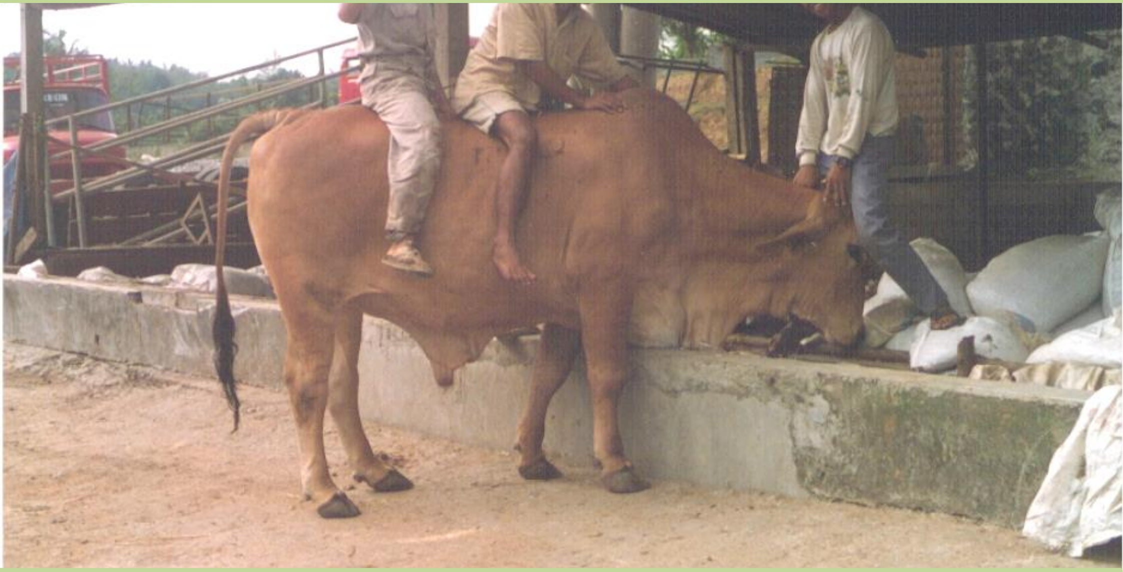
TROPICAL BEEF PRODUCTION AND HUSBANDRY OF AUSTRALIAN CATTLE AND BUFFALO IN SE ASIA

TECHNICAL SERVICES NOTEBOOK



David Ffoulkes

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TECHNICAL SERVICES NOTEBOOK

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This Technical Notebook was compiled by the Author whilst employed by the Northern Territory Government Department of Industry, Tourism and Trade, and former departmental names, and the support given by the Department is acknowledged.

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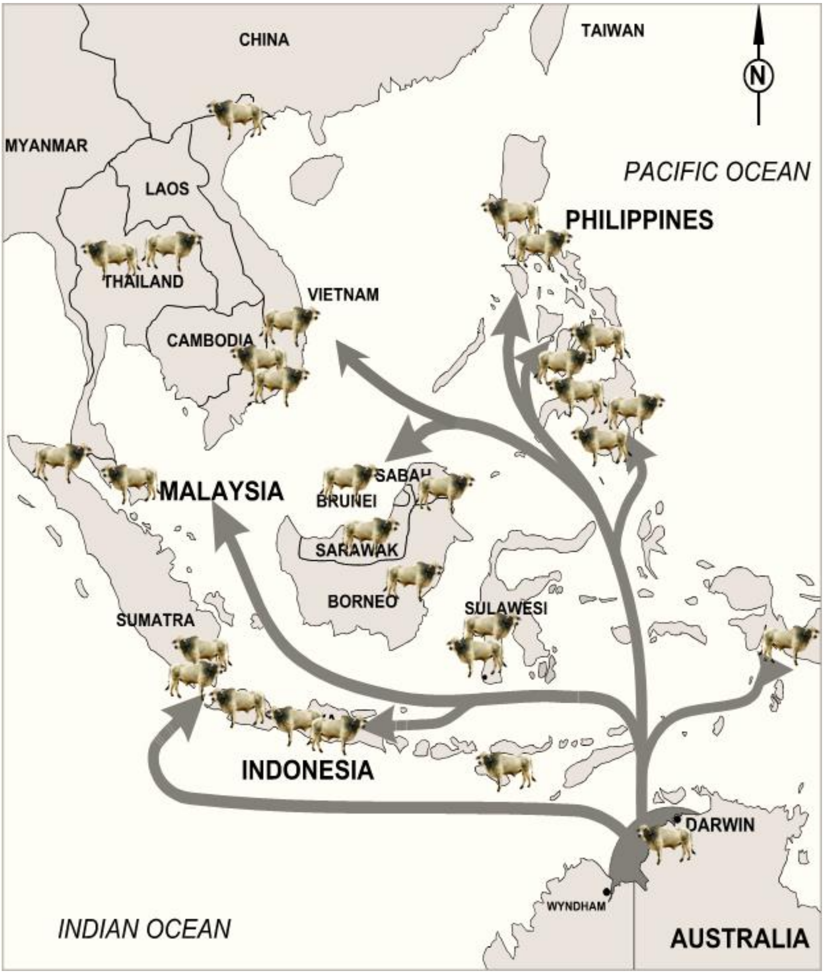

Map: Main areas of feedlot and breeding operations in SE Asia supported by NT DPI Technical Services program. Work experience and training courses for offshore government livestock officers were also conducted in the Northern Territory (see Introduction, page 5).

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GLOSSARY

ADG	Average daily gain (kg)
AEs	Animal equivalents
AI	Artificial insemination
AMLC	Australian Meat & Livestock Corp.
ASEL	Australian Standards for the Export of Livestock
ATP	Adenosine triphosphate
BCS	Body condition score
Bahasa	Indonesian language
BTV	Blue Tongue virus
(cc)	Creative Commons License (Wikipedia)
Ca	Calcium
CF	Crude fibre
ChAFTA, FTA	China-Australia Free Trade Agreement
CI	Consumption index (%)
CIF	Cost, Insurance, Freight
Conc.	Concentrate feed
CP	Crude protein
d	Day
DITT	Dept. of Industry, Tourism & Trade, NT
DM	Dry matter
DMD	Dry matter digestibility
DMI	Dry matter intake
DNA	Deoxyribonucleic acid
DW	Dressed weight
EBVs	Estimated breeding values
ESCAS	Exporters Supply Chain Assurance System
FCR	Feed conversion ratio
FEL	Front-end loader
FM	Fresh matter (as fed)
hd/ha	Head(s) per hectare
~	Approximately
HACCP	Hazard Analysis Critical Control Point
i.e.; e.g.	That is; for example
Lact.	Lactating/lactation
L w/d	Litres water/day
Lembu	Cattle (Malaysian)
LW (G)	Live weight (gain)
k	1000 units
M	1,000,000 units
max.	Maximum
ME	Metabolisable energy
Mga baka	Cattle (Filipino)
MJ	Megajoules
ML	Megalitre (1 million L)
MLA	Meat & Livestock Australia
N	Nitrogen
NPN	Non-protein nitrogen
NTDPI (formerly)	Northern Territory Dept. of Primary Industry
orig.	Original
P	Phosphorus
p., pp.	Page, pages
Preg.	Pregnant, pregnancy
Processing	ID, records, health check etc., for new arrivals.
PT	Pregnancy tested
RAM	Restricted animal feed material.
RDP	Rumen digestible protein
SEALS	SE Asian Livestock Services (Exporter)
TLC	Tender loving care
TMR	Total mixed ration
TSP	Technical Support Pgm.
UDP	Undegraded protein
VAT	Value-Added Tax
VFA	Volatile fatty acids
y	Year

1. INTRODUCTION

Australian cattle and buffalo from northern Australia are well suited to tropical beef production on an industrial scale, when supported by best practice management and husbandry, together with TLC from their human carers.

For more than a century live cattle from northern Australia have been shipped to SE Asian markets, and by the late 1970s, annual live cattle exports from Port Darwin reached nearly half a million head. Following the Asian Economic Crisis in 1997, total live exports ex-Darwin dropped significantly to 160,400 head (1998), but more recently numbers have ranged from 510,860 head (2015) to 373,836 head (2019).

