 15 months of age (Harlan Hughes, North Dakota State University, Table 5.2).

The relative economic value of female cattle is made up of several factors, including genetic improvement in the herd, sale values of progeny, the salvage value of the cow at culling, livestock inventory value, reproductive

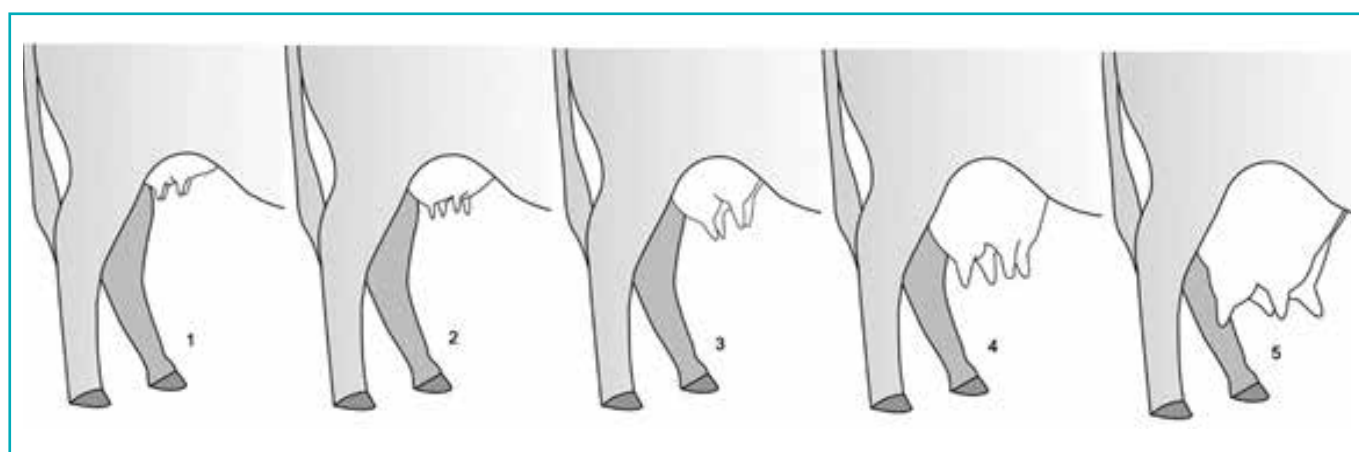


Figure 5.18. A range of udder shapes commonly seen in beef cows. 1 - Very tight and pronounced suspensory ligament, 2 - Tight, pronounced suspensory ligament, 3 - Intermediate, 4 - Loose, weak suspensory ligament, 5 - Very loose, very weak suspensory ligament. Udder types 4 and 5 are likely to require management intervention to keep cows healthy and productive and may be considered for culling. Source: http://beef.unl.edu/learning/udder_score.shtml.

Table 5.2. Effect of age, represented by the number of calves born to a cow, on the relative contribution to the profitability of the breeding herd. Source: Hughes, H. North Dakota State University.

Number of calves born to the cow	Relative Value of Cow in the Herd
1	0.81
2	0.89
3	1.23
4	1.22
5	1.33
6	1.05
7	0.91
8	0.75
9	0.56

← Older cows are of lower value to the herd than younger cows

rates, mortality rates, and feed supplementation costs.

Based on this data, Hughes concludes that the commercial beef cows in northern USA cold winter climates delivering their 8th calf are less profitable to the herd than first calving cows (relative value of 0.75 vs. 0.81). At this point, the herd benefits from their removal and replacement with heifers. Consequently, a culling policy based on removing 8.5 to 9 year old cows and after weaning the 7th calf would generate the highest return for the commercial herd.

During a herd development phase, where Australian cattle are imported to form the foundation of a specialist beef herd development program, it would be advisable to retain all imported cattle until after they wean their 8th calf at least, or are required to be culled for health or welfare reasons. This rationale is based on recovering the greatest return on the significant expense incurred in importing heifers, and the relatively small (7.5%) difference in profitability between 8th calvers and first calving heifers, in particular.

5.7. Heifers

Maximum breeding herd productivity is achieved when cows calve on or about the same date each

year, beginning at two years of age and ending when they leave the herd as aged culls. To help achieve this, heifers must be managed to reach puberty at a young age, conceive soon after first exposure to the bull, and rebreed while lactating with their first calf.

Management of breeding females begins at weaning. The ideal growth and body condition targets for female weaners being retained for consideration as replacement breeders differs considerably from the ideal targets for males (and undesirable females) during growth.

5.7.1. Selecting Replacement Breeders

Not all heifer calves born will go on to have a long and productive life as a breeder. Obvious factors such as poor health, physical problems or stunted growth will eliminate some young heifers from contention for selection as replacement breeders.

However, in a productive breeding enterprise it is common to have more young heifers on hand at first joining than required to replace culled breeders. In such circumstances, a selection process is required to determine those heifers most likely to have greatest benefit to the breeding enterprise and should therefore be retained.

The number of heifers required for mating each year largely depends upon whether the herd is building up breeder numbers, or only replacing those breeders being culled. Herd build-up includes:

- Increasing total breeder numbers; or
- Undergoing a considerable genetic shift within a stable sized herd. This genetic shift may be changing from one breed to another, or changing the genetic type within the resident breed (e.g. to an earlier maturity type or superior body structure and growth rate).

In each of these situations, a greater number of replacement heifers will be required each year than when only replacing culled adult breeders in a stable sized herd.

It is envisioned that most of the destination farms for Australian heifers will be increasing their breeder numbers, so a selection process with this in mind is the focus.

While the process is known as ‘selecting replacement breeders’, in practice it is often a case of selecting out the heifers not desired as replacement breeders, with those remaining in the group considered suitable for joining. Identifying those individuals who do not meet a minimum requirement in terms of their likelihood

to become productive and profitable breeders is the purpose of the selection process.

Selection process must consider several aspects:

- Weight
- Body condition score
- Body conformation
- Health.

In general the older, heavier heifers at weaning have the greatest chance of going on to become fertile, productive cows. Segregating out the smaller and younger heifers is therefore an important first stage of the selection process.

5.7.2. Targets for Heifer Development

For young heifers to become productive members of the herd, they must achieve production targets at various stages of their early development to ensure that they stay on track through until they reach maturity. Ideal weight and age targets are presented in the table below (Table 5.3). If these targets are not being met at any point in their growth cycle, the reason should be determined and if practical, changes made to management to achieve the targets.

Table 5.3. Suggested weight-for-age targets that young British breed female cattle should aim to achieve to optimize their chances of becoming productive breeders.

Stage of Production	Age (months)	Liveweight (kg)
Early weaning (optional)	3 to 4	100 to 150
Weaning	6	150 to 200
Yearling	12	300 to 320
First mating	14-15	300 to 360
After first calving	24	380 to 450
Mature adult weight	36	550

Heifers begin cycling at around 52% of mature body weight, but ideally heifers should be between 55% and 65% of their mature body weight at first mating. For cattle with a mature weight of 550kg, the likely expected size of Australian cattle currently being supplied to cold climate countries, this equates to a target weight of 300kg to 360kg at 14 to 15 months of age if it is intended to calve heifers at two years old.

Heifers below 300kg should not be mated until they gain more weight, as lower conception rates and increased calving difficulties will likely be experienced by heifers mated at these low weights.

BCS is another strong indicator of breeding potential. Heifers must have sufficient body reserves to initiate oestrus cycling, with optimal conception rates occurring at a body condition score of at least 3.0 at joining. Thin or lean animals with a body condition score of 2.5 or less, are less likely to conceive within a restricted joining period.

The fundamentals of desirable body confirmation and structural soundness are common for all types and ages of cattle, and are therefore relevant to the replacement heifer selection process. Similarly, all heifers selected as replacements must be in good general health.

5.7.3. Feeding Heifers

Feeding heifers correctly is an important activity to achieve high rates of pregnancy, successful calving, and calf survival. Undernourished and poorly grown heifers will be less likely to fall pregnant and if they do become pregnant will tend to have problems calving, reduced calf survival and poor future reproductive ability. Conversely, over-fat heifers will have difficulty calving due to fat deposits in the pelvic area and they tend to tire more quickly.

Weight gain and body condition development in heifers needs to align to the targets that need to be met in order for the heifers to be able to conceive when they are joined with bulls, and subsequently at calving (Table 5.3).

To achieve these targets, minimum daily growth rates of about 0.7kg/day are required to achieve mating at 15 months of age. Over this period, growth rates will vary as a result of a wide range of influences, therefore it is important to weigh and condition score the animals on a regular basis to check progress towards targets, and to adjust the feeding regime, if required, to maintain them on the planned growth path.

For example, supplementary feeding with grain and or hay may be required if pasture quality and quantity are inadequate.

In the first six months of pregnancy heifer nutrition is critical. Whilst the growing foetus requires very little additional nutrients above that of the heifer herself at this point, poor nutrition can result in poor pelvic growth of the maturing heifer and lead to subsequent calving difficulties.

During this period, protein is important to meet the growth requirement of the heifer, and during the last trimester of pregnancy dietary protein is required to support foetal growth and the production of colostrum.

Specific considerations when feeding heifers from weaning onwards include;

- Heifers will consume 2.2% to 2.5% of bodyweight of pasture or a fed-ration, depending on the quality of the diet
- Cows and heifers should be managed and fed in separate groups, as cows will out-compete heifers for feed, and the nutrition requirements of heifers are far greater than that of mature cows
- If heifers are calving in cold weather, more and higher quality feed (i.e. feed with a greater concentration of energy) will be required to meet the nutritional demands of lactation and cold weather
- Providing hay to heifers in cold weather will help to create warmth due to heat created through digestion, particularly of grass based hays. Grain may need to be added if the hay is poor quality.

5.7.4. First Mating

Heifers should be bred at about 15 months of age to calve the following year as two year olds. Providing that growth rates and condition score targets are met, calving heifers at two years of age is more profitable than delaying calving until three years of age. Only heifers that have not met condition score and weight targets should be considered for delayed mating if it is not economical to supplementary feed them to achieve the targets.

Cattle have an oestrus cycle about 21 days in length. Mating heifers for six weeks (42 days) permits each heifer to be exposed to the bull during two successive cycles, during which it is expected most fertile individuals will become pregnant. A six-week mating period also ensures that greater management control of the heifers can be exerted, including;

- Ensuring that the nutritional needs of the heifers are met
- A reduced period of intense supervision of calving is required
- Weaning and marking can be carried out at the same time for the entire drop of calves
- Replacement heifers can be mated as a group as they will reach target weights and condition score at a similar time when well managed.

However, if the enterprise is in a herd build-up phase, where increasing the total number of breeders is desirable, an extended joining period to three oestrus cycles (63 days) will increase the total number of calves subsequently born, but these later-calving heifers will likely have lower rates of pregnancy when joined a second time as their period of recovery between calving and being expected to conceive again is reduced.

Some beef enterprise managers join heifers a month before the main herd to allow greater supervision of the heifers at calving, and provide them with an extra month to regain body condition in readiness for the next breeding cycle.

However, in an environment with a defined window of ideal weather such as Russia, calving heifers a month

earlier when extreme cold weather is still a risk is not recommended unless the enterprise operators have considerable experience in managing calving at this time.

5.7.5. Selecting Appropriate Sires for Heifer Mating

Bulls selected for use with heifers must have characteristics that favour easy birth of their offspring, such as narrow shoulders and smooth body conformation. Where possible avoid sires known to sire high birthweight calves and/or display a broad shouldered phenotype that may contribute to dystocia. Additionally, if rapid genetic improvement of the breeding herd is desired, use of superior performance bulls with heifers (the most genetically advanced generation in a breeding herd) is desirable if such performance information is available.

Young bulls (up to three years old) are usually physically smaller and lighter than when mature (from four years of age) and are less likely to injure heifers during mating.

Artificial insemination (AI) is an alternative breeding strategy that, when well-managed, eliminates the risk of injury to the heifer during mating and allows easy access to leading genetics in the breed. However, AI has significantly lower conception rates than natural mating and this needs to be carefully considered before embarking on an artificial breeding program.

Care must be taken to ensure older bulls or AI sires used for several years are not mated to their own daughters when selecting sires to use with heifers. If heifers are first calved at two years of age, a bull in his third mating season will likely have sired some of the heifers being joined for the first time that year. Mating closely related animals decreases herd productivity and should be avoided. Consequently, sires for use with heifers need changing at least every second year.

5.7.6. First Calving

By the time they calve, heifers should weigh at least 440kg or about 80% of their expected mature body weight, and be in BCS 3.0 to 3.5. If these targets are achieved, the heifers will have less problems calving, as their body size will more easily cope with the delivery of the calf.

This is further helped by the use of bulls selected specially for use with heifers, and which produce lower birth weight calves. Heifers that calve early in the calving period are also less likely to have dystocia issues as the shorter gestation period tends to reduce the size of the calf.

First calving heifers must be fed sufficiently well to ensure that they milk well and support good calf growth, but also to enable the mother to continue their own growth and development. This involves feeding to at least a level that enables the heifer to maintain liveweight during the lactation period, and particularly between calving and re-mating to ensure that she resumes cycling quickly, and is able to achieve a second pregnancy in the shortest timeframe.

If heifers are not achieving target condition scores they must be relocated to better quality and quantity of pasture, supplementary feed, or the calves weaned early.

5.8. Relationship Between Feeding and Breeding

The level of nutrition is one of the major factors influencing both male and female cattle fertility. The nutritional status of the animal is reflected by body weight and body condition. Reproductive performance is closely related to live weight and body condition at the time of mating, thus weighing and body condition scoring are an essential part of any breeding program, and cattle should be evaluated on a regular basis.

For heifers that have not yet calved, an adequate quantity of feed is essential to maintain these non-lactating animals in a condition score of at least 3.0. This will increase fertility and they will be more likely to breed and produce a calf. Improving the body condition score of cows from 3.0 to 4.0 will increase pregnancy rates by up to 20% and conception will occur in a shorter period post-calving (Figs. 4.1, 5.17).

Lactating cows that have calves at foot should be returned to a condition score of 3.0 to enable satisfactory pregnancy rates to occur and for the cow to rebreed in the minimum timeframe. To ensure this, lactating cows require a higher level of nutrition than is required

for non-lactating cows to compensate for the energy demands of the suckling calf.

It is essential that cows re-breed quickly so that they can produce a calf each year. This will not happen if they do not get enough good quality feed. At conception, the BCS should be at least 3.0. Body condition may subsequently be managed to rise up to 4.0 by calving; to allow the cow to produce adequate milk for the calf and become pregnant again.

Body condition during pregnancy also has a significant effect on calving and the resulting calf. A best practice management program will ensure that the body condition of pregnant cows is monitored from 100 days before they are due and until calving (the third trimester), so that body condition can be managed to an ideal range using nutrition.

Consequences of cows that are below an ideal body condition during the third trimester of pregnancy include;

- A higher chance of abortions
- Poor reproductive cycling and re-conception
- Longer intervals between calves
- Less colostrum production and poorer calf immunity
- Poor milk production and weaker calves.

Over-fat cows, as indicated by a BCS at or approaching 5.0, suffer similar problems to under-conditioned cows, and tend to have larger calves and higher rates of calving difficulty (dystocia).

6. Calf and Weaner Management

6.1. Calf Processing

Calf processing involves a range of activities that together make managing the calves in a healthy and productive state an easier and more efficient task over their life. These include;

- Applying identification
- Castration of males
- Dehorning
- Vaccination against disease.

These activities may be done progressively throughout the calving period. The advantage of processing calves progressively includes minimising stress on the calf and the handler, but it requires considerable labour to regularly yard the cows, or capture and process the calf in the paddock. Alternatively, the whole calf crop can be processed at one time after calving has finished.

6.1.1. Animal Identification

Every calf should be given a unique number or name so that each individual can be easily identified. Cattle identification is commonly practiced throughout the world for two main purposes:

- To enable proof of ownership for those responsible for cattle welfare and management
- To assist with herd management through ease of identification of specific individuals.

Ear tags are the most common method of identifying cattle. Tags may use numbers and text, colours, shape, size and position in the ear to help identify individual animals (Fig. 6.1). Over the last decade, electronic Radio Frequency Identification (RFID) tags have been developed for use in cattle, and in Australia, electronic identification of cattle is a mandatory requirement that enables the ownership of cattle to be tracked throughout their lifetime.



Figure 6.1. Cattle identified with an electronic (RFID) tag (round button tag to the right) and a numbered management tag aids lifetime identification and traceability, and daily visual identification. Source; Banner Angus, Alberta, Canada.

Ear tags are not always a permanent method to identify cattle, as they may be lost or become unreadable during an animal's lifetime. From an animal welfare perspective, the preferred methods of identifying cattle are ear tagging, ear notching, ear tattooing, or freeze branding (see *TECHNICAL NOTE 6 - Cattle Identification*).

All calves should receive two forms of identification, so their identity is maintained if one identifier becomes lost or unreadable. These identifiers can be two of the same type (for example, identically numbered or named management tags, one in each ear); or different types (for example, a management tag and a RFID tag, or an ear tag and a brand or tattoo; Fig. 6.1), provided that a record of the link between them is kept.

Before embarking on any permanent identification program, a well-planned herd identification system must already be established. Permanent identification should only be used where it is beneficial to the producer by making record keeping considerably easier and more accurate, or is a requirement of a breed society. Applying permanent identification to cattle, when not required, can result in unnecessary pain and stress.

Numbering systems are the most common method used for individual identity of cattle. Designing a suitable numbering system for a particular herd must be carefully thought through. Ideally, no individual number should be duplicated within ten years (to prevent misidentification of animals) and should not be more than four digits (so it is easily read).

A common system involves including the last digit of the year of birth (for example, four in the year of 2014) as the first digit of an identification number. The remaining three digits of the number identify the individuals within that group of cattle born in 2014. For herds less than 1,000 cows this system accommodates a simple consecutive numbering system. For example, calves born in 2014 would be numbered 4001, 4002, 4003 and so on, while calves born in 2015 would be numbered 5001, 5002, 5003, etc. Many other numbering or naming systems exist, and managers must establish one that is meaningful and useful to them.

More detailed information on identifying cattle is provided in *TECHNICAL NOTE 6 - Cattle Identification*.

6.1.2. Castration

Castration is the removal of both testicles of a male calf by either surgical or non-surgical methods. While castration of bull calves is not practiced in some countries, modern, well-organised beef production systems have adopted castration as a best management practice for male cattle, unless they are to be retained for breeding. Castration makes male cattle safer to handle, easier to manage, and improves meat quality at slaughter.

Castration is best done as young as practical to minimise pain and stress and ideally before the calf is six months old. Where castration of a male older than six months is necessary, a skilled veterinary surgeon should perform the operation. Veterinary assistance may also be required in cases where both testicles do not freely descend into the scrotum, thereby inhibiting effective castration. Calves should always be restrained during the procedure to prevent injury to both calf and livestock handler.

Various methods of castration are available. The two most suitable methods are elastration, and surgical removal of the testicles. Elastration utilises a tight rubber ring to cut off blood supply to the scrotum and testicles, causing them to wither and fall off after several weeks. It is a bloodless procedure only suitable for calves up to two weeks of age. Elastration rings are less effective at totally cutting off the blood supply in calves older than two weeks, increasing the risk of infection.

Surgical removal of testicles is a common and very effective method of castration. As with any procedure that produces a wound, a risk of infection or excessive blood loss exists and proper care must be taken to minimise these risks.

More detailed information on castration of male cattle is provided in the *TECHNICAL NOTE 8 - Castration*.

6.1.3. Dehorning

Most cattle imported from Australia will be polled (hornless), and if bred to leading sires of their breed will produce polled offspring. However, if crossed with local breeds, some horned offspring may result and dehorning may be required.

Horns are removed to prevent injury both to other cattle and their handlers. Hornless cattle are less likely to injure themselves and other animals, particularly while being yarded or transported.

To minimise pain and injury, all horned cattle should be dehorned as young as possible; by three months of age is ideal, and before six months if no pain relief is used. Dehorning yearlings or adults, although sometimes necessary, is not recommended as it is very painful and has a high risk of excessive blood loss and infection. Dehorning older cattle should only be done by a veterinarian.

Horn tipping, or removal of the sharp points of the horn, is of little value except when the tip of a curled horn is impeding or causing irritation or injury to the cow.

The three recommended methods for dehorning young cattle are;

- Scoop and cup dehorner - Scoop dehorner are suitable for use on calves two to six months of age, preferably before their horn bud attaches firmly to the skull. They remove the horn by severing it with sharp blades. Cup dehorner must only be used when the horn is too big or solid for scoop dehorner. Cup dehorner are best for calves up to six months old where the horn bud is already firmly attached
- Dehorning knife - A special purpose dehorning knife can be used for dehorning young calves before the horn bud attaches to the skull. The aim is to cut or scoop out the horn bud plus a 1cm ring of skin around it to ensure no horn regrowth occurs
- Hot cauterizing irons - Hot cauterising irons for dehorning have a heavy, metal cylindrical head, hollowed out at the working end. Electric dehorning irons, similar to electric soldering irons, are available but the type that requires heating in a fire or flame is most common. Dehorning with hot cauterising irons is best for calves less than two months old as bigger horn buds will not fit in the 'O'- shaped opening of

the iron - which must be approximately 1cm larger than the bud all around.

Additional detail on dehorning cattle is provided in *TECHNICAL NOTE 9 - Dehorning*.

6.1.4. Vaccination

Vaccination is a procedure that improves an animal's immunity to disease. This is achieved by injecting small amounts of disease-specific antigens into the animal to stimulate the production of antibodies that confer immunity to the animal against that disease. For beef cattle, a wide range of effective vaccines are available for many common diseases that, when uncontrolled, can cause significant losses in a beef enterprise. Consequently, vaccination for the common diseases that impact on production is a vital part of successful beef enterprise management.

While immunity to some diseases is passed from mother to calf, as a general concept immunity to disease is acquired in response to an infection challenge posed by a disease as the animal grows. Older animals therefore have greater levels of immunity to disease than young animals, hence it is important to vaccinate all calves against the most important diseases at the earliest opportunity. All vaccines are accompanied by detailed instructions for use, and these must be followed to ensure that vaccination is successful, and this includes ensuring that calves are not vaccinated until they reach the minimum age specified by the vaccine manufacturer.

Most vaccines require two doses of the vaccine, spread 4 to 6 weeks apart. The first dose provides an exposure to a non-infective variant of the disease being vaccinated against, and this generates a small immune response. A second dose of the vaccine provided 4 to 6 weeks later initiates an amplified immune response that protects the animal if it is subsequently infected by the agent that causes the disease.

This immune response remains effective for most diseases for which there is a vaccine, for about twelve months. To maintain good immunity, a booster vaccination is required each year. A number of vaccines require more frequent administration, and the manufacturer's advice must be followed in all cases to ensure that vaccination is successful.

Additional detail on vaccinating cattle is provided in *TECHNICAL NOTE 7 - Vaccinating Cattle*.

6.2. Weaning

Weaning is the permanent separation of a calf from its mother. The primary aim of weaning is to remove the burden of lactation from the cow, enabling her to regain body condition in readiness for her next calf.

In cold climates, weaning should occur sufficiently prior to the onset of freezing weather to allow the newly-weaned calves to adapt to the silage/hay and concentrates based diet that they will most likely rely on over their first winter. In the northern hemisphere cold climate countries, October is generally the optimum time for weaning.

After weaning, males and females must be separated before they reach sexual maturity, especially if any uncastrated bull calves are present in the weaner herd. Even castrated males (steers) will ride heifers in heat and this can cause injury to the heifers and reduce weight gains.

Heifers and steers also have quite different management requirements after weaning. Heifers intended for future breeding need to achieve pre-determined weight and body condition targets from weaning to first mating, first calving, and rebreeding to become a successful breeder (Refer Section 5.7.2).

Similarly, steers intended for feeding and slaughter need to be managed to achieve weight and condition targets to ensure an efficient finishing program can be run.

6.2.1. Yard Weaning

Weaning cattle in confined yards, also called yard weaning, has been widely adopted and proven to be the best practice method to wean beef cattle.

Yard weaning is a simple and effective procedure that has implications for lifting long-term cattle productivity. Cattle that are yard weaned are more familiar with stockyards, water troughs, supplementary feeding, and people.

Yard weaning benefits young cattle likely to be retained as breeders and those destined for feedlots. Breeders require regular handling and supplementary feeding during their lifetime, and education in these practices early in their lives is highly advantageous.

In the feedlot, a healthy and productive feeder steer has to;

- Accept confinement and go on to concentrate feed and water quickly
- Adapt easily to the initial social/psychological and metabolic stress involved
- Achieve high feed conversion rates and weight gain through good adaptation; individually and as a group
- Have strong resistance to respiratory disease, partly as a result of social compliance and group cohesion
- Accept the presence of people, vehicles and horses at close quarters.

Yard weaned cattle have significantly greater chances of meeting these requirements than unweaned or paddock weaned cattle.

While training cattle during yard weaning, their individual temperament can also be assessed, and nervous or aggressive cattle can be identified for removal or special treatment.

The following requirements must be met to implement yard weaning as a management tool;

- Well-built, weaner-proof yards with solid opaque pen sides (rubber belting 1.2m wide is ideal)
- A reasonably sloped, well drained, non-bogging surface
- Pen stocking density of at least;
 - > 4m² per calf for 180 - 260kg calves, or
 - > 2.5m² per calf for 100 - 170kg early-weaned calves
- weaners are kept in the yards for 5 to 14 days, and they should only be let out from the weaning yards once they have settled and are eating freely
- Cattle are fed daily with a high quality hay or silage (at least 11.5 MJ of ME/kg DM and 15% protein)
- Good quality drinking water supplied in a trough
- Shy feeders and smaller weaners should be removed and managed as a separate group to prevent rapid and excessive weight loss
- Routine human contact each day, for example walking quietly through the yard at least two or three times each day
- Moving weaners through the cattle handling facilities (race, crush, etc.) will also improve their future handling.

6.2.2. Early Weaning

In some circumstances, weaning some or all calves before the planned weaning date is necessary. Poor calf health, inadequate milk supply from the mother, and weaning to prevent excessive body condition loss by breeders in adverse times (e.g. drought) may all be prompts to wean calves early.

Calves can be weaned as early as eight weeks old as long as a high protein and energy diet is provided (minimum of 11.5 MJ ME and 15 % protein). However, they are easier to manage if early weaned around 3 to 4 months of age.

If grain is used in the weaning diet, the grain must be introduced gradually over a period of 14 to 18 days, and always provide a fibre source. Providing a small quantity of supplementary feed to the cows whilst they still have their calves at foot helps to educate the calves to accept the supplement as they see their mothers consuming the feed and mimic their actions. Once calves are adapted to the supplement, they may even be 'creep fed' in the paddock prior to weaning to assist in the

transition to a prepared diet whilst they are in the yards during weaning. Creep feeding is enabled by placing the supplementary feed in a structure that can only be accessed by the calves and not the cows (Fig. 6.2).

6.2.3. Feeding Weaner Cattle

Weaner cattle have high requirements for both protein and energy to accommodate their requirements to grow and achieve reproductive maturity by 15 months of age, and for heifers in particular, to be able to subsequently calve by 24 months of age. Post-weaning diets should aim to provide rations containing 11.5MJ of metabolisable energy (ME) and a minimum of 15% crude protein. A diet of this quality will enable the weaners to gain weight at a rate in excess of 1kg per day.

Lower quality diets will reduce the daily gain of weaners. However, lower growth rates may be desirable in circumstances where heifers are assessed to be in an 'over fat' condition in the period immediately before they are due to be joined, and are at risk of lower conception rates at joining.



Figure 6.2. Creep feeding facilities can be either specially designed feed bins with calf-only access (left), or a small pen placed in the paddock with an access gate through which only the calves can pass. Source: Advantage Feeders, Georgia Simmental.

7. Winter Management

7.1. Adaptation of Australian Cattle

The objective of importing cattle from Australia to countries with cold climates is to improve the performance and productivity of local beef industries. This can only be achieved if the cattle adapt quickly to cope with the local environment, and grow on to become productive breeding animals.

There is general concern in some sectors that Australian beef cattle are not suited to the climates of these importing countries. This is despite the same breeds already existing in these countries (Fig. 7.1). However, beef cattle imported to these countries are predominantly British breeds such as Angus and Hereford.

Having been derived originally from cold climates, British breeds possess an inherent genetic adaptation to these environments, and as a result both breeds

continue to have an extensive international presence in cold climate countries. Notably, in recent years many breeding lines have been imported to Australia from the cold climates of Canada and northern USA to further improve Australian beef cattle genetics. Consequently, the genetic basis for cold climate adaptation is strong in Australian lines of these breeds.

The timing of arrival of cattle in countries with cold winter climates can affect their performance in the months after arrival. In the year of importation, Australian cattle can be vulnerable to extreme winter conditions due to their immature size as heifers.

With animal welfare as a key consideration, the optimum arrival time is in spring, summer and early autumn. This allows them to experience mild conditions during the post-transport recovery period, and to adapt to the local



Figure 7.1. British breed cattle exist throughout the cold climate countries, exhibiting a natural adaptation to the cold winter climate. Source: Dr Bazarbai Inerbaev, Siberian Livestock Institute.

conditions. If they arrive outside of this optimum period, additional care and attention will be required to manage their nutritional and welfare needs (Refer Section 7.2 and 7.3).

Over the 6 to 12 months immediately following importation, these cattle need to be given the best opportunity to adapt to the local environment so that they continue to mature at an appropriate rate, and become productive members of the producers' herd.

Through this period, the critical requirement is to provide adequate shelter, and the dietary energy and protein that the animals require to reach full maturity whilst adapting to the higher energy requirements of cold weather. At the same time, the goal is to have these heifers become pregnant by 15 months of age and have their first calf at 24 months.

Experience shows that with good management in the first 6 to 12 months after arrival, beef cattle imported to these countries from Australia are fully adapted to the local environment by the second winter period.

7.2. Winter Management Essentials

To ensure that cattle survive and continue to grow and meet production targets through the winter period in countries with very cold winter conditions, some essential principles need to be understood and implemented. These include;

- **Shelter** - all cattle need some form of shelter available to them during winter. Shelter may take many forms including sheds, wind fences, groups of trees and shelter belts, topography, hay bales, and other structures. The purpose of shelter is to provide the animals with protection from the extremes of winter, such as very low temperatures (below -20°C) high wind (wind chill), and heavy rain.