From the mid-90s, the NT Government, through the former Department of Primary Industry (DPI), provided technical support to the offshore clients of NT livestock exporters to help develop and improve their feedlot and breeder operations. This also included training for government officials and farmers involved in livestock development programs using cattle imported from northern Australia. Much of the Technical Support Program (TSP) was externally funded by Meat & Livestock Australia, the Crawford Fund, and the Australian Government.

As manager of the TSP in SE Asia, ruminant nutrition knowledge and previous working experience in tropical livestock production in southern Africa, Central America and Indonesia, was crucial for providing incisive advice, together with team members Barry Lemcke and Chris Regan with their practical expertise and training skills. NT Government staff, including our Vietnamese interpreter Thai Tung, and private sector stakeholders who participated in the program, are also acknowledged for their input. A map showing cattle feedlot and breeding operations in SE Asia that have been supported by the TSP, can be found opposite page 1.

The purpose of this Notebook, which has mostly been sourced from 20 years of visits, advisories and training, is to provide all stakeholders with a handy knowledge base for planning and operating beef enterprises in SE Asia using cattle and buffalo from northern Australia.

David Ffoulkes
June 2021

2. ENTERPRISE PLANNING

Know the market and production pathways to produce quality goods and services that satisfy consumers and profit the business.

2.1. Markets

The first step in planning a beef enterprise is to secure a profitable market base for the products of beef production. This requires a good knowledge of the local beef industry and development of a network of contacts. The main marketable products are slaughter stock from feedlot enterprises, and feeders (feedlot replacements) and breeder stock (heifers and bulls) from beef cattle breeding enterprises. Consideration should also be given to niche markets such as Kobe beef and marketable byproducts such as composted manure. The ability to produce a consistent supply of product that meets market demand in terms of quantity, and consumer expectation for quality, is most likely to ensure the best returns to the enterprise.

Slaughter stock: The major markets for beef in SE Asia are the city (wet) markets, supermarkets and restaurants, with peak demand for beef at religious festivals and national holidays (see Table 1 and 2, page 9). The general market requirements for slaughter stock for these different markets, in terms of live weight (LW), carcass dressed weight and fatness, are illustrated in Figure 2.1.

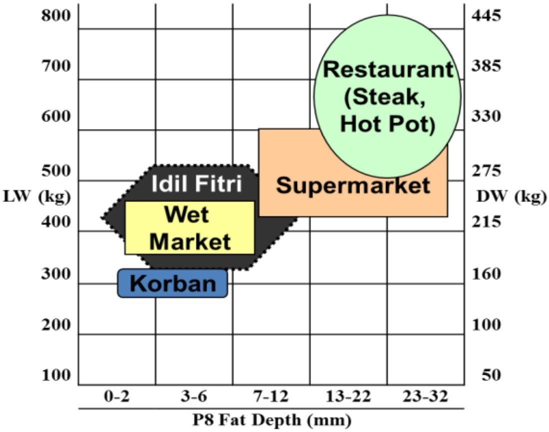


Figure 2.1: Graphic of live weight (LW), carcass dressed weight (DW) ranges and fatness for beef markets in SE Asia.

Wet markets: These are public markets in SE Asian cities, which are the main beef retail outlets for domestic consumers. Target slaughter weights of cattle sought by wet market butchers range between 390-450 kg LW, with a preference for lean carcasses (P8=3-6 mm) (see *Fatness* below, Figure 2.3), no drip and yellow coloured fat (Philippines).

Figure 2.2 Philippines wet market.

Tenderness is not such an important attribute for traditional dishes and cooking methods, therefore the cheaper cuts and offal dominate the beef products that are available in the wet market. Bulk orders are often purchased through wet market butchers by street food venders and small manufacturers of beef products (e.g. meat balls).

Fatness: The main reference points for measuring carcass fatness (fat depth under the skin) are at the 12/13th rib adjacent to the eye muscle and P8 site on the rump (see Figure 2.3). This is assessed in the live animal by Body Condition Scores (BCS) and P8 Rump Site estimates (see Appendix 1, page 226-7). Some large enterprises and abattoirs may use ultra sound devices to measure fatness.

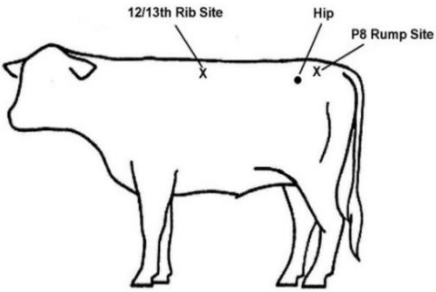


Figure 2.3: Assessment of fatness in live animal using P8 site.

Cold chain: The demand for chilled/frozen beef product is from up-market hotels and restaurants, meat shops and supermarkets seeking premium cuts. The key attributes for quality are colour, tenderness and juiciness. In the past this product was supplied by meat importers, now some local feedlots and abattoirs have the capacity to meet these requirements and often own their own butcher shops and restaurants, or are contracted directly by restaurants and supermarkets to supply cold-chain product. Target specifications are generally for a 225 kg carcass with 12 mm of fat cover over the rump (P8 site) or a Body Condition Score (BCS) of 4 (see Appendix 1).

Seasonal demand:
There is peak demand for beef during religious and national festivals that are celebrated in SE Asian countries (see Table 2.1, page 9). The biggest spikes in demand occur during the Islamic festival of Idul Fitri (Lebaran) that follows Ramadan, and Idul Adha (Korban). Demand also increases during the Christian festivals of Christmas and Easter, and for New Year celebrations (based on lunar and western calendars) and various national holidays. The dates of Islamic festivals are strictly based on the lunar calendar, therefore each year the dates of these festivals fall progressively earlier by 11 days in the Christian calendar (see Table 2.2, page 9). By 2033, the Islamic holiday of Idul Fitri will start two days before Christmas Day when there will likely be an un-precedented demand for beef.

Figure 2.4: Locally produced chilled beef from Australian cattle (Vietnam).

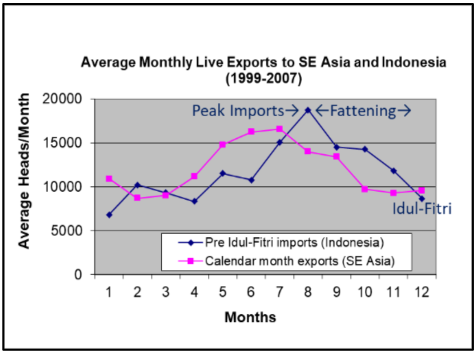


Figure 2.5: Australian cattle exports to Indonesian feedlots usually spike 3-4 months before Idul Fitri. .

Table 2.1: SE Asian national festivals causing spikes in beef consumption.

SE Asian Countries	Western Calendar	Lunar Calendar
Brunei, Indonesia, Malaysia	Christmas New Year	Idul Fitri (Lebaran) Korban.
Philippines:,	Christmas New Year,	Easter (Mar-Apr), Idul Fitri
Vietnam	Christmas New Year	Tet (Feb)
China	Christmas New Year	Chinese New Year/Spring Festival (Jan-Feb), Mid-Autumn Festival (Aug)

Table 2.2: Approximate dates of Islamic festivals up to year 2028 (2033)

Christian Year	Islamic Year	Lebaran (Idul Fitri)	Korban (Idul Adha)
2020	1441	24-May	31-Jul
2021	1442	13-May	20-Jul
2022	1443	03-May	10-Jul
2023	1444	22-Apr	29-Jun
2024	1445	9-Apr	17-Jun
2025	1446	29-Mar	7-Jun
2026	1447	19-Mar	27-May
2027	1448	8-Mar	17-May
2028	1448	26-Feb	5-May
2033	1455	22-Dec	1-May

The Australian live cattle export trade to Indonesia and Malaysia peaks around 3 months before Lebaran and Korban as SE Asian feedlots import feeders to fatten for these festivals. In Vietnam, the live trade for slaughter cattle peaks just prior to the New Year festival of Tet in February. Easter holidays in the Philippines fall within the March-April period depending on the lunar cycle, and this causes a spike in demand for slaughter cattle from local feedlots (see Figure 2.5 (pink line), page 8).

Trader's specifications: Wet market traders and butchers mostly buy cattle directly from livestock owners for slaughter, because cattle markets mostly trade in cattle for breeding and fattening. A price is usually negotiated on the basis of visual assessment of live weight and body conformation, with tight belly, body length, and fatness being important quality factors. Other important criteria are skin colour, hairiness, and intact horns (non-polled).