It is critical to avoid cattle becoming wet through the hair coat to the skin, as the subsequent risk of freezing temperatures can cause the water on the hide to freeze and fatally compromise their ability to regulate their body temperature. If cattle do become wet, hypothermia must be prevented by moving the cattle to shelter (e.g. a shed, preferably with a heat source) and assisting them to dry completely before they return outdoors

- **Water** - cattle need a constant source of water during winter, as most feed consumed during this period has a low moisture content and cattle require water to enable efficient rumination and digestion to occur. For cattle that are grazing in paddocks or large confinement areas, snow can be used as a water source. However this requires that the cattle learn how to use it. Lactating cattle have much higher water requirements and must be provided with fresh, clean water daily, and snow must never be used as a water source for lactating cattle as they are unable to consume enough to meet their requirement
- **Nutrition** - The energy requirements for cattle increase substantially during the cold winter period; for example for non-pregnant cows, for every 5 degrees (Celsius) decline in temperature below 0°C, the energy requirement increases by approximately 10% (data modelled using Cowbytes®, Alberta Agriculture and Rural Development). Attention must be paid to meet the daily energy need of cattle of varying classes so that they continue to grow and meet production targets. Delays and setbacks in animal growth have long term effects on productivity and are costly to the business
- **Bedding** - Frostbite is an ever present threat to the body extremities, including ears, udders, feet, and scrotum. Frostbite can be prevented by a range of actions that include provision of bedding straw and hay throughout winter. Bedding is an essential requirement for cattle managed outdoors.

Additional frostbite prevention measures include maintaining adequate energy levels in feed, shelter to prevent wind chill, and ensuring that cattle are kept dry (e.g. calves born in winter should be captured and dried immediately, and placed in a shed for the first 24 hours with the cow)
- **Access** - irrespective of where cattle are managed during winter, daily access must be maintained so that the animals can be attended to and their health and welfare monitored and responded to. This requires good planning prior to winter to select sites where access can be guaranteed. Where cattle are in confinement, sufficient room should be made available to stockpile waste snow that may

accumulate on the site and impede access (e.g. on roadways and around sheds and buildings)

- **Worker safety and comfort** - extremely cold conditions are not only hazardous to animals, but also to farm workers. Consequently, precautions are required to maintain equipment in good working order, provide workers with appropriate cold-weather and safety clothing, and that work sites such as working areas in yards are located under shelter with radiant heating installed. Moreover, a daily check-in and check-out process with a nominated supervisor, family member, or other staff should be standard practice so that worker absence can be responded to quickly
- **Feed management and storage** - stockpiled hay and silage needs to be vermin proof, and as a contingency to reduce the risk of loss of haystacks from fire, multiple storage sites should be established
- **Animal selection** - conditions such as sunburn can severely affect cattle during winter as a result of

reflection of ultra-violet light from snow on sunny days, particularly if they are maintained outdoors. Risks are higher in breeds such as Herefords, but can be managed by selecting cows with pigmentation on udders, and around the eyes

- **Feed efficiency** - Feed efficiency is a key profit driver for cattle industries worldwide, and is most important in production systems where a high proportion of the diet is 'cut and carried' to animals, such as conserved forages and grain supplements, that incur costs to conserve, store and feed out. Selection of cattle that are efficient in feed conversion is therefore a priority. By virtue of their larger size, large cows require more feed to maintain their productivity than smaller size cows (Fig. 7.2). Consequently, the cost of production tends to be higher for larger cows. An ideal target for countries with cold climates dependent on 'cut and carry' feeding for a large proportion of the year is a breeding cow with a mature bodyweight in the range 540kg to 630kg.

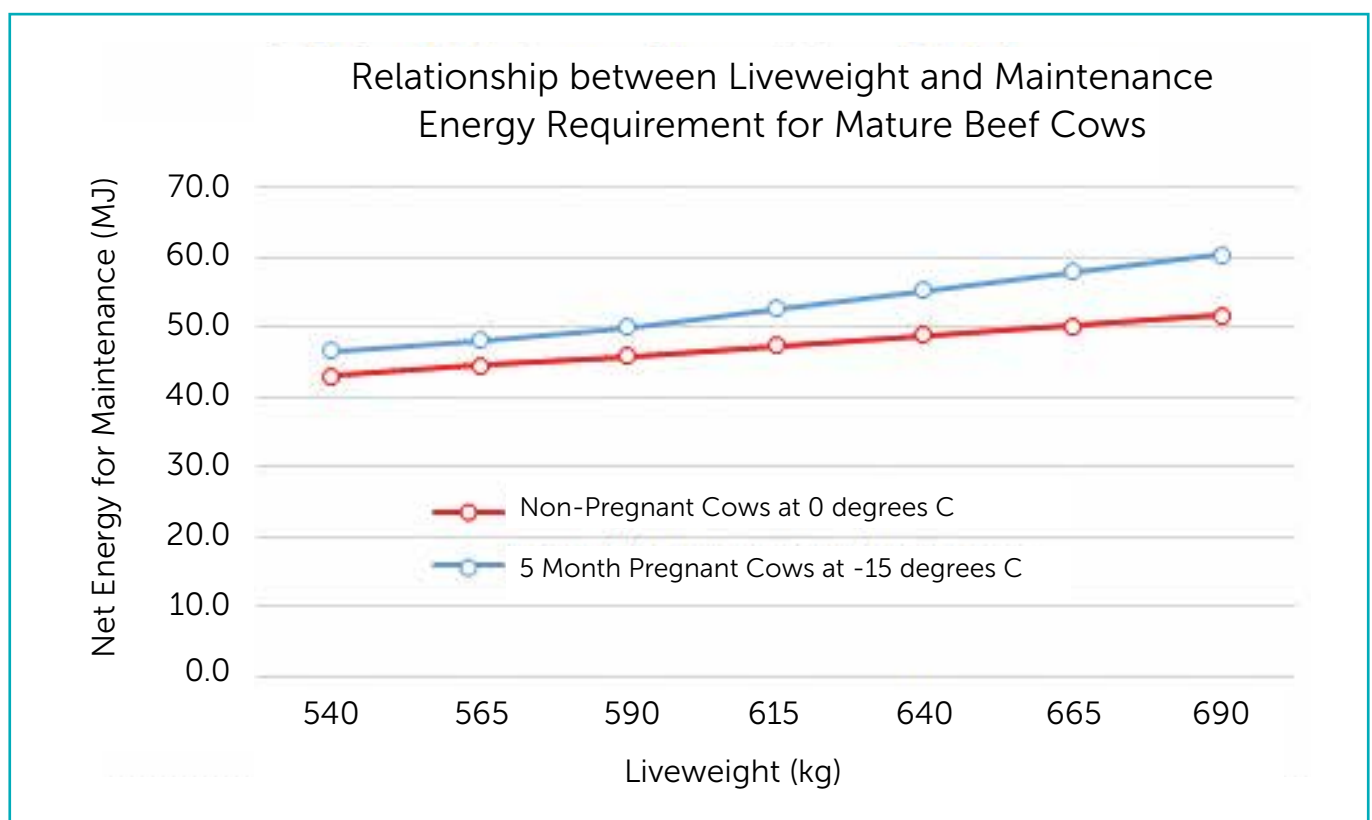


Figure 7.2. Net energy required for maintenance for non-pregnant and pregnant cows of varying weights and ambient temperatures. Cows with greater bodyweight have larger energy requirements. Source: Data modelled using Cowbytes®, Alberta Agriculture and Rural Development.

7.3. Managing the Welfare of Cattle in Winter

Whilst cattle are highly resilient to a wide range of environmental conditions, both extremely hot and cold conditions can place their welfare in jeopardy. Managers of beef cattle must pay particular attention to the primary needs of their herd and implement precautionary measures to ensure that their animals remain fit and healthy even under the most extreme circumstances. For beef cattle, several simple processes can ensure that the majority of weather extremes can be managed with optimal outcomes.

7.3.1. Bedding

Throughout winter, irrespective of the location of feeding, adequate bedding must be provided for the cattle.

A bedding mound constructed with straw provides an insulating layer on top of the frozen ground that enables cattle to sit or lay down on the mound rather than the bare ground.

In countries such as Russia and Kazakhstan where bedding mounds (barrows) are widely used, the combination of daily addition of straw, faeces and urine by the cattle, enables compost processes to become established and the mound generates heat. This provides a comfortable and warm under-layer for the cattle to rest on during winter (Fig. 7.3).

Similar bedding mounds are utilised in the Canadian and northern USA beef industries (Fig. 7.4). A key difference between the use of bedding mounds in North America, Russia and Kazakhstan is that North American producers



Figure 7.3. Composting bedding mounds in Novosibirsk, Russia. Source: International Agriculture for Development.



Figure 7.4. Composting bedding mounds in Canada. Source: International Agriculture for Development.

remove the mound at the end of each winter, whereas they are retained for many years in Russia and Kazakhstan, resulting in large mounds being produced over time.

Canadian producers remove the mounds each year due to perceived concerns related to hygiene and animal health, and utilise the nutrients contained in the bedding materials as fertiliser for pastures and crops. Long term experience in Russia and Kazakhstan indicates that there are no significant concerns for animals reusing bedding mounds year after year. This is likely due to the effects of the composting process on potential pathogens.

If bedding is not provided, cattle are placed at risk of losing excessive body heat and require more dietary energy to compensate for this loss and maintain productivity. In addition, the risk to breeding bulls and cows of frostbite

on the scrotum and udder, respectively, is increased.

Bedding may be provided by using straw or poor quality hay at a rate of 1kg per head per day to the bedding area in the yard. Distribution of the bedding straw can be made simple with a tractor powered bale processor (Fig. 7.5).

As the cattle camp on the bedding area, faeces and urine that are deposited on the mound begin composting the straw, and heat is generated in the mound that further encourages cattle to camp on the area, and over time a mound is formed that provides highly effective insulation for the cattle against the cold.

In the case of confined feeding in pens or feeding in the paddock, straw bedding and shelter remain essential requirements.

7.3.2. Water

All cattle need clean and reliable water sources to survive. The type of water source can vary depending on the water resources that are available on the beef property, and where the animals are feeding. For example, cattle in winter yards may be provided with flowing water in troughs that are heated by low voltage currents or ground insulated (Fig. 7.6).

Cattle being fed in paddock-based wintering sites may utilise animal-primed water systems that rise to the surface and into a water receptacle as a result of the animal moving a specially designed device (e.g. a frost-

free nose pump, Fig. 7.7), and then the water falling back below the frost line to prevent freezing in the pipes. In these cases, water delivery pipes need to be buried in the ground at a depth below the frost line to ensure that water can continue to flow.

When cattle are grazing stockpiled forage, pastures, or swaths and bales, they may be able to use snow as the main water source. In these instances, the snow needs to be clean and fresh, and a backup plan is needed when snow melts or becomes dirty. A cow unfamiliar to using snow for water will take one to three days to start to consume snow as this is not a natural behaviour - it is a learned behaviour.



Figure 7.5. Bale processors can be used to add straw for bedding in yards or at winter feeding and shelter sites. Source: International Agriculture for Development.



Figure 7.6. An insulated water point - water is prevented from freezing by thick, insulated outer core, and exposure to the air is limited by the small surface area of the drinking holes. Source: International Agriculture for Development.



Figure 7.7. A frost-free, nose operated water pump with an insulated water delivery riser allows cattle to access drinking water in freezing weather conditions. Source: Frost Free Nose Pumps (www.frostfreenosepumps.com).

Icy snow can be problematic as it is more difficult to consume, and can cause abrasion injuries to the soft tissues around the nose and mouth.

Some classes of cattle should always be provided with fresh drinking water and not rely on snow. This includes calves, as they do not perform well on snow, and cows within one month of calving or that are in early lactation, as they are unable to consume enough snow to satisfy their increased demand for water.

In a system where cattle are moved from paddock to paddock, a portable watering system installed on a trailer may be a practical option.

Cattle breaking through ice in streams and dams is a significant risk and these water sources need to be managed, particularly during early winter and spring when the ice is at its thinnest.

7.4. Traditional Indoor Winter Management Systems

Managing cattle during winter across many cold climate countries has traditionally been achieved by keeping the cattle indoors throughout late autumn, winter and early spring (mid-October to mid-May). Throughout this period, cattle rely completely on daily feeding with forages that were conserved in the preceding summer, including hay, silage and high dry matter haylage prepared from natural pastures, and forage crops such as maize, cereals, and legumes (sainfoin and alfalfa). Beef cattle are rarely fed grain supplements as these are reserved for dairy cattle.

Traditional winter cattle sheds are dark, poorly ventilated, and the roof is low in height (Fig. 7.8). Unless high quality management is applied to cattle in these sheds, they are



Figure 7.8. Traditional cattle sheds in Russia are dark and poorly ventilated. Source: International Agriculture for Development.

prone to respiratory diseases and other infections during winter, as heat and humidity within the heavily-stocked sheds contribute to ideal conditions for a number of pathogens.

Most winter sheds also have an adjoining outdoor yard that can be used to provide the cattle with an area to move and 'loaf' during winter. However, this is not always the case.

Where outdoor pens are associated with the sheds, cattle health is improved as the cattle spend a considerable amount of time outdoors, resulting in lower levels of exposure to the humid conditions that persist inside the shed. This is despite the very cold outdoor temperatures that prevail in mid-winter.

7.5. Opportunities to Manage Cattle Outdoors During Winter

Managing beef cattle outdoors throughout winter and without the use of sheds is not a common practice outside North America.

Experience in other cold climate countries has shown that alternative management based on maintaining the cattle outdoors throughout the winter is possible, and is achieved at a substantially lower cost of production, including a reduced requirement to invest in buildings, machinery and labour.

Strategies for outdoor management vary considerably between producers. However, the two main strategies practised successfully are;

- Feeding in confinement
 - > In winter yards
 - > On winter feeding sites
- Winter grazing
 - > Stockpiled pasture or forage
 - > Forage swaths.

7.5.1. Feeding in Confinement

Confinement Yards

Confinement feeding in well-constructed feedlot-style confinement yards is a simple winter strategy and is not a significantly large step forward for producers who have previously utilised sheds. The confinement yards are similar to those utilised as loafing yards in shed systems. However, a key difference is the use of wind fencing to provide protection against wind chill during the coldest weather conditions rather than a shed (Fig. 7.9).

Design principles for a confinement yard are similar to those for feedlot planning, and require consideration of suitable surface materials and slopes for siting and constructing the pens, providing sufficient area for the cattle to be contained, and waste management structures to capture effluent that may run-off the site as the snow and ground thaws during spring (see *TECHNICAL NOTE 2 - Planning and Confinement Facilities*).

Preparation of confinement facilities with compacted pen surfaces increases the utility of the yards and also enables them to be used year-round for activities such as finishing young cattle prior to slaughter. If the pen floor is not constructed from a suitable compactable material, the surface can become muddy and 'pugged', particularly in the shoulder periods of the season leading into winter and spring when the ground is not frozen.

During these periods, the cattle can accumulate muddy dags on their coat that, if present at slaughter, can impact on the value of the animal received, and increase the risk of bacterial contamination of the carcass during slaughter and hide removal. Provision of bedding mounds in pens can also assist to prevent the accumulation of dags.

Winter Feeding Sites

Confinement feeding may also take place without the need to develop confinement yards (Fig. 7.10). In these situations, shelter needs to be provided in some form that enables the cattle to cope with harsh winter conditions when they occur (Refer Section 2.3.4).



Figure 7.9. Winter confinement yards with wind fence protection for beef cattle in Canada. Source: International Agriculture for Development.



Figure 7.10. Winter feeding sites may be developed without the need for constructing confinement yards. Source: International Agriculture for Development.



Figure 7.11. Bale-grazing is a widely-used option in North America to feed cattle on wintering sites without requiring investment in containment yards. Source: International Agriculture for Development.

As is the case for confinement feeding in yards, a daily supply of feed needs to be provided to the cattle throughout the period of confinement. Feed can either be provided in a similar form and manner as in confinement yards, or alternatively 'bale-grazing' is a developing practice in North America (Fig. 7.11).

Bale grazing involves the use of large round or square bales that are placed on the winter grazing site and set out in many repeating straight lines that can be 'fed-off' to the cattle at regular periods by controlling access to the bales with electric (or other cattle-proof) fences. Cattle on wintering sites such as these also require a source of fresh water, and a frost-free water source needs to be provided throughout winter.

Because of the high density of livestock on the confined area of a winter grazing site, manure accumulation can be a significant environmental problem if not factored into initial site planning considerations. Consequently, wintering sites should be located away from environmentally sensitive areas such as riparian zones adjacent to water courses, or alternatively some site engineering is required to prevent run-off of nutrient rich waste water into sensitive areas during the thawing period in spring.

7.5.2. Winter Grazing

Extending the grazing season for as long as possible is growing in popularity and effectiveness in North America, where the cost of providing conserved forages and grain supplements to cattle through winter has proved uneconomic in some situations. Consequently, many producers have developed alternate strategies to produce and utilise pasture and forage resources through much of winter 'in the paddock'.

The focus of producer-led research and development has been to develop grazing systems that allow grazing to continue longer into the autumn and early winter period than traditionally practiced, and similarly in spring, developing grazing resources that can be used earlier than traditional management has allowed in the past.

Extending the grazing system offers the opportunity to reduce the cost of feeding cattle by utilising more on-ground resources. Options for extending the grazing season include stockpiled pasture or sown forages, the grazing of swaths of sown forages, and bale grazing (Fig. 7.12).

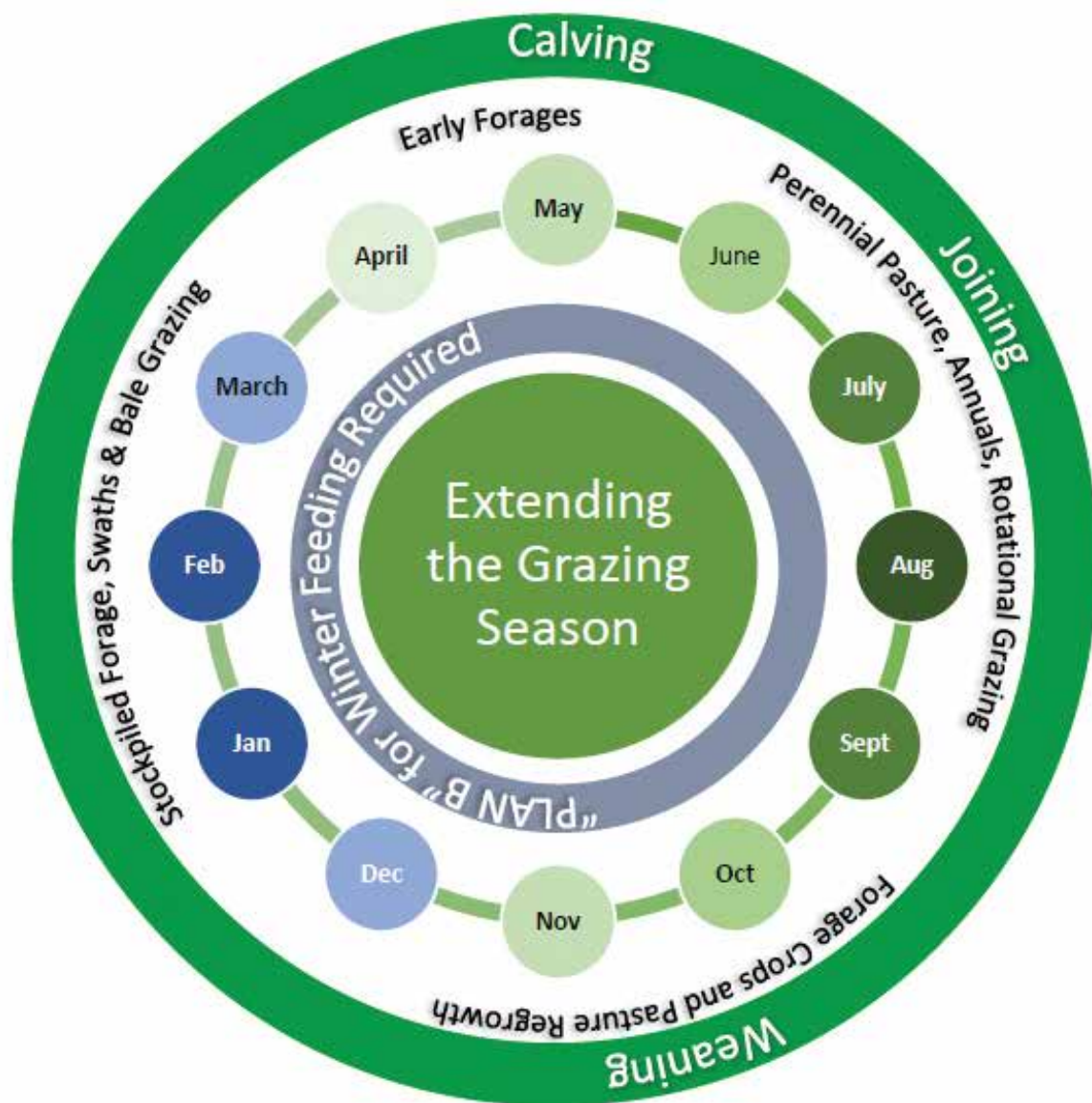


Figure 7.12. Options to extend the grazing season.

Even though it is possible to successfully extend the grazing system in most environments, some conserved forage will still need to be fed to the herd for a number of weeks in most years, and this needs to be factored into the winter feed budget.

Since weather patterns are slightly different from year to year, this impacts on the way that the grazing season

can be extended. Consequently, when developing and implementing a winter grazing program, it is essential that a Plan B, worst case scenario winter management strategy is developed simultaneously, and alternative, reserve feed resources are available to feed the herd in the event that the climate becomes unfavourable to allow a planned winter grazing program to proceed. For

example, if snow becomes too deep for grazing earlier than anticipated, or early rain reduces the quality and quantity of swath grazing reserves.

The Plan B program has a focus on confinement feeding; either in yards or on wintering sites. With this in mind, planning the winter feed management program requires that preparation for both eventualities are completed well before the onset of winter, including feed budgeting and securing the total reserve quantities of feed required to sustain Plan B.

7.5.3. Managing Winter Grazing

It is essential that cattle begin the winter grazing program in good body condition, at least BCS 3.0, that they are able to maintain good body condition throughout winter, and that shelter, water and feed are always available. Planning, management, close monitoring and responding to the environment are absolutely critical. To maintain body condition, cattle should be segregated into 'like' groups for grazing; for example old cow groups, heifer groups, and steer groups.

Before winter grazing commences, the quality of the feed should be tested to determine the energy, protein, and fibre concentrations in the feed. This will help understand whether the feed will meet the nutritional needs of the cattle, and therefore whether the cattle will need to be given supplements while grazing the particular forage. It is also a good practice to provide the cattle with access to a source of supplementary minerals, salt and vitamins.

Throughout the winter grazing period, the cattle need to be checked daily. Although the cattle are grazing in paddocks, bedding is still required for the cattle, and this should be placed in the sheltered area set aside in the paddock to provide protection against extreme cold and unpredictable bad weather events.

Bedding straw will ensure that cattle have insulation against the freezing effect of the ground when they lay down. Also, in freezing conditions, cattle cannot be allowed to get wet to the skin, as the water in the hair coat will freeze and can rapidly lead to hypothermia.

Contingency plans (Plan B) need to be in place whenever a winter grazing program is implemented, as bad weather can quickly impact on feed accessibility and cattle condition (e.g. where the snow becomes too deep, an ice crust forms on the swath, or when a field turns to mud when the snow melts).

If the snow is icy or crusted over, animals can wear the skin off their noses and the hair off their lower legs. In these circumstances, the cattle need to be removed immediately and an alternative feeding and management strategy applied; such as feeding in confinement or bale grazing.

7.5.4. Grazing Stockpiled Forage

Stockpiled forage is where pasture and hay fields are saved for winter grazing after pasture growth has stopped. Cattle can effectively graze pastures with snow coverage, up to a depth of about 0.6m (600mm).

For the stockpiled pastures to be good quality, the field needs to have been grazed or cut for hay once before allowed to regrow for autumn and winter grazing otherwise the pastures will be 'over-mature' and of very low nutritional value. In any case, the nutritional value of stockpiled forage is best suited for mature dry cows in early-mid gestation.

Stockpiled forage plants should be tall so they are easily accessible for the cattle. If stockpiled pastures are to be grazed after snow, the mass of the forage needs to be higher. Grasses are best used in the autumn before snow covers over the grass.

Erect perennial grass species are good species to use as stockpiled forage as they stand up so they can be grazed more easily by livestock. By contrast, soft grasses should be grazed in the autumn before they get lost under snow cover.

Legumes are not suitable for use in stockpiled or swath grazing as they lose their leaves quickly after the first frost which results in declining forage quality.

7.5.5. Swath Grazing

Swath grazing is a method of feeding conserved forages to cattle during winter in the paddocks in which they were grown. Annual cereal crops such as triticale, barley and oats can be used to prepare forage swaths, and experience in Canada in particular demonstrates that high yields of high quality forage can be preserved to be fed out to cattle during winter.

The cereal crops are sown in early spring (May in most circumstances), and then cut and swathed using a swathing or windrowing implement at the end of August or September, depending on the location and the maturity of the crop. The swaths tend to sit up on top of the cereal stubble, and as the weather turns cold, the forage is preserved by the dry weather conditions. The swaths are left in the fields for the cattle to graze (Fig. 7.13).

For best results from swath grazing, paddocks need to be selected where;

- The condition of cattle can be easily monitored
- Water is available
- Wind protection is provided
- Supplementary feed can be provided to animals if needed.

Although experience in North America shows that cattle can graze through snow up to 0.6m deep, low lying areas where snow accumulates should be grazed earlier in winter before the snow gets too deep. If there is heavy snow on the swath, it is possible to open up access to it by driving a tractor down the swath to break through the snow, or to use a grader blade or the bucket of the tractor loader to push the snow off the swath.



Figure 7.13. Remnants of swaths grazed by cattle during winter. Source: Mary Macarthur, The Western Producer.

When cattle need to graze through snow there should be;

- High forage volume
- Adequate forage quality
- Softer snow type
- High stocking density so as to break the snow crusts.

To estimate how much of the swath will be utilised, assume that a cow will use about 2.5% of its body weight per day. For example, a 600kg cow will consume 15kg of dry matter of swath feed per day.

Access to the swath can be controlled by using portable electric fencing so that high utilisation rates can be achieved. If the cattle are allowed uncontrolled access to the entire field of swathed material, much will be wasted as the cattle trample on the material and reduce its quality. With controlled access, the electric fence can be moved every 1 to 3 days, this way there will be less wastage of feed. Straw bales can be used to monitor when the cows are ready to move. When they start to eat the straw bales it is time to be moved on.

When selecting crops for swath grazing, the best crops to choose are those with a good dry matter yield potential. Barley, triticale and oats are the most commonly used cereal crops. If barley is used, smooth awned varieties are better as the rough awns can get caught in the cow's mouth and cause a condition known as 'lumpy jaw'.

Seeding for swath grazing should take place in late spring to early summer (May to June) when soil tractability and soil moisture are favourable for sowing. When the crop is at the soft dough stage it should be cut as this provides the best quality forage for grazing.

Early seeding in mid-May has up to 25% more yield than late seeding. However, this leads to an early harvest which has risks associated with swaths being exposed to the weather for longer periods in autumn, and this can result in yield and quality loss from leaching and the growth of moulds. If a long season species of crop is chosen this will allow for early seeding and reduce the problems associated with early swathing.

7.5.6. Bale Grazing

Bale grazing is a very simple system where forage is harvested as round bales, and the bales are moved to an open area selected for use as a winter feeding site (Fig. 7.14). The bales are arranged in lines across the site at about 6m spacing, and portable electric fencing is used to control the rate of access of the cattle to the bales. The cattle then 'self-feed' from the bales, and as they consume the material, the electric fence is moved back to expose more fresh bales for the cattle.

Round bales work very well in bale grazing systems. Their shape and construction prevents significant weather damage to the conserved feed if it rains, as the rain tends to shed off the bale, unlike square bales that tend to absorb much more water. Some quality loss is evident in round bales, however this is confined to the outer 100mm or so of the bale.

An advantage of bale grazing compared to grazing swaths and stockpiled pasture is that the snow can accumulate to greater depths without impacting on the ability of the cattle to access the baled material, and snow depths of greater than 1m can be managed. Where snow accumulates in front of the bales, this can be easily moved with a tractor equipped with a loader bucket, or a snowmobile can be run up and down in front of the bales to make a track by packing down the snow.

Areas that are used for bale grazing through winter have significant quantities of manure and urine deposited on the site from the cattle as they feed and camp. When identifying an area for bale grazing, the producer must consider the risk of nutrient runoff from the site in spring as the snow thaws, and ideally locate these sites away from water courses and on level ground. In the spring, these sites subsequently make good areas for sowing forage crops or new pasture, as the added fertility gained from manure and urine deposition provides an excellent source of nutrients for the crop.

As is the case for all other outdoor grazing systems, site access throughout winter, shelter, bedding, and water

are essential requirements for bale-grazing systems; as is daily monitoring.

7.5.7. Developing a Winter Feed Budget

Early planning for winter is a key discipline for beef cattle enterprises in countries with cold winters. This includes planning to have sufficient quantity and quality of winter feed on hand for the winter feeding program.

To understand the quantity of feed required, a winter feed budget needs to be developed. In its simplest form, a feed budget is used to identify;

- The type of cattle to be fed
- Number of cattle to be fed
- Liveweight at the start of feeding, and target weight at the end of feeding

- The number of days that feed will be required to be fed
- Rate of feeding (e.g. as a percentage of body weight)
- The feeds to be used.

The resulting list of animals, weights, feeds, quality and quantity form the basis of the feed budget (Table 7.1).

As a part of the preparation of the winter feed budget, planning should also be implemented for a Plan B management option in the event that the preferred winter management system is not able to be implemented for part or all of the planned management period.

A completed winter feed budget will then indicate the quantities of each type of feed that is required to be prepared over the spring, summer and autumn



Figure 7.14. Bale grazing is an effective and low cost winter feeding strategy for cattle, with the bales also providing protection from wind and weather. Source: International Agriculture for Development.

in order to feed the cattle under the planned winter management system, and a contingency feed budget (Plan B) that is required if the preferred strategy is unable to be implemented.