General wet market specifications or custom fed slaughter cattle are preferred for festivals and weddings depending on socio-economic level of the customer. For example, targeting the Korban market (see Infobox 2.1, Figures 2.6, and 2.7 (next page)) pays a higher premium for 2-year old bulls weighing 275-300 kg LW, horned or semi-polled, white to grey skin colour and no blemishes (i.e. no tipped horns or branding scars, etc.). Livestock owners and feedlot managers can develop their own specifications for finished animals based on observations of carcass and meat quality requirements of different markets. For example, live cattle destined for a cold chain market can be visually selected to meet precise carcass specifications (e.g. medium steer/heifer (2-4 teeth), 225 kg dressed weight, P8 fat = 13-22 mm) based on sex, live weight, age, fatness and body condition, i.e. steer/heifer, 425 kg LW, age 24-30 months, BCS=4) (see Appendix 1).

Infobox 2.1:
Targeting Korban Market

1. 2½ years before Korban, run cows with bulls for 2-3 months, then do pregnancy testing (see Fig.2.7, page 11).
2. After giving birth, provide nursing cows supplementary feed during early lactation and creep feed for the calves after 3-4 months of age.
3 Wean calves at 6 months of age, and identify suitable males to prepare for Korban.
4. Provide good quality green forage and 0.3 kg rice bran, 3 times a week.
5. At 3 months before Korban, replace rice bran (above) with a daily supplement of 0.5 kg cracked corn mixed with 0.5 kg rice bran (Grade 1), and feed until reaching the requirements for Korban.

Figure 2.6: Young Brahman bull suitable for the Korban market in Indonesia

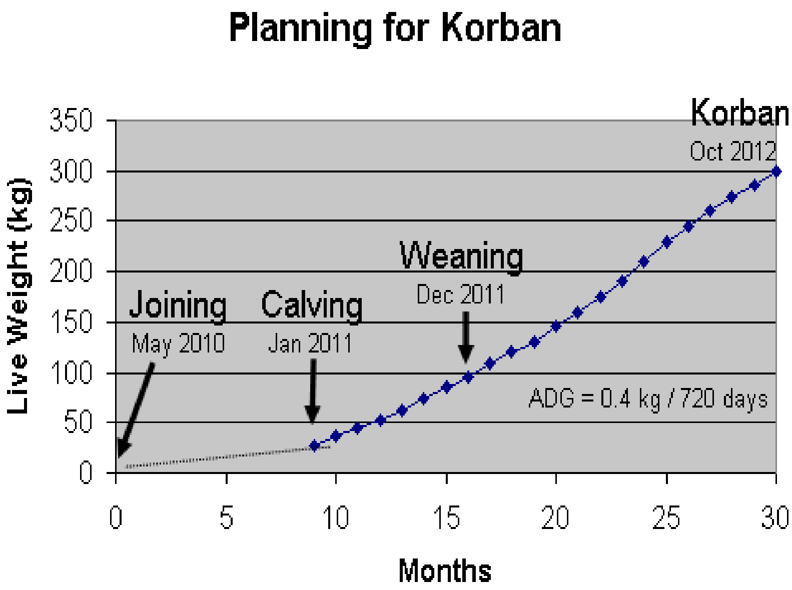


Figure 2.7: Timeline graphic for producing young bulls for the Korban market (see Infobox 2.1, page 10, for details).

China-Australia Free Trade Agreement (ChAFTA): Before the signing of the FTA in December 2015, Australian live cattle exports to China were limited to temperate beef cattle (mainly Angus) for breeding purposes. The FTA now allows opportunities for live export of feeder and slaughter cattle subject to strict quarantine measures against potential animal health issues in China, particularly the Blue Tongue Virus (BTV) (see *Blue tongue*, page 165). Cattle exports from BTV areas in Australia are limited to slaughter stock only for abattoirs in southern China, after being quarantined in the BTV-free zone for 60 days and then BTV-tested clear before shipment (see Figure 2.8, next page).

Figure 2.8: Blue Tongue Virus Free Zone in Australia (lighter yellow area) from where live cattle can be exported directly to China. *Source:* (Animal Health Australia, BTV zone map)

Ongoing imports of Australian breeder stock by Chinese livestock companies are for crossbreeding programs with local cattle to improve meat quality for the high-end hot pot restaurants and steak houses that are growing in popularity.

The prospect of large numbers of feedlot cattle being exported to China from northern Australia is not likely to happen in the near future because of the BTV quarantine restrictions. However, as the live cattle trade gradually increases from Australia's BTV-free zone to the cooler areas of China due to rising demand for beef, quarantine restrictions could be lifted for the export of northern Australian cattle to feedlots in China's sub-tropical southern coastal region, in areas where they would not be a health risk to other ruminants, such as sheep.

An information sheet (English and Chinese) has been prepared to promote NT cattle exports to China together with an explanation of Australian regulations and procedures for exporting livestock to China (see Appendix 2).

Carcass products: A well-dressed carcass represents about 54 % of the animal's live weight. The byproducts (offal, blood, hide, head etc.) are also saleable items, which can be worth as much as the carcass. Yield of saleable meat is approximately 70% of carcass weight. Premium and lower value cuts make up about 24% and 45% respectively of saleable meat, and the remainder is fat trim and bone. The location and yield of major retail cuts from Australian beef carcasses are shown in Figure 2.9 and Table 2.3 (next page), and examples from Meat & Livestock Australia (MLA) beef cut charts for Australia, Indonesia, Philippines, Vietnam and China are in Appendix 3.

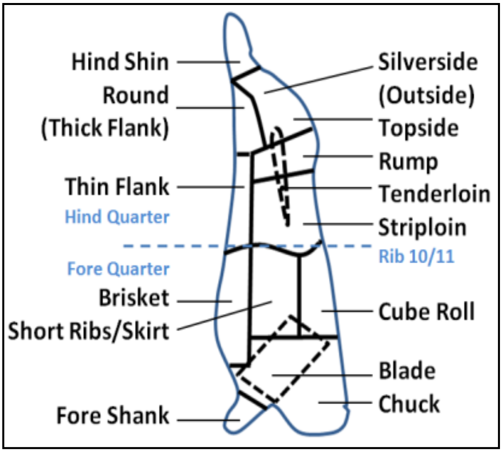


Figure 2.9: Carcass location of major Australian retail beef cuts.

Table 2.3 Average carcass yield of Australian retail beef cuts from northern cattle.

Beef Cuts (bone-out)	% Carcass	Weight (kg)
Primals:		
Topside	6.2	14.3
Round	3.7	8.5
Rump	3.8	8.8
Tenderloin	1.6	3.7
Striploin	4.4	10.1
Subprimals:		
Silverside	5.7	13.1
Brisket	7.1	16.3
Cube Roll	1.7	3.9
Blade	5.5	12.7
Chuck	5.4	12.4
Other Saleable Beef:		
Shin and Shank	4.6	10.6
Skirt	0.2	0.5
Flank Steak	0.4	0.9
Meat trim (Mince)	18.4	42.3
Total Saleable Beef	68.7	158.1
Fat trim	12.0	27.6
Bone	19.3	44.4
Carcass	100	230

Source: Various

Feeders: SE Asian feedlots in the past have mainly imported feeder cattle as steers or spayed heifers for feedlot replacements. More recently, orders for feeder bulls have been in increasing but difficult to acquire in volume from Australian stocks due to the practice of castrating young males as a management procedure. Ideal feedlot entry weights for steers and heifer feeders are 300-350 kg (350-375 kg for bulls) and BCS of 2-3 to ensure good value adding potential in the feedlot.

Replacement heifers: Northern Australian breeding heifers are exported as unmated or pregnancy tested in-calf (PTIC) heifers shipped before 3rd trimester (190 days). These are needed by in-country cattle breeders to replace culled cows or to start/expand a breeder herd enterprise. Australian heifers are also in demand for government cattle breeding programs and local farmer cooperatives, and are a good market opportunity for establishing in-country Australian breeder herds under oil palm. Unmated heifers should weigh at least 275 kg and have a BCS=3-4 before mating.

Breeder bulls: Young entire male progeny of Australian commercial breeder herds are ready for sale as breeding bulls from 18 months of age and weighing 350 kg or more. Fertility testing of bulls adds to the sale price, and additional premiums come with pedigree history and estimated breeding values (EBVs) such as growth rates and reproduction performance (see *EBVs*, page 125). Young bulls from established in-country Australian breeder herds are also sought after by local lot-feeders for finishing. High-grade bulls sourced from Australian stud farms may go through a period of infertility when moved to a different climate and/or environment.

Culled breeders (cows and bulls): The body condition of unproductive breeder cattle that are not too old (<10 years) can be improve in the feedlot over a 45 day period to add value as slaughter stock. This is also a good market opportunity for in-country Australian breeders culled from the herd

Manure and compost: Feedlots produce large amounts of manure per week and this is a valuable commodity as an organic fertiliser and a source of energy. Many feedlots recycle manure as fertiliser to reduce the cost of inorganic fertiliser inputs for growing stockfeed, or to provide energy (biogas) for electricity generation. Other feedlots outsource shed cleaning operations in return for the manure, or integrate compost production as another commercial output of the feedlot enterprise (see *Storage and processing waste* (page 107), *Biogas production* (page 108) and Appendix 11.

2.2. Production Systems Overview

The core business of beef cattle production revolves around the reproductive cycle of the breeder herd, comprising of bulls, cows, and calves. The cycle involves the sequential activities of mating, pregnancy, calving and weaning[1]. Breeder herd progeny (weaners and yearlings) are normally segregated and grown out on pasture before re-joining the breeder herd as young bulls and heifers, or enter the feedlot as feeder replacements for fattening. Culled cows and bulls from the breeder herd may also be finished in the feedlot (see Figure 2.10).

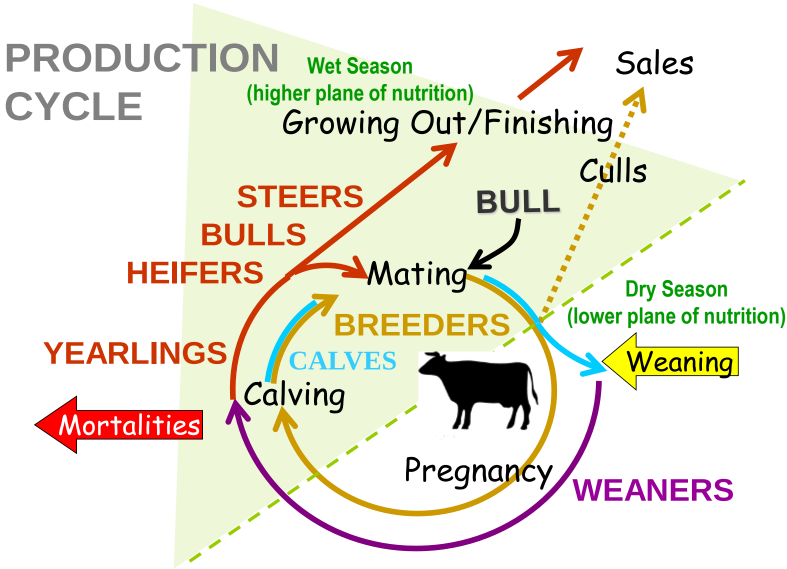


Figure 2.10: Production Cycle of Cattle Breeder Herd

[1] Separating calves from mother cows (dams) is called weaning.

Most cattle producers in SE Asia are smallholder farmers who may own just a few tethered cows or manage a dozen or more breeders as part of a farmer's cooperative or government program. Cattle are also used for draft power to cultivate the land and to pull carts ladened with produce. Progeny and older animals are usually sold at local markets or traders may buy direct from the farmers.

Many government agricultural programs have imported cattle from northern Australia to distribute amongst the villages of subsistent smallholders, in an effort to transform them into commercial farmers. These programs have mostly failed because of the unsuitability of imported cattle for traditional management systems. There are also more progressive farmer cooperatives that apply best practice management of imported cattle and have been more successful in making profitable gains.

There are also vertically integrated company ranches and oil palm estates that run large numbers of breeder cattle to produce feeder and breeder replacements for themselves and the market. They may supply other feedlots with feeders or use their own feedlots to finish their cattle according to market requirements. Other forms of beef cattle enterprises are agistment, share farming and custom feeding, all of which involve business arrangements between cattle owners and landholders for mutual benefit (see *Agistment*, page 20). The components of the beef production chain, and type and scale of enterprises found in SE Asia are presented in Figure 2.11 below.

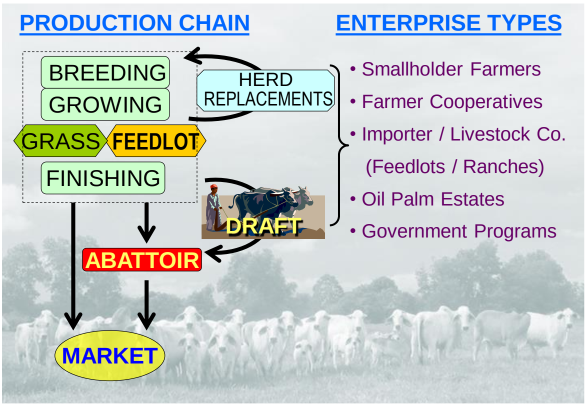


Figure 2.11: Beef production supply chain and type/scale of enterprises found in SE Asia.

Breeding operations: Setting up a breeder herd with imported Australian cattle requires a pasture grazing area with a carrying capacity of approximately 1-2 ha/head or a feedlot-type structure called a breedlot with access to cut-and-carry forage, or a hybrid of both. These types of operations need facilities such as ramps, yards, fencing, and water supply. The initial nucleus breeder herd is established from imported Brahman crossbred in-calf heifers and a Brahman bull for each 25 breeders. Within a few years, the herd will produce the different classes of progeny (i.e. weaners, yearlings, heifers and young bulls) to complete the composition of the breeder herd operation (see Figure 2.10, page 15). To expand the herd, a breeding program would be developed, with a number of options available to maintain the integrity of the original herd (see *Maintaining herd integrity*, page 126).

SE Asian government programs often facilitate the importation of Australian breeder cattle to establish nuclear herds and upgrade local breeder cattle. Smallholder farmers with a few cows rely on these government programs and cooperatives to provide bulls or artificial insemination services to get their cows pregnant.

General production targets for northern Australian cattle breeder herds are given in Table 2.4.

Table 2.4: Production targets for breeding and feedlot operations using imported Australian commercial cattle with high Brahman content.

BREEDING OPERATION	PRODUCTION TARGETS
Pregnancy Rates	>80%
Calving Rates	>75%
Calving Interval	16 months
Weaning Rates	>65%
Weaning LW	>120 kg (6 months)
Heifer Joining LW	>300 kg
Feeder Stock	325-350 kg
Slaughter Stock	425 kg
Bull LW	450 kg (600 days)
FEEDLOT OPERATIONS	**PRODUCTION TARGETS**
Backgrounding (LW gains)	250-325 kg (270 days)
Finishing (LW gains)	325-425 kg (90 days)

Integration of cattle and oil palm: Increasing numbers of oil palm companies and smallholder farmers are running beef cattle herds in their plantations to reduce herbicide and fertiliser costs[2], and to maximise the use of land resources to produce and sell cattle as a second income source. Australian breeder stock is often imported to improve productivity of the herds and quality of the beef.

The amount of understorey forages available for grazing in oil palms plantations differs significantly according to canopy densities related to tree age and uneven terrain. Efficient utilisation of the understorey forages for cattle production needs to be well managed with continuous monitoring to balance forage availability and carrying capacity. Land areas that contain steep slopes or areas susceptible to flooding, or known to have predators such as tigers, are not to be used for cattle grazing.

Figure 2.12: Australian cattle under Oil Palm

The production system involves the herding of cattle from one grazing area (or cell) to another, using electric fencing around the cell to confine the animals. When grazing is completed, the cattle are herded to a new cell of ungrazed forage (see ***Grazing strategy***, page 130 for more details). Depending on the size of the cell, period of grazing and density of cattle, there will inevitably be spoilage of edible grass of up to 50% due to trampling and defaecation.

Facilities are required for unloading, handling and holding cattle, together with portable electric fencing, water tanker and troughs that can be moved daily from cell to cell. See more details at **3.8 *Cattle under oil palm***, page 144.

[2] Grazing cattle prevents overgrowth of understorey forages and produces large amounts of manure thereby reducing the need for herbicide and fertiliser.