The feed budget will generally be prepared on a dry matter basis, thus these quantities will then need to be

converted to an 'as fed' basis that includes the correction for the moisture content of each of the components of the ration. A contingency for waste and feed spoilage should be added as an additional buffer to the budget.

This quantity may be as much as 10% for grain, and up to 25% for hay, silage and haylage.

Table 7.1. Example of a winter feed budget for a beef cattle breeding enterprise (on a dry matter basis).

	HEAD	START DATE	END DATE	DAYS	GROWTH KG/D	LIVEWEIGHT (KG) START	LIVEWEIGHT (KG) END	FEED % LWT	SWATH	SWATH	PASTURE	PASTURE	HAY	HAY	SILAGE	SILAGE	GRAIN	GRAIN
								Dry Matter	% in diet	Qty Tons	% in diet	Qty Tons	% in diet	Qty Tons	% in diet	Qty Tons	% in diet	Qty Tons
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
PLAN A Weaner Heifers	130	1 st Nov	31 st Dec	60	0.84	200	250	2.75	90	43.4	-	-	-	-	-	-	10	4.8
		1 st Jan	30 th Apr	119	0.84	250	350	2.75	-	-	-	-	30	38.2	50	63.8	20	25.5
TOTALFEED - PLAN A Tons, Dry Matter								175.7		43.4				38.2		63.8		30.3
PLAN B Weaner Heifers	130	15 th Oct	15 th May	212	0.84	200	350	2.75	-	-	-	-	30	62.5	50	104.2	20	41.7
TOTALFEED - PLAN B Tons, Dry Matter								208.4						62.5		104.2		41.7

Formulas:

To Calculate Column ...

$$D = C - B$$

$$J = [A \times D \times H \times (I/100) \times (G-F)/2]/1000 \text{ (= number of cattle x days fed x \% feed quantity x \% rate of feed in diet x average liveweight)}$$

$$L = [A \times D \times H \times (K/100) \times (G-F)/2]/1000$$

$$N = [A \times D \times H \times (M/100) \times (G-F)/2]/1000$$

$$P = [A \times D \times H \times (O/100) \times (G-F)/2]/1000$$

$$R = [A \times D \times H \times (Q/100) \times (G-F)/2]/1000$$

8. Finishing Beef Cattle

A RELATIVELY SMALL NUMBER OF LIVE CATTLE ARE EXPORTED to cold climate countries as feeder steers. However, management of locally-bred feeder cattle is increasing in these countries as a result of a significant focus on developing local beef industries.

The importation of feeder steers increases the recognition of the beef breeds being used and improves the quality of beef produced for both domestic and export markets.

Cattle finishing is generally a two-stage process known as i) Backgrounding, and ii) Finishing. These two phases accommodate the progressive changes in growth that see changing rates of bone, muscle and fat deposition in the animal as it matures. As cattle grow, the body prioritises nutrients firstly for bone growth, then muscle growth, followed by fat deposition (Fig. 8.1.).

8.1. Backgrounding

Backgrounding cattle, typically castrated male cattle (steers), commences as soon as they are weaned and continues until they are placed on a finishing diet. Surplus heifers may also be directed to a backgrounding program and treated similarly to steers and finished for slaughter.

The main purpose of backgrounding is to manage the cost of feed required to grow the cattle to a suitable size and stage of maturity so they can then be finished quickly and economically for a target market.

The growth curve of beef cattle is such that for the early part of the animal's life, growth is focused on developing skeletal size and muscle mass to support the lifetime needs of the mature animal. Nutrients consumed during

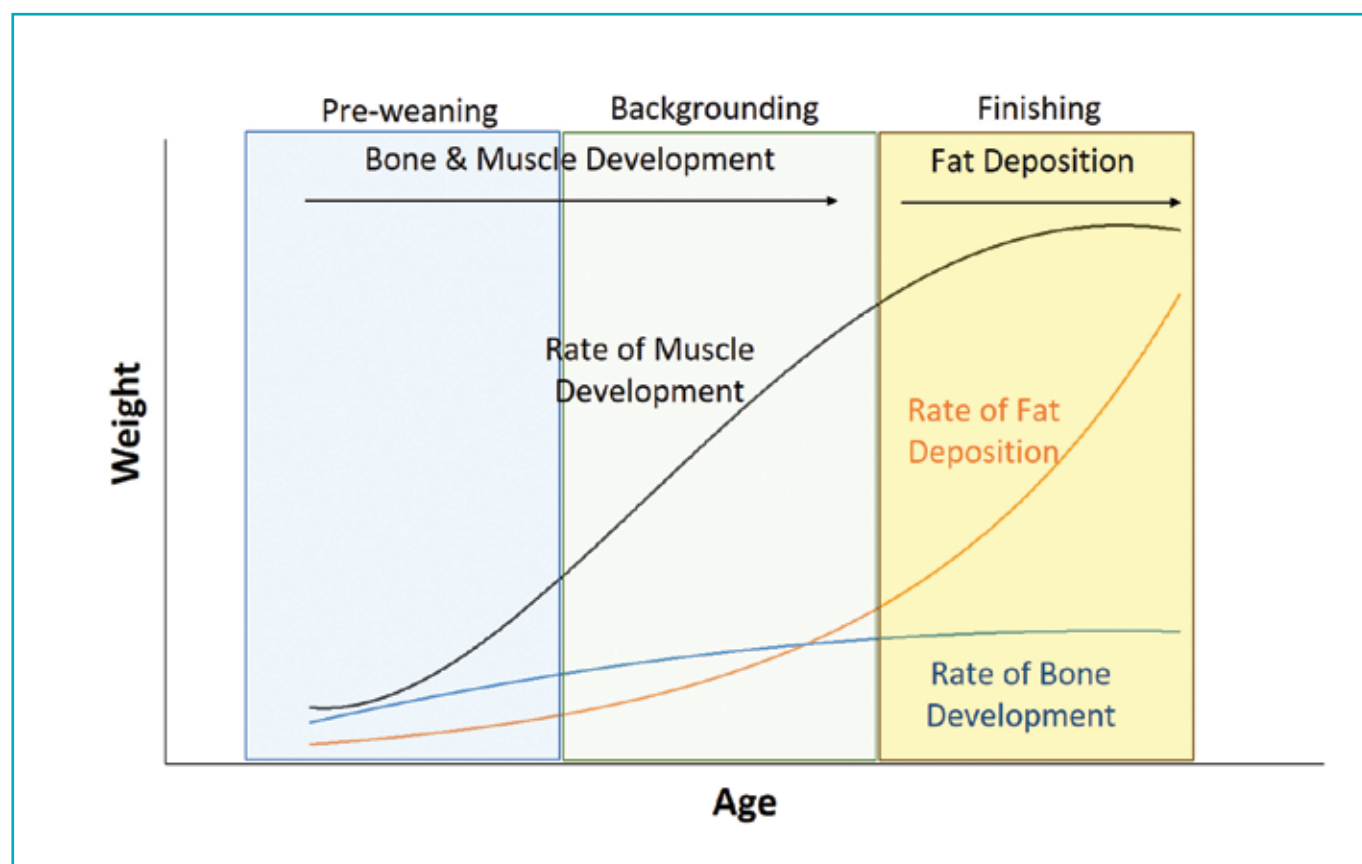


Figure 8.1. Relative change in muscle, fat and bone accumulation with maturity in beef cattle. Source: Adapted from Bruns, K. (2005). South Dakota State University.

this early period are partitioned preferentially to these tissues, and if provided with an unrestricted supply of nutrients, weight accumulation in this developmental phase is optimised.

As the animal matures, proportionately more nutrients are partitioned to the deposition of fat, including internal fat reserves, fat between muscle seams, subcutaneous fat, and intramuscular fat, in preference to muscle and the skeleton. Intramuscular fat in particular, or beef marbling as it is known, is an important determinant of eating quality of beef, thus finishing cattle with a focus on marbling is a key attribute in producing prime eating quality beef. In the theoretical beef growth curve, liveweight gain slows as the animal partitions nutrients to fat deposition as it matures.

In practice, backgrounding diets aim to control the growth rate of the cattle, to about 0.8 to 1.0kg per day, and may involve pasture grazing if backgrounding occurs during the spring, summer or autumn when grazing resources are available. If the backgrounding phase is conducted during winter, they will be fed conserved forages and lower quality feed inputs such as straw, chaff and grain screenings, with modest levels of dietary energy. This strategy allows the young cattle to develop their body size (frame) and muscle mass whilst minimising the cost of feeding, particularly during winter when feed costs are high.

Feeding programs for backgrounding are based on factors such as the breed and weight of the cattle, and the projected slaughter date and target weight. Backgrounded cattle are generally fed to reach weights of between 360kg and 400kg, from where an additional 100kg to 150kg of liveweight gain is achieved in the feedlot using finishing rations.

After weaning, cattle that are backgrounded on pasture should have access to good quality pasture throughout summer and autumn that will enable them to maintain a positive growth path and be able to be finished to a market specification, either in a feedlot, or on pasture the following year.

8.2. Finishing

The finishing phase of beef cattle production is planned to achieve rapid weight gain and fat deposition to produce carcasses that are consistent with the attributes required by the target market. Finishing periods vary according to the size and condition of the animals and may vary from as little as 50days, to more than 150days.

In most cold climate countries, finishing will be managed in a feedlot or confined feeding yards and will produce cattle weighing 450kg to 500kg, and carcasses of 220kg to 275kg, over a 100day finishing period.

If high quality pasture or forage is available in adequate quantities throughout summer and autumn, it is also possible to finish cattle in the paddock with these feeds. These 'grass-fed' cattle are increasingly perceived to have a marketing advantage in many international markets due to the higher concentration of omega-3 fatty acids in the resulting beef. If consumed in sufficient quantities, these compounds have health benefits for consumers. By comparison, grain-fed cattle finished in feedlots have very low levels of omega-3 fatty acids.

Feeding During Finishing

For cattle finished in a feedlot, a diet high in energy is fed to promote rapid weight gain and fat deposition. To achieve this, the cattle must first adapt to the high energy diet over a two week induction period and then be maintained on the diet until the target weight and body condition is achieved. Cattle entering the feedlot can be successfully inducted to their new surroundings by:

- Feeding unprocessed hay for the first five days, particularly if they have come off pasture. This helps them settle down and become familiar with the feedlot pens and feed bunks and encourages them to eat
- On day 2 or 3 introduce a starter ration containing chopped silage or hay (75% by weight), and an introductory level of grain (25% by weight), or a concentrate feed. Placing up to 3kg per head of this

on top of the hay in the feed bunk encourages the cattle to consume the starter ration and to continue their adaptation to the feedlot

- The starter ration should be formulated to contain 14% to 15% crude protein and 10 MJ of metabolisable energy (ME) per kg
- On day three, reduce the unprocessed hay by 10% per day, and increase starter ration by 10% per day until day seven
- On day eight, stop feeding unprocessed hay, and the starter ration makes up 100% of the diet
- Monitor intake of feed by the cattle daily and identify and remove any cattle that are not settling down in the feedlot. Remove them from the mob for separate feeding and management.

By the end of the second week of feeding, the daily dry matter intake of the ration by the animals should reach 2.5% to 2.7% of bodyweight. When this point is achieved, the finishing ration can be progressively 'stepped-up' to increase the quantity of grain in the ration, by about 10% every 3rd or 4th day, and reducing the quantity of the roughage component (Table 8.1).

Introduction of the finishing ration over a 21 to 28 day period enables the cattle to adapt to the progressively increasing content of grain in the ration, and limiting the development of metabolic conditions such as acidosis (grain poisoning). Limiting grain intake to no more than 85% of the diet, and providing 15% of the diet as roughage adds additional safety to the feeding regime, as very high grain diets (in excess of 85%) are difficult to manage successfully to avoid a significant incidence of

Table 8.1. Induction steps for a grain feedlot finishing ration (on a dry matter basis). Source: McKinnon (1996), Manitoba Agriculture

Day	Energy (MJ/kg)	Crude Protein (%)	Calcium (%)	Phosphorus (%)	% of Grain	% of Roughage
1-3	10.0	14.0	0.60	0.40	25%	75%
4-6	10.4	13.0	0.60	0.40	35%	65%
7-9	10.8	13.0	0.55	0.35	45%	55%
10-12	11.2	12.5	0.55	0.35	55%	45%
13-16	11.6	12.5	0.50	0.30	65%	35%
17-21	11.9	12.0	0.50	0.30	75%	25%
21-onwards	12.1	12.0	0.45	0.25	85%	15%

sub-acute and acute grain poisoning (see Section 4.5.6). Other management processes to help avoid grain poisoning include;

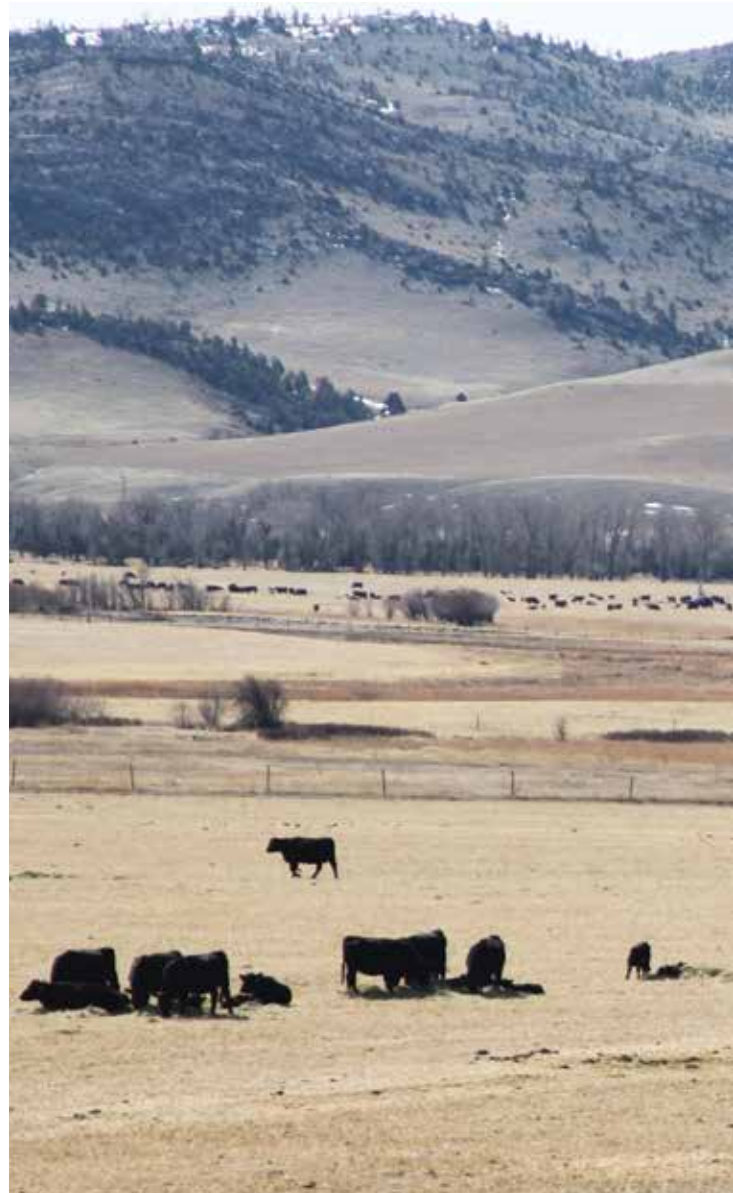
- Feeding cattle at the same time each day
- Ensuring feed bunks do not run out of feed, i.e. prevent having excessively hungry cattle
- Cleaning old feed (and any manure or other contaminants) out of the feed bunk at least weekly, and more regularly if required
- Including stock lime (calcium carbonate ground to pass through a 50 micron screen) in the ration, at a rate of 1% to 2% on a dry matter basis
- Daily monitoring of cattle to identify sick or injured animals or shy-feeders, and removing affected animals to be managed separately to recover and readapt to a finishing ration.