Feedlot operations: SE Asian feedlot operations using imported Australian cattle range in size from a few stalled feeders at the smallholder level (see Figure 2.13) to thousands of heads in large commercial feedlots. High capital inputs are needed to establish the larger feedlot operations, in terms of infrastructure, equipment, and purchases of imported cattle. Proximity to a port, feed resources and markets are key considerations for minimising ongoing operational costs. Importers, in collaboration with exporters, are required to follow Australian regulations (see **3.13 Live Cattle Export Regulations**, page 196) regarding the treatment of cattle along the in-country supply chain, including the discharge procedures at the port, trans-portation, feedlot management and the slaughter process.

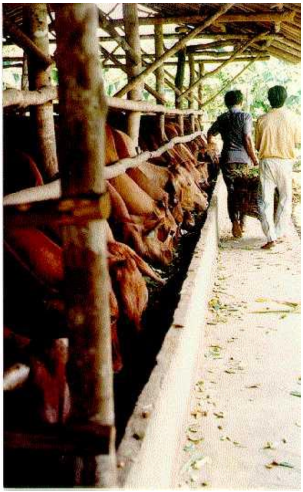


Figure 2.13: Smallholder feedlot

In northern Australia, young cattle (weaners, yearlings)[3] destined for export to SE Asian feedlots are generally grown out on native pastures[4] until they reach the target feedlot entry live weights (LW) prior to export[5]. On arrival at feedlots in SE Asia, feeders are introduced to fattening rations with high levels of concentrate feed, which are fed for 3-4 months until target slaughter weights are achieved. Younger feeders weighing less than 300 kg at feedlot entry should receive background rations until reaching the fattening stage at 325 kg LW, in order to avoid over-fatness at the target slaughter weight. Generic production targets for northern Australian commercial feeders are given in Table 2.4 (page 17). The stages of production in feedlot operations are illustrated in Figure 2.14 (next page).

[3] Includes steers (castrated at weaning) and young males and females.
[4] Limited improved pasture areas are available in the Northern Territory (e.g. Douglas Daily District in the Top End) and on some individual properties.
[5] Live weight restrictions for feeder cattle (e.g. < 350 kg) and feeder/breeder ratios per shipment may be required by country of importation (e.g. Indonesia).

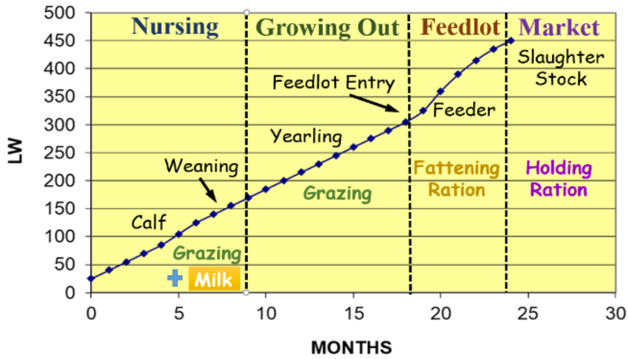


Figure 2.14: Stages of production for live cattle exports to SE Asian feedlots.

Agistment: This refers to an arrangement between a livestock owner and landholder to run cattle on the landholder's land for a fee or in exchange for a young animal (a common payment at smallholder level). The landholder usually manages the cattle on behalf for the cattle owner, which is different from a tenancy arrangement whereby the cattle owner looks after his own cattle. Livestock owners may want to agist their cattle for a number of reasons:

- No land available (landless cattle traders).
- No pasture available (e.g. due to overgrazing).
- Market opportunity that requires extra land (e.g. backgrounding feeders).

Landowners have their own reasons for making their land available for agistment:

- Casual business opportunity with steady income.
- Excess land on an existing cattle property.
- Smallholder farmers are able to get cattle ownership (through in-kind payment) by agisting cattle for their owners on common land.

Custom feeding of someone else's cattle in a feedlot is also a form of agistment. The feedlotter may charge a daily fee per head or a percentage of profit from sales, but there may also be penalties in the contract if production targets are not achieved.

Share farming is usually a partnership between the cattle owner and landowner where both are involved in the day-to-day running of a joint cattle production enterprise. Profits from cattle sales would be split between the business partners.

Feasibility: The knowledge gained from enterprise planning is key to deciding which cattle production system is the most viable, and feasible to establish. There should be enough information collected to make informative assumptions for preliminary budget projections of different production systems, and potential profit margins from specific operations.

For feedlot operations, feed costs can be a significant proportion (± 20%) of total operational costs (including purchase of feeders). Projected feed requirements for the fattening period are based on daily feed intake and expected live weight of animals at the mid-way point (X) of the operation (see Figure 2.15), multiplied by numbers of cattle. For breeder herds, feed costs are relatively lower and include supplementary feeding as well as managing pastures (e.g. cultivation, fertilisers, weedicides, etc.).

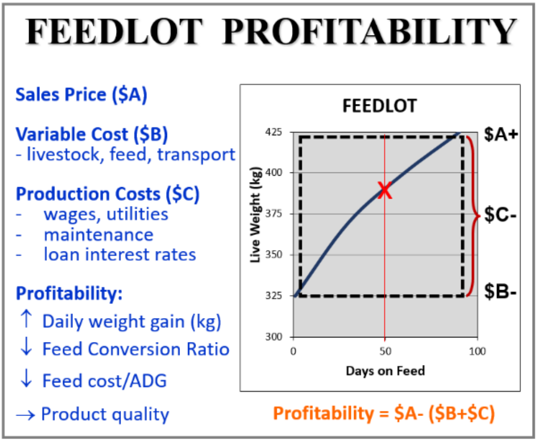


Figure 2.15: Main costs of feedlot operations and profit drivers.

Preliminary budgets are short-term due to the variable cost components involved (e.g. livestock prices, stock-feed and transport costs). Sale prices can also fluctuate, and significantly affect profitability. Fixed costs (e.g., wages, utility costs, maintenance, and fixed loan interest charges) are relatively stable over a longer period (Figure 2.15).

Feedlot profitability depends largely on minimising the cost of fattening by having good growth rates and low feed conversion rates (FCR), thereby lowering feed cost per kg weight gain and raising feed efficiency. Once the enterprise is up and running, the preliminary assumptions can be replaced with actual data to produce a more accurate business model. For more details, see **3.12 Budget Projections**, page 188.

2.3. Management Processes (Overview)

Enterprise planning is followed by enterprise management. At every scale of beef cattle production, the implementation of good management practices is crucial to the success of the business. This requires a systematic management approach (based on ISI 9001:2000 standards) and a good knowledge of operational requirements and procedures.

For example, the smallholder farmer who leaves his animals tethered in the same place each day or the commercial feedlotter who does not train his stockman to handle cattle properly, both these management decisions can adversely affect the potential productivity of their cattle and ultimately the profitability of the business. These decisions are often taken as the result of poor knowledge about the husbandry of cattle and their requirements.

The establishment of operational requirements and procedures based on best practice is essential in the development and management of the cattle enterprise, in order to maximise productivity and efficiency of the production system. This involves good planning and setting of realistic targets, implementation of standard operating procedures (SOPs), monitoring of enterprise performance against targets and making improvements as required. This will help to ensure that a high quality management system underpins a profitable cattle enterprise. The quality management system is illustrated in Figure 2.16 (see next page).

Product quality: The short definition of quality is ‘Performance to requirements’ which, in the context of quality management, means that the management system has performed to achieve the given target outputs. However, the quality of the outputs (i.e. products and services) in reality are determined by market requirements and the satisfied expectation of customers. The important components of management to achieve quality products are as follows:

- Focus on what customers and markets want in terms of product and quality.
- Ensure to have a well-trained labour force and good working environment.
- Use a process management approach (Plan, Means, Do (SOPs), Review, (Improve); see Figure 2.16 below).
- Measure performance of business activities, target outcomes and customer feedback.
- Implementation and evaluation of identified improvements.

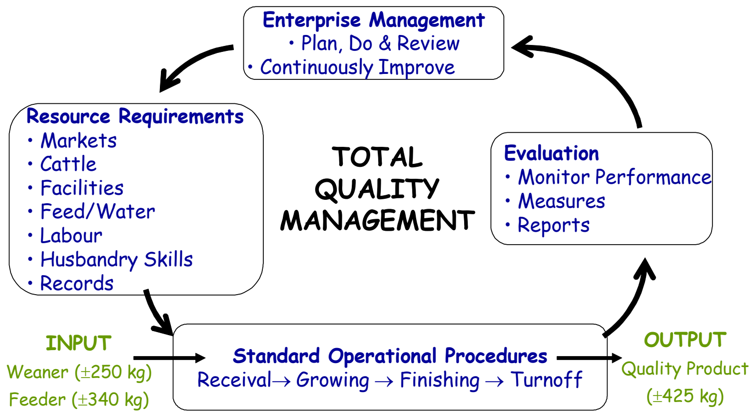


Figure 2.16: Illustration of the Quality Management System for cattle enterprise management (from ISO 9001:2000 Standards).

See **5. ENTERPRISE MANAGEMENT PROCESS,** page 219, for further details.

3. OPERATIONAL REQUIREMENTS AND RESOURCES

Ensuring that collective knowledge and adequate resources support the operational needs of the production system.

3.1. Location, water resources, and infrastructure

Location: The choice of location for cattle operations can significantly affect the viability of the business. Not all external effects such the local weather or environmental conditions will be ideal, but a location with too many adverse factors would be an unwise choice, therefore careful consideration should be given to the following criteria:

- Proximity to major ports, abattoirs, and markets reduces transport time and costs.
- Risk assessment of local seasonal weather system and historical events (e.g. droughts, floods) and mitigation needs (e.g. infrastructure to reduce heat stress in extreme hot weather) identified.
- Flat or undulating terrain and suitability of soil type for forage cultivation and/or pasture grazing assessed.
- Sufficient quantities of potable surface and/or bore water for operational requirements and the need for water storage during drier seasons.
- Presence of an elevated breezy area of flat terrain to accommodate the footprint of cattle handling yards, storage shed and feedlot site.
- Direction of the prevailing wind to ensure a feedlot is not sited directly upwind from villages and settlements; with a buffer of 1 km or more around the site to reduce smell pollution, (residences associated with the site should be located in the path of the prevailing wind and upwind of the site).
- Effluent drainage from holding yards and overflow from effluent ponds due to heavy rain events cannot go directly into streams and rivers. Possible location of effluent ponds and ways to trap effluent overflows into natural depressions and flat cultivation areas should be considered, in conjunction with local regulations.
- East-west alignment of cattle pens is important to maximise the roof-shadow footprint over the cattle yards. The angle of sunshine however is greater in summer (smaller in winter) for sites north of the equator (vice versa for locations in the southern hemisphere), and may require extra shade structures to be built[6].

[6] The angle of summer sunshine reaches further under the north side of a feedlot roof, as sites are located further north from the equator.

Water security: Cattle grazing operations require water troughs in each paddock; water is usually gravity fed to troughs from an elevated water storage tank. Where possible one trough can be shared between two paddocks through the fence line to save on piping. Piping should be buried underground to keep the water temperature cool. Cattle need about 15% of body weight of water daily, half of which can be obtained from grazing fresh green grass, but during the dry season when the grass has dried-off, the animals will rely on drinking water for their total requirements. It is therefore recommended that the storage capacity of the main supply tank can supply 2-3 days of total drinking requirements, and that each trough has the capacity to provide daily water needs according to maximum stocking rate of cattle in each paddock (see Infobox 3.1).

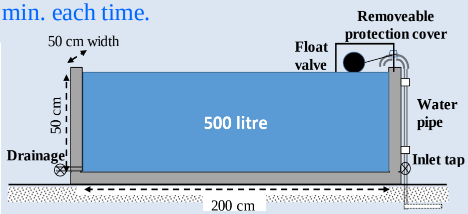
Infobox 3.1

Example of planning water for grazing cattle.

Paddock 1(of 3):	**Water Consumption (L/d)**
(Herd size: 26 head)	
> Bull (450 kg LW x1 head x15%)[1] =	68
> Dry Cows (425 kg LW x 25 head x 15%)[1] =	1,594
> 500 L water trough:	Total 1,662

> Cattle herd drinks 2-3 times daily (i.e. 3 x 554 L), or once in ±1 hour.
> Animal drinks for 1-2 min. each time.

Note: Trough drinking capacity is 8 hd/10 min (½ hour for herd + 30 min refill) twice daily (assuming 21 L/min flow rate)[2].



Trough dimensions

1. The 15% LW rule of thumb for water allowance can vary with fresh forage consumption (overestimated) to high temperature conditions (underestimated) (see Table 3.6, page 61).
2. See ***Water flow rates into drinking troughs***, page 298 for more details.

Feedlots and breedlots are also recommended to have at least 3 days of drinking water supply to meet total feedlot capacity requirements of water. The water should be stored in gravity-fed elevated water tanks in case of power failure or other supply issues. The amount of water stored needs to take into account a number of factors:

- Total numbers of cattle at feedlot capacity.
- Average live weight.
- Average midday, summer temperature.
- Average water content of rations.
- Water required for cleaning pens.

An example of water storage calculations is given in Infobox 3.2 below.

Infobox 3.2

Calculation of 3-day storage of water for a feedlot operation capacity of 1,000 head.

Factors

(a). Feedlot capacity: 1000 head
(b). Feed DMI: (375 kg LW, Conc., 30°C) = 52.5 L/hd/d*
(c). Plus cleaning water: 15 L/head/d

Daily requirement

(d). Cattle: (a x b) = 52,500 L/d
(e). Cleaning water: (a x c) = 15,000 L/d
(f) Total 67,500 L/d

Storage requirement

(f) 3 days: (3 x f) = 202,500 L

* See Table 3.11, page 62.

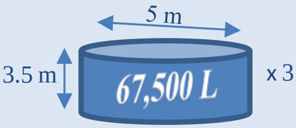


Figure 3.1:
Water storageTanks.

Land resources and infrastructure: A shortage of land for cattle production in SE Asia means that production systems generally range from semi-intensive to intensive. Smallholder farmer cooperatives often have access to limited common grazing areas for cattle during the day. In the evening, the animals are corralled together or individually and given supplementary forage. Often improved pastures are planted or bulk forages like Elephant grass (*Pennisetum purpureum*) are cultivated in common areas to increase the quantity and quality of available forage.

More extensive cattle grazing systems are found in oil palm plantations where cattle are herded daily from one grazing area to the next. In Malaysia, it is recommended that a viable cattle breeding enterprise of 40 breeders require a minimum of 400 ha of land under oil palms trees aged between 5-15 years. Yearling progeny are either sold or grown out in feedlots constructed near the plantations, using processed palm fronds and palm kernel cake (PKC) as the bulk of the feedlot ration (see **3.9 Cattle under oil-palm**, page 144, for more details).

Fully intensive production systems (e.g. feedlots) which rely on manual feeding of cattle in yards, have a much smaller requirement for land. A feedlot with a capacity for 2,000 head would require at least 7 ha of feedlot infrastructure, including handling and holding yards, ramps, feed storage sheds, water tanks, silos, waste disposal ponds, office and residence. Many feedlot operations in SE Asia contract farmers to grow the forage required by the feedlot while other enterprises have their own cropping areas. In the case of a 2,000 head capacity feedlot, a further 27 ha of cropping area would provide 15% of the feedlot ration as forage (see Figure 3.2).

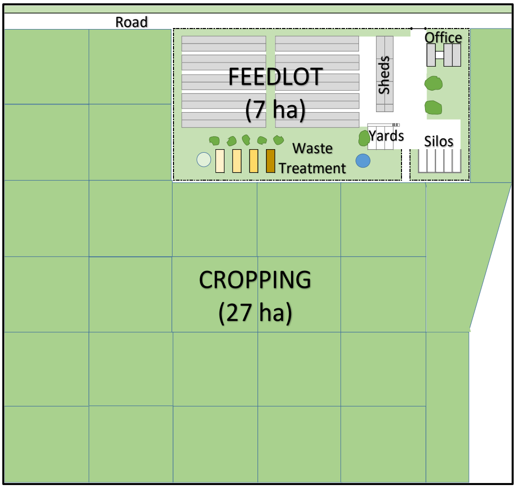


Figure 3.2: Minimum footprint of a 2,000 head capacity feedlot with cropping

Facilities and equipment: All cattle operations have a minimum requirement for the following cattle facilities and equipment listed below:

<u>Ramp</u>: For unloading and loading cattle trucks (see Figures 3.3 and Appendix 4 for more details).

Figure 3.3: (Left to right) Simple ramp, handling yards, race and crush.