8.3. Health of Cattle in the Feedlot

Cattle entering a finishing program need to be in good health before and during the program in order to generate the highest returns for the enterprise. Much of the health program is administered to the animals as either calves or weaners and includes;

- Vaccination - priming and booster doses against clostridial diseases, bovine respiratory disease, etc.
- Treatment for internal parasites (e.g. intestinal nematodes) and external parasites (if required)
- Prior handling in stock yards - for example yard weaning and grain feeding.

During the finishing phase in a feedlot, low-stress handling techniques will substantially aid in keeping the cattle in good health and condition, and daily monitoring is essential to enable sick and injured animals and animals off-feed to be identified and separated for management in 'hospital pens' until they either recover, or are culled early.



9. Forage Production and Conservation

FORAGES ARE PLANTS AND PARTS OF PLANTS, other than harvested grain, that can provide feed for grazing animals, or that can be sown and harvested for feeding. Sown forages are often the prime source of feed in ruminant production systems, and the success of the system is dependent on how effectively the forages are grown and managed.

9.1. The Soil

Soil is the supporting medium for all plants and forages, and as such soil texture and fertility are overriding influences on the productivity and persistence of forages. Several factors contribute to soil fertility including nutrient concentration and nutrient availability, and are understood by examining the chemistry of the soil.

9.1.1. Soil Texture

Soil texture is the relative proportion of the various soil particle size fractions in soil. These fractions include clay, silt and sand, and the proportion of each of these fractions in each soil determines the soil texture class (Fig. 9.1). In an agricultural perspective, soil texture classes are able to be used to describe soil with similar behaviour and management needs.

Soil texture is commonly determined in the field by assessing the behaviour of a small handful of soil when moistened and kneaded into a ball. Based on feel of the soil and the assessment of the bolus, the soil sample can then be classified into a texture class. For example, a soil sample which can be formed into a long ribbon

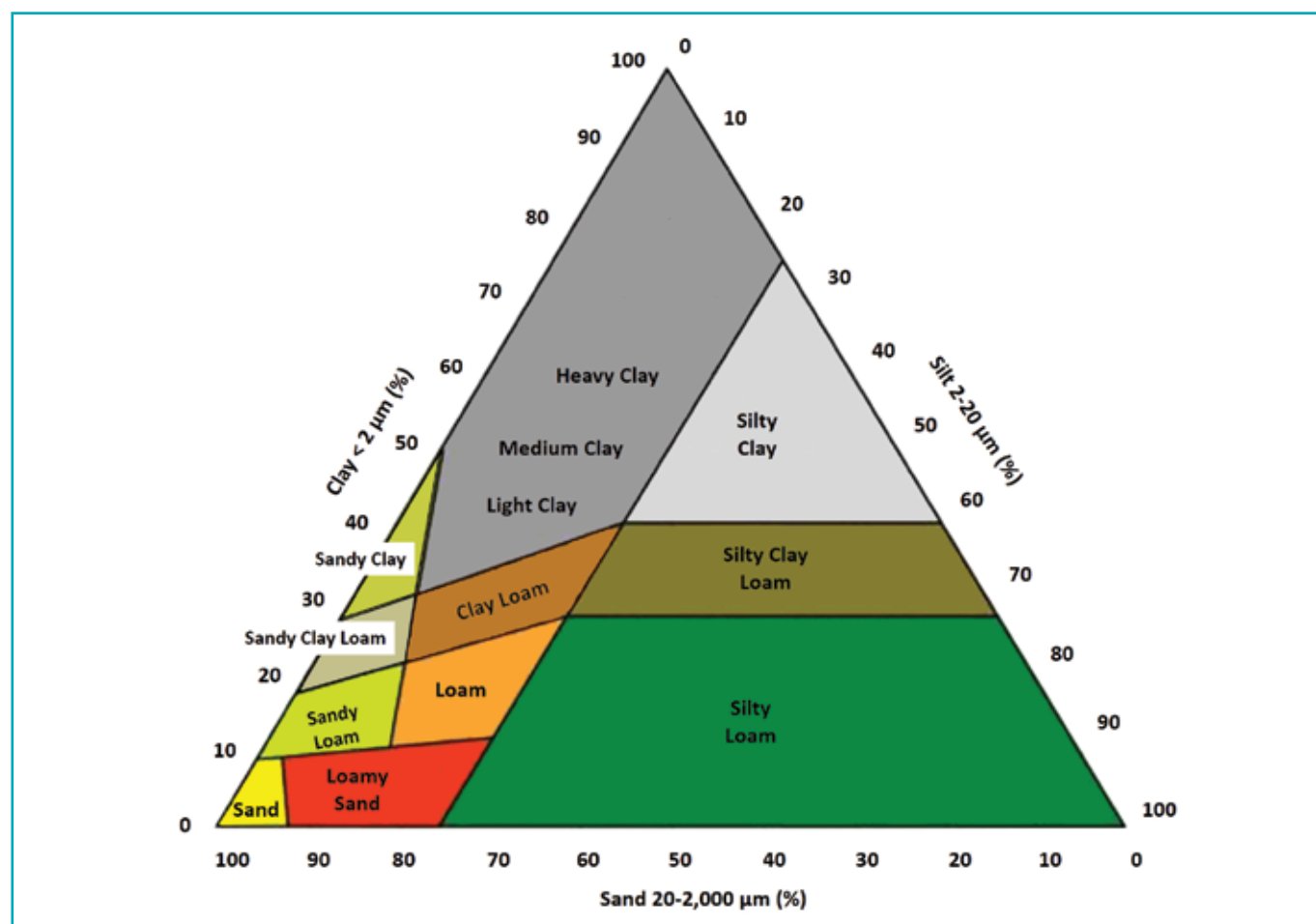


Figure 9.1. The soil texture classification triangle. Soils can be classified based on the occurrence and proportion of particle sizes. Source: University of New South Wales.

of approximately 50 to 75mm, is coherent, has a plastic feel and fine to medium sand can be felt and heard, would be considered to belong to the Sandy Clay soil texture class.

Soil texture has a substantial bearing on the agricultural capacity of the soil, in that it determines the ability of the soil to store both moisture and nutrients. Soils dominated by clay particles are largely impermeable to water and restrict the movement of plant roots, whilst sandy soils have relatively poor soil moisture holding characteristics, but allow free and unrestricted movement of plant roots through the soil.

9.1.2. Soil Chemistry

Two components of soil chemistry help to understand the agricultural potential of the soil. These include plant-available nutrients and soil pH.

Plant Nutrients

There are 15 essential nutrients that plants require in order to meet their needs. Three of these nutrients may be obtained from the atmosphere through photosynthesis; hydrogen, carbon and oxygen. The remaining 12 are obtained from the soil. Of these, the primary agricultural macro-nutrients are nitrogen, phosphorus, potassium, sulphur, magnesium and calcium. These elements have the most substantial effect on plant growth. The remaining essential nutrients, or micronutrients, are required in much smaller quantities.

Whilst macronutrient availability drives plant growth, micronutrient deficiencies will limit the plants ability to obtain its maximum potential yield.

Plant nutrients are closely associated with (bound to) soil particles and organic material. The mechanism of adsorption and desorption of these nutrients with soil particles is important since it is only when they are detached and in solution with water that they become available to plants. Conversely, when they are adsorbed to soil particles, the leaching of these nutrients down through the soil profile is reduced.

The texture of the soil and also the presence of organic matter is therefore important to soil fertility, as different

soil particles have different abilities to absorb nutrients. The smallest particles, clay, have the greatest ability to adsorb and 'store' nutrients, whilst sandy soils have a comparatively smaller ability to adsorb nutrients, and are more prone to nutrient loss as water passes easily through the loose soil structure, taking with it any nutrients that have been released from the soil particles. Consequently, our most arable and agriculturally productive soils tend to be composed of a balance of soil particle sizes that are able to store both high levels of nutrients and soil moisture.

Soil pH

Soil pH, or the measure of the level of acidity or alkalinity in the soil strongly influences the availability of essential nutrients in the soil, including elements that might be toxic to plants.

Plant growth is usually best in neutral soil conditions (pH 6 to 7), when most nutrients are readily available (Fig. 9.2), although species vary significantly in their adaptation to pH extremes.

Soil pH is easy to measure either in a laboratory using a pH meter, or in the field using chemical indicators that change colour as pH changes. Laboratory tests may be carried out using water or a buffer solution of calcium chloride (CaCl₂). The CaCl₂ determination is normally 0.5 to 0.8 lower than the water determination.

Soil pH can affect the availability of major elements to plants, particularly phosphorus. However, some of the most important effects of pH lie with the trace elements and phytotoxic elements, such as aluminium (Al) and manganese (Mn). For example, Fig. 9.2 shows that molybdenum (Mo) becomes less available and aluminium becomes more available as soil becomes more acid i.e. with decreasing pH. The former is an essential nutrient, required in minute amounts for plant growth, and in somewhat larger amounts for effective legume nitrogen fixation. The latter is toxic to plant growth.

Manganese, which also becomes more available with decreasing pH, is an essential nutrient at low concentrations in the soil, but becomes toxic at higher

levels. Hence, knowing the pH can give a guide as to what deficiencies or toxicities may exist at a particular site (Table 9.1). This is not to say that all acid soils will

give problems with Mo deficiency or Al toxicity. It simply points out that these might be considered if problems occur on an acid soil.

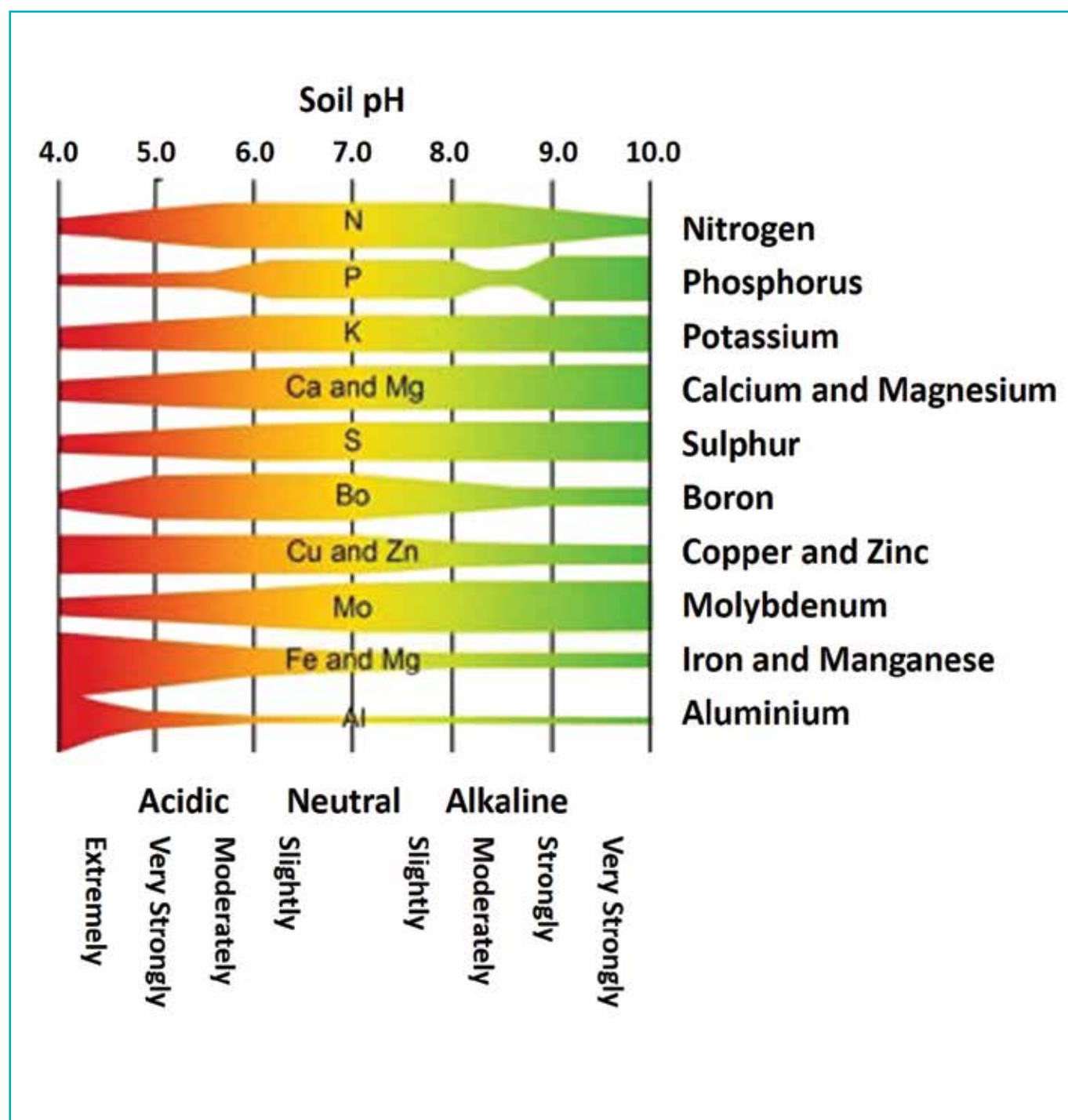


Figure 9.2. Change in nutrient availability with pH. Source: University of New South Wales.

Table 9.1. Common plant nutrient deficiencies and toxicities influenced by pH

Acid soil (e.g. below pH 6)		Alkaline soil (e.g. above pH 8)	
Deficiency	Toxicity	Deficiency	Toxicity
Phosphorus Molybdenum	Aluminium Manganese	Iron Manganese Zinc	Rare



Figure 9.3. Developing skills to identify healthy plants (left) from nutrient deficient plants (right), such as potassium in alfalfa, will aid the profitability of a beef cattle business. Source: International Agriculture for Development.

9.1.3. Testing Soil Fertility

Chemical tests are available to monitor the nutrient levels in both the soil and plant tissues, and provide reliable estimates of soil and plant nutrient status. For plant tissue tests, critical nutrient levels in the plant are strongly species-related and interpretation is only meaningful if samples are taken from a defined part of an actively growing plant, at a defined stage of growth e.g. immediately prior to flowering.

It is often easier to become aware of the symptoms exhibited by various species in response to a particular deficiency or toxicity, and to assess plants for vigour and any abnormalities that might indicate a problem. Symptoms, which include yellowing or reddening of whole or part of leaves, stunting of growth, striping or

puckering of leaves etc., vary slightly among species, but the experienced forage manager soon becomes able to recognize and diagnose a problem (Fig. 9.3). With the assistance of nutrient analysis, an appropriate fertiliser program can be developed to ensure that plant growth is maximised.