<u>Race and handling yards</u>: The race is used for weighing, pregnancy testing, treating sick or injured animals and selection of cattle into two or more groups in adjacent yards (see Figure 3.3 and Appendix 4 for more details).

<u>Feed and water troughs</u>: As a rule of thumb, adult cattle require about 50 cm of lateral headroom at the feed trough, allowing enough space for body and shoulders when all the animals are feeding side by side at the same time. Assuming enough floor space, pen capacity for 25 m long feed trough is (25/0.5 =) 50 head of adult cattle. Exceptions are young, lighter cattle that require less head room (e.g. 35 cm), allowing for a higher pen capacity of (25/0.35 =) 70 head. Less trough space per head is needed for continuous feeding. Feed and water troughs should be sheltered from rain and hot sun to avoid spoiling feed, and to keep drinking water cool.

Figure 3.4: Examples of feed troughs using steel pipe or cable constraints

Figure 3.5: Water troughs for paddocks or feedlots.

Water troughs need to be located away from feed troughs to prevent contamination by feed dropping into the water. In holding yards, the water trough can be located at the side (and shared between two yards) or along the back fence. Water piping is best buried underground to keep to the water temperature cool, and automatic float valves are preferable to taps. (See Appendix 4 for more details).

Feedlot holding pens: Holding yards are designed to allow $\geq$ 3.5 m^2 hard floor space per head in SE Asian feedlots[7] (5-7 m^2/head for buffalo). For example, 65 head of adult cattle would need a total of 225 m^2 of floor space, with yard dimensions of 30 x 7.5 m and a 30 m feed trough on the front side of the pen. The feed trough and part of the yard is covered by a solid roof, allowing 2.5 m^2 floor space (per animal) to shelter from inclement weather especially monsoonal rains. Shade cloth can provide extra protection from the hot sun during the summer. Breedlot holding yards have lower densities (6-9 m^3/breeder) to accommodate cows with nursing calves. The yard floors need to slope away from the feed troughs at a rate of 1.5-2% to allow effluent and rainfall to flow into the drainage system (see Appendix 4, page 240).

Figure 3.6: Examples of structures to shelter cattle from rain and sun

[7] *Note:* Density of 9 m^2/head is standard for large open dirt floor cattle feedlots in Australia; and 5-10 m^2/head (indoors) recommended for buffalo in India [1], and at least 4.5 m^2 for housed buffalo in Italy [2].

<u>Crush, head bail and scales</u>: The purpose of the crush is to restrain animals humanely and provide a safe environment for personnel to carry out health checks, injury treatments and pregnancy testing or artificial insemination (AI), as well as for ear-tagging, dehorning and other procedures. The crush is located at the end of the race and is usually mounted on digital scales so that animal live weights can also be recorded[8].

The head bail of the crush should be able to restrain the head of all sizes of cattle without causing excessive stress. When the head bail is not required (e.g. weighing cattle), it must be capable of opening and closing like a gate. Cattle are more likely to enter the crush and put their heads through the bail if it is left half open with a clear view ahead for the animal. As soon as animal enters the crush, and puts its neck in the bail, it can be quickly closed around the neck but not excessively tight, and at the same time, close the crush entry gate (see Figure 3.7 and 3.8 below, and Appendix 4 for more details).

Figure 3.7: Crush used for pregnancy testing and head bail used for health treatments (right).

Figure 3.8: Weighing cattle with digital scales

[8] Portable platform digital scales can also be placed in the race just before the crush.

Gates and fences: Swing gates are used for cattle walkways and yards, and sliding gates are used in races. Cattle walkways, and yard gates are usually 3 m wide and handling yard gates are 2.5 m wide, with chain latches to secure the gates rapidly. Handling yards should have entry and exit gates located at opposite corners of the yard. The gates need to open from the corner (i.e. not

Figure 3.9: Bamboo and steel pipe fences for handling and holding yards.

hinged from the corner) and swing 360º to enable easier handling of cattle along the fence line. Steel pipe or bamboo fencing are generally used at feedlot facilities and barbed wire fencing is mostly used for grazing operations. For ramps and races, and other intense handling areas, the recommended height of the top rail is 1.8 m, whereas a lower rail height of 1.6 m may be used for handling and holding yards (see Figure 3.9 and Appendix 4, page 241, for more details).

Forage chopper: Fresh forage should be chopped (3-5 cm) to ensure stems can be consumed by cattle and for mixing with concentrate feed to form a complete ration. The size of the chopper depends on daily tonnage requirements, and machines can range from manually operated, electric or petrol driven choppers capable of processing 1-3 t/h, to tractor-operated

Figure 3.10: Manually operated forage chopper and tractor-operated harvestor/chopper.

harvester/chopper machines that produce 6-8 t/h chopped forage. The smaller choppers are suitable for smaller feedlots that cut and carry forage, or are supplied by surrounding farmers, whereas the mobile harvester is more appropriate for larger feedlots that grow their own forage (see Figure 3.10).

3.2. Cattle and buffalo handling

Everyone involved in the cattle business should have a duty of care for the welfare of the animals. In particular, livestock owners and their stockmen need to know how to handle cattle (or buffalo) properly to minimise stress and danger to both animals and workers. All personnel that are going to work closely with cattle should be trained in the basic skills of handling cattle appropriately before they are allowed to work with the animals.

Welfare and safety benefits: The animals themselves are the most valuable asset of cattle or buffalo operations. Apart from ethical reasons for the humane treatment of animals, there are both operational and commercial benefits of a low stress approach to handling cattle, as follows:

- It is easier to handle low stressed animals and therefore quicker to finish necessary stock movements; i.e. aggressive behaviour by stockmen is counterproductive, causes unpredictable behaviour by stressed animals and delays the task at hand.
- There are fewer injuries and mortalities of animals and a safer environment for workers.
- Low stressed cattle produce better quality beef by avoiding defects like dark-cutting meat[9] that affects meat quality and price.

Low stress cattle handling: Experience and knowledge of cattle behaviour have enabled cattlemen to communicate effectively with their animals, due to a greater understanding of the *flight zone*. This method of working with cattle creates a more natural and calmer environment and is much less stressful and safer for both animals and stockmen. Other factors such as poor infrastructure design, unnecessary distractions, and changes to routine, can also disrupt cattle behaviour and cause stress. Understanding cattle handling from the animal's perspective has helped change our approach to their management for mutual benefit.

[9] Final pH of good quality beef is around 5.5. Dark-cutting meat from stress or bruising has a higher pH value (>6.0), due to low lactic acid and glucose levels in the muscle, leading to reduced cold storage shelf life and darker-coloured meat.

Flight zone: Wild hooved animals like antelope, horses and wildebeest are well adapted to running away from predators, as did the ancestors of wild cattle (*aurochs*) before they were domesticated. Today's domesticated cattle still have this flight instinct to a greater or lesser extent when imminent danger is perceived (e.g. noise, approaching human or dog, etc.). This instinct is described as an imaginary 'bubble' around the animal which 'bursts' into flight at a critical point of proximity to approaching danger. For example, cattle grazing in a paddock will ignore a person approaching them until that person reaches a certain distance from the cattle, at which point the cattle raise their heads for a moment, and shortly after, they walk or run away as the person continues to comes closer. The critical point of this reaction is the awareness of perceived danger (i.e. raising their heads) and its proximity, marking the edge of the bubble or *flight zone*. This zone varies according to the degree of domestication of the cattle and individual temperance, and it can be used effectively to move cattle calmly from one place to another.

Positioning of stockmen: Figure 3.11 shows the flight zone around the animal (1) and segments of its *vision span* (2). Stockmen get the attention of cattle by waving their arms and jumping up and down (but not shouting) to establish the flight zone and this is used to direct the animal's movements. The animal will move forward when stockmen are in the *push zone* (3), with the speed of the animal controlled by pushing into the flight zone (faster) and retreating out of the flight zone (slower). When moving an animal or mob of cattle

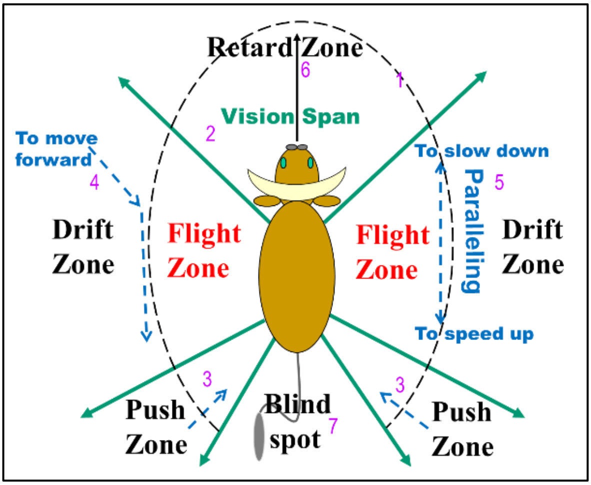


Figure 3.11: Using the flight zone's positioning of stockmen to control cattle.

forward in an open paddock or along a fence line towards a gate, additional stockmen are positioned in the *drift zones* (just outside the flight zone) to keep the mob moving straight ahead; or a single person at the rear of the mob can alternate between the left and right *push zones* to maintain a straight line.