9.2. Forages in Farming Systems

Forages are as much a part of a farming system as the crops that are grown and the animals that are kept, and should be treated accordingly. Before deciding which forage to grow, the producer needs to consider the following:

- How much land is available and suitable to grow pastures and forages?

- What labour and financial resources are available for forage development and management?
- How many livestock require feeding?
- What type and class of livestock require feeding?
- What level of production is expected?
- What other sources of feed are available?
- What is the feeding value of all these feeds?
- How will livestock be fed during winter?
- Is the forage permanent or a short-term forage? (i.e. will the forage be part of a crop rotation?)
- How will the forage be utilised - grazed or conserved?
- What forage species are adapted in the area?
- Which forage species are best suited to the farming system?

These questions help to define the role of the forage in a particular farming system.

9.2.1. Plant Adaptation

Plants have evolved to grow and reproduce under a particular range of environmental conditions, and in general, the further they are removed from their native environment, the less thrifty they become. For example, some plants grow in deserts, others in swamps; some grow in fertile soils, others in infertile soils; some grow in cold climates, others in hot climates. There is also considerable variation between and within plant species in their adaptation to various soil conditions.

Plants that are eaten by animals also have developed specific adaptation to frequency and intensity of defoliation. Plants that are rarely grazed or browsed in their native environment tend to be taller and more upright than those that are frequently heavily grazed, the latter often being more prostrate, with stems that root down on the soil surface (stolons) or even creep below the soil surface (rhizomes).

It is important, therefore, to know the characteristics of plants, their tolerances and susceptibilities to ensure that they are compatible with the system into which they will

be introduced. Use of plants that are poorly adapted to the local environment will result in an unsustainable system.

9.2.2. Forage Species

Most sown forages come from the two large groups of flowering plants; the grasses and the legumes. About 10,000 grass species and 18,000 legume species have been identified around the world. Apart from this large number of species, there are many genotypes within each species, giving enormous variation overall. However, not all grasses and legumes are eaten by grazing animals and not all legumes fix nitrogen.

Over the years, researchers around the world have identified species in the various agro-ecological zones with characteristics that might be valuable in sown pasture systems (good palatability and feeding value, wide adaptation, persistence under grazing etc.). Large collections of genotypes within these species have been made by trained plant collectors, and saved in seed banks called Genetic Resource Centres in many of the key countries. New varieties are produced from research programs selecting the best types from the wild collections, or breeding programs designed to combine useful traits identified in the various wild species.

Forages are classified in various ways; on the basis of plant relationships, plant types, or adaptation (Table 9.2). Hence, a producer might need a late flowering, perennial grass, adapted to a poorly drained, infertile clay soil to satisfy the forage needs in their particular system.

9.2.3. Legumes

Legumes are a group of flowering plants that produce their seeds in pods. What makes legumes different from most other plants is the ability of many of them to extract nitrogen from the atmosphere by using a symbiotic relationship with bacteria (rhizobia) in root appendages called nodules.

Why is this important? Since nitrogen is the basis of all proteins, the productivity of agricultural systems is therefore strongly related to the amount of available

Table 9.2. Forage classification systems.

Characteristic	Categories
Plant family	<ul style="list-style-type: none"> • grass (Poaceae, formerly Gramineae) • legume (Fabaceae, Mimosaceae, Caesalpinaceae, formerly all grouped in Leguminosae) • other - includes brassicas (Brassicaceae, formerly Cruciferae), daisy group (Asteraceae)
Preferred environment	<ul style="list-style-type: none"> • temperate • Mediterranean • subtropical/upland tropical • tropical (wet tropics, seasonally dry tropics)
Growth cycle	<ul style="list-style-type: none"> • annual • perennial • biennial
Growth habit	<ul style="list-style-type: none"> • herbaceous (stoloniferous, rhizomatous, upright, prostrate etc.) • sub-shrub (small woody-stemmed plant) • shrub (large, multi-stemmed woody plant) • tree
Flowering time	<ul style="list-style-type: none"> • early • mid-season • late
Soil adaptation	<ul style="list-style-type: none"> • texture (sand, loam, clay etc.) • fertility (low, medium, high) • drainage

nitrogen in that system. Unfortunately, atmospheric nitrogen cannot be used directly by plants, but can be used by certain microorganisms, including rhizobia. The rhizobia form a mutually beneficial relationship with the legume, the bacteria obtaining nutrient from the plant and the plant obtaining “fixed nitrogen” in the form of ammonia (NH₃) from the bacteria.

As a result, legumes generally have a high level of protein and non-protein nitrogen in their tissues without the addition of nitrogen fertilisers. This characteristic can be used to provide high quality feed for livestock and to improve soil fertility. A very vigorous legume can fix over 500kg/ha of nitrogen (equivalent to over one tonne of urea), although in most cases, the amount of nitrogen fixed is considerably less, averaging about 100kg/ha.

Legumes fix most nitrogen when growing conditions are best; with adequate moisture and temperature, and soil fertility, particularly phosphorus, sulphur and molybdenum. The amount of nitrogen fixed is closely related to the amount of legume leaf per unit area. A sparse stand of heavily grazed legume may fix as little as 10kg/ha of N.

In countries with cold climates, legumes that are sown for use in pastures for grazing animals are typically perennial species that persist for a number of years under ideal growth and grazing conditions (Table 9.3). Annual legumes are not widely sown in these areas. However, the potential exists to utilise annual legumes such as subterranean clover (*Trifolium subterraneum*), balansa clover (*Trifolium*

michelianum), and annual medics (*Medicago spp.*) in improved pastures, and local evaluation is required to assess their potential.

9.2.4. Grasses

Grasses form the bulk of grazing pastures worldwide. A considerable effort has been expended to develop improved cultivars of successful and adapted grasses across the great range of environments where livestock are grazed. However, unlike legumes, grasses are not able to obtain nitrogen to support their growth from the atmosphere and must therefore rely on soil sources of nitrogen to support their protein requirements for growth.

As a consequence, the productivity of grass based pastures is primarily limited by nitrogen availability, since most soils are incapable of supplying sufficient nitrogen from soil-derived sources to support the

growth potential of the grass. This is particularly evident wherever selected and improved grass species and cultivars are sown with the view to establish highly productive pastures for grazing.

In countries with cold climates, grasses that are sown for use in pastures for grazing animals are typically perennial species that persist for a number of years under ideal growth and grazing conditions (Table 9.4). Although some annual grasses are sown in these areas as specialist forages for conservation and feeding to animals during winter, for example millet (*Echinochloa utilis*) and sorghum (*Sorghum bicolor*), the potential exists to utilise a range of other annual or biennial grasses such as ryegrass (*Lolium multiflorum*, *Lolium rigidum*) in improved pastures for either seasonal grazing or fodder conservation. Adoption of these species requires local evaluation to assess their potential.

Table 9.3. Common perennial legumes suited to most winter climates, and their tolerance to drought, and soil acidity and alkalinity. Adaptation of these species to local conditions is dependent on annual rainfall and requires local validation. Source: Forage Adaptation; Manitoba Agriculture, Food and Rural Development.

Common Name	Scientific Name	Winter Hardiness	Drought Tolerance	Acidity Tolerance	Alkalinity Tolerance
Alfalfa Purple flower Yellow flower	<i>Medicago sativa</i> <i>ssp. sativa</i> <i>ssp. falcata</i>	Good Good	Good Good	Low Low	High High
White Clover	<i>Trifolium repens</i>	Good	Poor	Moderate	Moderate
Sainfoin	<i>Onobrychis vicifolia</i>	Moderate	Good	Low	High
Sweet Clover	<i>Melilotus albus</i>	Moderate	High	Low	Moderate
Alsike Clover	<i>Trifolium hybridum</i>	Moderate	Poor	Moderate	Moderate
Red Clover	<i>Trifolium pratense</i>	Poor	Low	Moderate	Moderate

9.2.5. Selecting the Right Species

Success of a livestock enterprise often depends on selection of the forage species best suited to the production system and environment. There is little benefit in sowing a forage that is not well-adapted to a given environment, nor is there any point in growing a forage that is inappropriate within a given farming or management system. Having determined a number of forage options for a particular farm, it is then important to know the effect the forage might have on a particular type or class of livestock.

Forages vary markedly in their dry matter productivity, feed quality, palatability and soil adaptation. Well fertilised grasses tend to produce higher dry matter yields than legumes, whereas legumes tend to have higher quality than grasses. Consequently, animal production per hectare may be higher with grasses, but production per animal higher with legumes. This is a generalisation,

and is very dependent on the species involved and the level of management applied.

9.2.6. Anti-nutritional Factors

Many forages have the potential to adversely affect certain livestock by virtue of anti-nutritional chemicals in the tissues e.g. alkaloids, coumarins, tannins, and oestrogenic compounds. However, the fact that a forage can produce an adverse effect in livestock should not necessarily preclude its selection. Many grasses and legumes can have a deleterious effect on animal health and production, but if managed correctly, they can produce greater benefit than a problem-free species.

For example Alfalfa (*Medicago sativa*), often referred to as the "King of legumes", can cause bloat and death in grazing livestock, but in the right environment and system, and with careful management, it can be a wonderful asset.

Table. 9.4. Common perennial grasses suited to most winter climates, and their tolerance to drought, and soil acidity and alkalinity. Adaptation of these species to local conditions is dependent on annual rainfall and requires local validation. Source: Forage Adaptation; Manitoba Agriculture, Food and Rural Development.

Common Name	Scientific Name	Tolerance of			
		Winter	Drought	Acidity	Alkalinity
Altai Wild Rye	<i>Elymus angustus</i>	High	High	Moderate	Moderate
Crested Wheatgrass	<i>Agropyron cristatum</i>	High	High	Low	High
Intermediate Wheatgrass	<i>Thinopyrum intermedium</i>	Good	Moderate	Low	High
Meadow Brome	<i>Bromus biebersteinii</i>	Good	High	Moderate	Moderate
Kentucky Blue Grass	<i>Poa pratensis</i>	High	Moderate	High	Low
Meadow Fescue	<i>Festuca pratensis</i>	Good	Moderate	Moderate	Low
Meadow Foxtail	<i>Alopecurus pratensis</i>	Good	Low	High	Moderate
Orchard Grass	<i>Dactylis glomerata</i>	Moderate	Moderate	High	Low
Perennial Ryegrass	<i>Lolium perenne</i>	Poor	Low	Moderate	Moderate
Pubescent Wheatgrass	<i>Agropyron trichophorum</i>	Good	High	Low	Moderate
Russian Wildrye	<i>Elymus junceus</i>	High	High	Moderate	High
Smooth Brome	<i>Bromus inermis</i>	High	Moderate	Moderate	Moderate
Tall Fescue	<i>Festuca arundinacea</i>	High	Good	High	High
Tall Wheatgrass	<i>Thinopyrum ponticum</i>	High	Low	Moderate	Moderate
Timothy	<i>Phleum pratense</i>	Good	Low	High	Low

9.3. Establishing Pastures and Forages

9.3.1. Preparation for Sowing

Sowing forages or a pasture involves good planning in the year before the pasture is sown. During this period, a weed control strategy can be implemented that will enable the newly sown pasture to establish under the best conditions, and minimise the establishment of weeds. The control strategy may include management activities that prevent the existing pasture setting seed, including;

- Cutting the existing pasture for silage
- Hard grazing of pasture regrowth
- Use of herbicides
- Cultivation.

Pastures and forages must be sown into a well prepared seedbed that enables good soil to seed contact to maximise germination. The seedbed can be either cultivated or tilled, or no-till sowing methods can be employed on areas that have had good chemical control of weeds applied beforehand. In both cases, good attention must be paid to the sowing depth of the seed to ensure good emergence.

For effective germination, the optimum sowing conditions are into a moist soil bed, and to have the good contact between the seed and the soil. This is best achieved with a fine, firm seedbed.

9.3.2. Seed Quality

To ensure success when sowing new pasture or forage seeds, a few important steps should be followed. These include ensuring that seed is;

- a) True to variety: Be sure that the seed is really that of the variety you wish to plant. The best way to do this is to obtain seed from a reputable source and to check the label
- b) High quality: Use only high quality seed to establish the pasture. Quality is measured in terms of purity and level of germination. Try to obtain a recent seed analysis statement for the seed you are planning to sow, since this will show these details. Pay special

attention to the weed seed in the sample since you do not want to introduce new, potentially serious weeds into your system. The analysis will also give germination details for the sample, which includes the percentage germinable and hard seed. If the seed has <50% viable seed, this indicates poor seed health, and usually results in poor field germination and establishment

- c) Low dormancy: Many grasses are subject to post-harvest dormancy, which means germination improves, sometimes for over 12 months after harvest
- d) Stored favourably: It may be necessary to store seed for a period before sowing. Germination can decline rapidly if seed is stored at high temperature and humidity, so there are some basic rules to follow if seed quality is to be maintained:
 - Ensure seed has a moisture level <10% before storage. Seed dies faster with increasing seed moisture
 - Keep seed in cool, dry conditions, since the higher the temperature and the relative humidity, the more rapid is the decline in seed quality. While refrigerators may be cool, they also operate at high relative humidity and may not improve keeping quality of seed. Air conditioning is a better alternative
 - Smaller seeds need special care since they inherently tend to have shorter shelf life
 - Protect from seed-eating vermin such as insects and mice
 - Check germination before planting
- e) Treated (if required):
 - (i) Scarification: The seedcoat (testa) of legumes is often impermeable to water, thus slowing germination. This "hard seed" gradually breaks down with weathering, allowing the seed to germinate. If the hard seed level is too high, it can result in poor germination immediately post-sowing when it is important for the sown species to compete with regenerating weeds.

The level of hard-seededness can be reduced by scarifying the seed coat being careful not to damage the embryo

- (ii) Inoculation: For pasture legumes to be useful, they require the presence in the soil of a strain of nitrogen-fixing bacteria (rhizobium) suited to an effective symbiosis in the legume root nodules (Fig. 9.4).

Some legumes are very specific in their rhizobium demands. Where there is doubt that a suitable strain of rhizobium exists in the soil, a culture of the bacterium is introduced, usually on the seed in the form of a peat culture (a black powder), in a process called inoculation. Peat cultures should be kept well sealed, moderately cool, and out of the sunlight until they are used. The rhizobial culture is mixed into a slurry with an inert glue such as methyl cellulose and

mixed with the seed to provide a thin coating over the seed. The seed should then be spread out in the shade to dry before sowing. Seed should be sown as soon after inoculation as possible. If a commercial rhizobium culture is not available, seed should be mixed with soil from around a vigorous plant of the same species. This soil will contain enough of the suitable strain of rhizobium to achieve effective nodulation.

9.3.3. Post-Emergence

In the period following emergence, ensuring that the plants have optimum conditions to become well established is the priority. This includes applying the required quantity and type of fertiliser that matches the plants' requirements, and monitoring the field for competing weed species, insect pests, and diseases. It may be necessary to apply pest-specific herbicides,



Figure 9.4. Nitrogen-fixing nodules on legume roots. Source: Terraprima, Creative Commons (Nitrogen-fixing nodules in the roots of legumes).

insecticides, or fungicides to remedy any significant challenges to the health of the pasture or forage. These decisions need to be made with the confidence of the correct diagnosis of the problem, and access to good equipment to apply the chemical or fertiliser, and competent labour skills to complete the task.

Newly sown pastures can be lightly grazed as soon as the plants have established roots that are sufficiently deep to prevent the plant from being pulled from the ground by the cattle. Early grazing has the additional benefit of promoting tillering by grasses, i.e. establishment of multiple stems.

9.4. Pasture and Forage Management

Being able to successfully manage pastures and forages under grazing by livestock and forage conservation is one of the most valuable skills for producers to develop. It is a complex skill that requires a good understanding of the way that plants grow and respond to their environment; including soil type, fertility, rainfall, temperature, disease, and grazing by animals, and cutting for conservation. Some basic principles to manage pasture and forage are discussed below.

9.4.1. Area Required / Stocking Rate

Ensure that there is sufficient area of pastures and forages available to satisfy the nutritional needs of the livestock on the farm. This can be roughly calculated by considering how many animals are to be fed for the year, and their annual feed requirement per head. For example, for a 400kg animal consuming 2.5% of its body weight as dry matter each day this is equivalent to 10kg per head per day. If fed all year, it will therefore require 3,650kg dry matter per year.

Then, knowing that a well-fertilised pasture on the property is capable of producing 4,000kg dry matter per year, for example it would therefore theoretically support just over one animal per year, assuming all the dry matter is utilised. However, substantial quantities of forage are wasted due to trampling and fouling in grazed systems, and other losses in cut-and-carry systems. It is therefore better to stay on the conservative side and plan to allow for these losses. Under grazing, this may amount to as much as 60% or more of the pasture grown, and for conserved forages up to 25%. Consequently, in this example, the pasture used for grazing would only support less than 0.5 animals per

hectare, but if used as conserved feed may still support one animal per hectare.

9.4.2. Grazing

Grazed as regularly as is feasible to obtain optimum feed quality. Feeding value declines rapidly with age of regrowth as increasing amounts of indigestible lignin are laid down. Although longer intervals between grazing or cutting may result in higher DM yields, animal production is usually poorer (assuming similar amounts of feed provided) because feed quality is inadequate to support the anticipated level of performance.

Always maintain a green leaf residue after grazing or cutting. The rate of regrowth is initially directly related to the amount of leaf remaining on the plants to intercept light and support photosynthesis. With severe cutting or heavy grazing, there is a delay in active regrowth while plants redevelop enough leaf area to support growth. Plants that are over-utilised will also see their root mass decline which affects the recovery of plants from utilisation and stress.

For legumes, the amount of nitrogen fixed is related to the photosynthetic leaf area on the plant, thus leaving a green leaf residue after grazing further supports the nitrogen balance of the pasture. It is important to remember that the amount of nitrogen in a system drives the productivity of the system.

9.4.3. Controlling Weeds

Weeds compete with the sown species and reduce productivity of the pasture. They can result from inadequate land preparation or excessive grazing. If seed is sown into a weedy seedbed, the already-established weeds suppress the developing forage seedlings. If pastures are over-grazed, cattle select palatable forages, leading to a build-up of unpalatable species i.e. weeds.

Weeds at establishment can be controlled by spraying with selective herbicides. While weeds in established pastures can be similarly controlled, the most effective control is adoption of more lenient grazing management practices.

Judicious high cutting can also be a valuable tool to tip things back in favour of the sown species, particularly where annual weeds are a problem. Chemical weed control should be seen as a last resort once other control measures have been unsuccessful, since chemicals are expensive and not always environmentally "friendly".

9.4.4. Developing a Fertiliser Program

To maintain the long term productivity of pastures and forages, it is necessary to develop a fertiliser program that aims to at least replace the nutrients removed from the system by grazing and forage conservation. In a grazing system, a proportion of nutrient is returned to the soil in the dung and urine, but in a forage conservation system, large amounts of nutrient may be directly removed from the area where the forage is grown.

To calculate the amount of nutrient removed, we need to know the approximate forage yield and the chemical composition of that plant material. Since the amount of water in plants varies greatly with species, soil moisture, and age of the plant, it is normal to express the yield in terms of kilograms (kg) or tonnes (T) of dry matter (DM) per hectare (ha); dry matter being the weight of material with all water removed (see Section 3.2.6).

Table 9.5 gives approximate minimum values for concentrations of nutrients in the dry matter for unrestricted plant growth. These levels vary considerably between species, with age of regrowth and the amount of available nutrient in the soil e.g. nitrogen and potassium concentrations in grass may vary from 0.5% to over 3%.

If we were to consider developing a fertiliser requirement to replace the key macronutrients removed from a grass pasture producing an annual yield of 4T/ha dry matter, and assuming that the pasture plants have the nutrient

composition below (Table 9.5), then the forage produced would contain the amounts of major elements shown in Table 9.6.

If the 4 T/ha produced in this example was removed from the field and conserved as silage or hay, these quantities of nutrients (Table 9.6) would be completely removed from the field as well. Using these quantities, it is then possible to calculate the amount of fertiliser required to replace these elements when referenced to the chemical composition of available fertilisers (Table 9.7).

In this example, we might then choose to use superphosphate, muriate of potash, and urea as our fertilisers to replenish the nutrients removed by the conserved forage. To calculate the amount of fertiliser to deliver each nutrient, the quantity of nutrient required is divided by the percentage of nutrient in the fertiliser (Table 9.8). Therefore, to replace;

- 60kg/ha of nitrogen would require 130kg/ha Urea
- 40kg/ha potassium would require 80kg/ha Muriate of Potash
- 8kg/ha phosphorus would require 89kg/ha Superphosphate
- 4kg/ha sulphur would require 37kg/ha of Superphosphate.

As can be seen from the example, the quantity of superphosphate required to replenish the sulphur removed is less than that required to replenish phosphorus. In this

Table 9.5. Typical critical nutrient levels in the dry matter of plants. Source: Epstein, E. (1965). In: Plant Biochemistry (J. Bonner and J.E. Varner, eds.), pp. 438 – 466. Academic Press, London.

Major Elements	Symbol	mg/kg	%	Trace Elements	Symbol	mg/kg
Nitrogen	N	15,000	1.5	Chlorine	Cl	100
Phosphorus	P	2,000	0.2	Iron	Fe	100
Potassium	K	10,000	1.0	Boron	B	20
Sulphur	S	1,000	0.1	Manganese	Mn	50
Calcium	Ca	5,000	0.5	Zinc	Zn	20
Magnesium	Mg	2,000	0.2	Copper	Cu	6
				Molybdenum	Mo	0.1
				Nickel	Ni	0.1

case, the decision on rate of superphosphate application would be based on which nutrients are most limiting. Under most circumstances this would be phosphorus, and the decision would be to apply superphosphate at 89kg/ha, and accept that a surplus of sulphur would be applied. This would not be detrimental to plant growth or animal performance.

Whilst the replacement method is a useful guide to the annual fertiliser requirement, additional nutrient losses occur from the soil each year, such as:

- Leaching (washed through the soil by rain and irrigation)
- Erosion of topsoil
- Chemical activity in the soil
- Being bound up in plant roots and other organic material in the soil.

To accommodate these additional losses, it will therefore be necessary to use greater quantities of fertiliser if soil fertility is to be maintained and the system to be truly sustainable.

Levels of nutrient required in well-managed systems will depend on soil characteristics, species used, level of

production required, and production system (cut-and-carry systems require greater maintenance inputs than grazing systems).

9.4.5. Forage Conservation

In cold winter climates, being able to conserve forage of adequate quality for use during the winter period is a vital management skill that adds substantial value to the enterprise and significantly reduces the annual cost of production of beef. Traditional management of cattle in these climates relies upon full ration feeding using hay and silage and may extend for seven months. Consequently the enterprise must place an appropriate level of priority on preserving the highest quality feed to support the productivity and profitability of the herd. Poor quality conserved forages are a real cost to the enterprise (Fig. 9.5, 9.6).

Metabolisable energy, crude protein and neutral detergent fibre are the key nutritive factors that determine if the animals will meet their production targets, and forage should aim to be conserved to optimise levels of these nutrients, both at the time of harvest, and throughout the period of storage until use.

Nutrient	Amount removed (kg/ha/yr)
Nitrogen (N)	$4,000 \times 1.5/100 = 60$
Phosphorus (P)	$4,000 \times 0.2/100 = 8$
Potassium (K)	$4,000 \times 1.0/100 = 40$
Sulphur (S)	$4,000 \times 0.1/100 = 4$

Table 9.6. Approximate amount of nutrient in four tonnes of dry matter.

Fertiliser	Nutrient (%)			
	N	P	K	S
Superphosphate	0.0	9.0	0.0	11.0
Triple superphosphate	0.0	21.0	0.0	1.5
MAP	10.0	21.9	0.0	1.5
DAP	18.0	20.0	0.0	1.6
Urea ((NH ₂) ₂ CO)	46.0	0.0	0.0	0.0
Sulphate of potash (K ₂ SO ₄)	0.0	0.0	41.0	18.0
Muriate of potash (KCl)	0.0	0.0	50.0	0.0
Sulphate of ammonia ((NH ₄) ₂ SO ₄)	21.0	0.0	0.0	24.0
Gypsum (CaSO ₄)	0.0	0.0	0.0	18.5

Table 9.7. Nutrient concentration in some commonly used fertilisers.

Table 9.8. Fertiliser requirement (kg/ha) to replace nutrients removed in 4T dry matter per hectare.

Fertiliser	Quantity required to replace ... (kg/ha)			
	N	P	K	S
Superphosphate	-	89 kg/ha (=8/9%)		37 kg/ha (=4/11%)
Urea	130 kg/ha (=60/46%)	-	-	-
Muriate of potash (KCl)		-	80 kg/ha (=40/50%)	-



Figure 9.5. Preserving high quality forage for beef cattle is a key profit driver in cold winter climates. Hay stored without cover is subject to high rates of loss and degradation of quality. Source: International Agriculture for Development.



Figure 9.6. Poor quality plastic and insufficient overlapping at the edges will result in poor quality silage as air is able to enter the stack. Source: International Agriculture for Development.

10. Record Keeping

IT IS ESSENTIAL THAT BEEF PRODUCERS KEEP RECORDS of what is happening with their animals or what may have been done to the animals, and when.

Records of what has been done to the land on which they graze, or when and how often they graze any particular

area, should also be maintained.

Information contained in these records will give the beef producer an indication of how profitable and productive the enterprise is. See table below.

Table 9.8. Information for beef producers to include in recording of animals for maximum productivity.

Animal Recording Notes	
Animal Identification	Each animal should be given a number or name so that they are easily identifiable. Some form of permanent identification such as a brand, eartag, earmark or tattoo will help to prove ownership and will help to prevent or resolve disputes over ownership. Any other information that a producer has on animals should be recorded and be aligned to that individual animal.
Mating and Calving	The date which each cow was mated, the number of times she has been mated before becoming pregnant and the bull that served her should be recorded. If the mating was by artificial insemination (AI) then insemination date and the bull used should also be recorded. From these records a calving date can be estimated and the cow closely watched around the due calving time. The date of calving, sex of the calf and if there were any problems should also be recorded.
Animal Health	Record any veterinary assistance that may be given - who did it and when. It is important to record what was done, what drugs or chemicals may have been used and the reason for doing this. A list of any drugs or chemicals along with their recommended 'use by date' should also be maintained.
Grazing	Where cattle graze a number of paddocks or particular areas, knowing how many animals were in that area and for how long can help prevent overgrazing and this in turn helps to ensure that the animals are getting enough to eat. The amount of pasture that is available for the cattle to eat should also be recorded. They should be moved out of an area before all the pasture is eaten leaving enough pasture to cover the ground and to grow for the next grazing.
Feeding	When animals are stalled or shedded, record what they are being fed, the various amounts of each different feed, and when changes are made and why. Information on where the feed came from allows the producer to do something about it if the quality is poor, infested with insects or contaminated.
Weighing	An accurate set of scales are essential for weighing. Weighing will help the producer know how the animals are growing and when they will be ready for sale.
Marketing	Records of which animals were sent to which market and why should be maintained. Also the estimated weight if applicable and the total price received. Knowing how much it cost to transport the animal to market and if any selling costs were incurred is important as the producer may be able to find another market where the money paid for animals is equivalent but the costs are less.

11. Additional Reading

Wind Fencing

[http://www1.foragebeef.ca/\\$Foragebeef/frgebeef.nsf/all/frg4952/\\$FILE/Eletter.pdf](http://www1.foragebeef.ca/$Foragebeef/frgebeef.nsf/all/frg4952/$FILE/Eletter.pdf)

<http://www.cps.gov.on.ca/english/plans/E8000/8368/M-8368L.pdf> (wind fence construction)

[http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex4516?opendocument](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex4516?opendocument)

<http://www.agriculture.gov.sk.ca/Default.aspx?DN=adb8ecee-7d31-4f72-8d83-c71ac97baba4>

<http://www.agf.gov.bc.ca/resmgmt/publist/300Series/307230-1.pdf>

Swath Grazing

[http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex9239](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex9239)

Cattle Husbandry

<http://www.mla.com.au/News-and-resources/Publication-details?pubid=4007> (branding, castrating and dehorning)

http://www.nt.gov.au/d/Content/File/p/Anim_Man/211.pdf (freeze branding)

<http://www.publish.csiro.au/Books/download.cfm?ID=4831> (animal welfare code of practice)

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/111250/beef-cattle-vaccines.pdf (vaccination)

<http://www.mla.com.au/News-and-resources/Publication-details?pubid=6198> (low body condition score cattle)

<http://www.dpi.nsw.gov.au/agriculture/livestock/beef/feed/publications/creep-feeding-beef-calves> (creep feeding)

<http://www.depi.vic.gov.au/agriculture-and-food/livestock/beef/breeding/simple-performance-records-for-beef-cattle> (keeping records)

<http://futurebeef.com.au/topics/husbandry/weaning/> (weaning)

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/148355/Live-beef-cattle-assessment.pdf (

Herd Health & Welfare

<http://www.mla.com.au/files/5098112d-aaec-4c68-b757-9d640173cb91/mbfp-herd-health-and-welfare.pdf>

http://www.livecorp.com.au/sites/default/files/publication/file/is_it_fit_to_load.pdf

<http://www.animalwelfarestandards.net.au/files/2011/02/Land-transport-of-livestock-Standards-and-Guidelines-Version-1.-1-21-September-2012.pdf>

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0016/101338/grain-poisoning-of-cattle-and-sheep.pdf

Internal Parasite Control

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/146693/cattle-worm-control-the-basics.pdf

http://www.livecorp.com.au/sites/default/files/rd_report/project_file/live.0113_ringworm_in_live_export_dairy_cattle.pdf

http://www.wormboss.com.au/files/pages/worms/flukes/liver-fluke/Prime_Fact_813___Liver_fluke_the_basics.pdf

http://www.wormboss.com.au/files/pages/worms/flukes/liver-fluke/Prime_Fact_446___Liver_fluke_disease_in_sheep_and_cattle.pdf

http://chinchillavet.com.au/Portals/chinchillavet/PDFs/Cattle_Worm_Control_part1.pdf



A JOINT LIVESTOCK EXPORT
PROGRAM INITIATIVE WITH ILRIC