When cattle are confined in a handling yard, laneway or race, a stockman can control cattle movements forward by approaching the fence diagonally from the side, and then parallel towards the rear along the edge of the flight zone (4). *Paralleling* (5) up and down next to a line of cattle in a race or laneway will get them to speed up (by walking towards the rear) or slow down (by walking towards the front). Note that stockmen may need to position themselves outside of handling yards and laneways to do these movements for flightier cattle with wider flight zones.

The *Retard Zone* (6) can be a dangerous position for inexperienced stockmen. Cattle moving forward towards a stockman in a laneway will generally stop at their flight zone and then move away to the side, e.g. through an open gate. However, danger arises when cattle are moving too quickly or cornered by someone inside the flight zone; in this case, an animal will eventually challenge the person by trying to escape past or over that person, followed by the rest of the mob. Before this happens, the person should retreat quickly out of the flight zone (and over the fence if necessary) and allow the animals to calm down. This scenario is especially important to avoid when separating individual animals from a group in handling yards without using a race.

Infobox 3.3: 7 STOCK HANDLING PRINCIPLES

(i) The flight zone around an animal causes it to react if you come too close (i.e. if you apply pressure).

(ii) Your position determines the animal's reaction.

(iii) Body language is the strongest form of communication with animals.

(iv) If you apply constant pressure to a cornered animal, it will want to challenge you!

(v) When pressure is applied, it should then be released. Use this repeatedly to keep a mob moving calmly forward (e.g. through gates, down lane ways or races etc.).

(vi) Every mob of cattle has a leader; so, focus on the leader and the mob will follow.

(vii) Closely observing animals tells you where you should be relative to the flight zone.

Other stress factors: A low stress environment for cattle also means having suitable facilities and aides (i.e. 'cattle talkers') that guide the animals' movements smoothly from one location to another. Attention to the design of yards, laneways, floor surfaces with good foot traction, and location of gates, is paramount for stress-free handling, as follows:

- Well-designed facilities for moving cattle encourages them to use their natural instinct to follow each other and find their own way without excessive pushing by stockmen, thereby reducing stress.
- Stockman should be aware of incidental environmental factors that could affect the movement of cattle, such as;
  > bright reflections (e.g. from metal or water,
  > loose chains or ropes,
  > banging (e.g. metal on metal) or high pitched noises (e.g. pneumatics),
  > clothes hanging on fences,
  > feed/fertiliser bags and rubbish lying on the ground,
  > people moving close by,
  > uneven floors and slippery surfaces,
  > drain coverings,
  > moving from light to dark areas, or shadows,
  > sharp corners and dead ends.

Eliminating these types of obstacles will make stock movements much easier.

- The use of sticks, whips, tail twisting, electric prodder etc. causes increased stress for animals, which makes them more difficult to handle. These practices are also contrary to animal welfare principles. The use of 'cattle talkers' will help to move a baulking animal, by tickling its hindquarters, or rattling the 'talkers' near the animal's ear (see Figure 3.12.). Other methods include offering fresh forage as a lure.

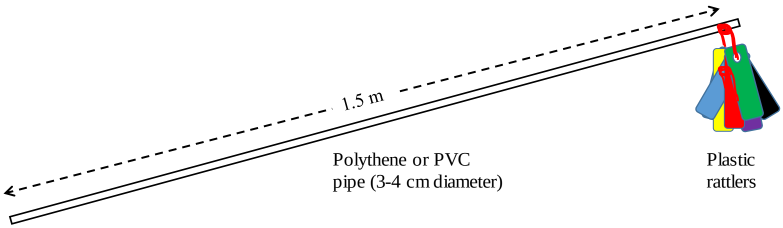


Figure 3.12: Cattle talker

- Separation of individual animals from a mob of cattle can be traumatising for the separated animal. If an animal is to be held in a yard because of an injury, or is waiting to be transported, it is better to have one or two other animals as company to avoid causing stress.

3.3. Cattle types

In SE Asia, the local cattle breeds include the Indonesian Bali cattle (sapi Bali), Madura cattle, white Ongole, other Zebu-types, the Malaysian Kedah Kelantan cattle (lembu), Philippines and Vietnamese natives, and the Chinese Yellow cattle (see Figure 3.13, next page). These breeds are well adapted to traditional farming systems, where the beef component is usually the end product after animals have fulfilled the many different purposes of their ownership (e.g. draft, manure, racing competitions, symbol of wealth, dowry and financial security).

Local breeds of cattle are slow growing and small in size (except Zebu) with carcasses of relatively high bone to meat ratio (i.e. low dressing percentage). In terms of production efficiency, these cattle are not suitable for industrial scale beef production to meet the growing demands of the beef trade in these countries.

In northern Australia, cattle breeds have been developed specifically for industrial scale beef production (see Figure 3.14, page 38). Large numbers of cattle are exported to SE Asia for fattening and breeding operations because of their adaptability and productivity under SE Asian climatic conditions. Australian buffalo (*Bubalus bubalis*) from the Northern Territory (NT) are also exported for meat production, mostly to Brunei and Vietnam.

Breeds and traits: The main breeds of cattle are *Bos indicus* and *Bos taurus*. *B. indicus* are tropically adapted breeds (e.g. Zebu, Madura, Ongole, Brahman, Sahiwal), and *B. taurus* are native to temperate regions and include British breeds (e.g. Hereford, Shorthorn, Angus) and European breeds (e.g. Charolais, Simmental, Limousin). The tropically adapted African Sanga breeds (e.g. Tuli, Boran, Senepol) are also classified as *B. taurus*.

Bos javanicus (banteng) (e.g. Bali cattle, which are specific to Indonesia), is the domesticated version of the wild banteng. Other SE Asian countries have their own subspecies of wild banteng (e.g. *B. lowi* (Sabah)). These deer-like cattle are widespread in rural communities of SE Asia and are used for draft, ceremonial feasts, dowries and symbols of wealth (see Figure 3.13).

Figure 3.13: Common breeds of local cattle found SE Asia.

Indonesian Bali cattle (sapi) (*B. javanicus*)

Indonesian Ongole beef cattle (sapi potong) (*B. indicus)*

Vietnamese Yellow Cattle (gia súc) (*B. indicus*)

Cambodian Ongole Cattle (*B. indicus*)

Malaysian lembu (cattle) Kedah Kelantan.

Filipino native (mga baka) (cattle).

Figure 3.14: Northern Australian cattle and NT buffalo

Brahman bull.

Droughtmaster.

Senepol.

Buffalo: Swamp (left), Riverine (right).

Riverine buffalo.

Lot-fed Brahman steers.

In Eastern Indonesia, Bali bulls are fattened by village farmers and sold to traders who live export them to markets in Java. This breed is early maturing (see *Cattle Maturity Types*, page 45), very hardy and highly fertile, but slow growth rates and poor mothering ability are the main setbacks to their overall productivity. Bali cattle have been crossbred with other breeds to improve productivity; however, Bali cows sired by Brahman bulls produce an infertile male (F1) offspring [3]. The Madura cattle of East Java are also the result of a banteng and Indian Zebu (*B. indicus*) hybrid from centuries ago, and in this case, the male progeny are fully fertile.

The British and European *B. taurus* breeds emerged after centuries of selection of physical traits relating to the productivity of native cattle from different regions of the continent. British breeds (i.e. Angus) are early maturing and produce a relatively smaller carcass with high meat to bone ratio compared with European breeds (i.e. Limousin), which are later maturing and bigger framed animals that produce a large carcass of lean meat (see Angus and Limousin cattle in Figure 3.15).

The original *B. indicus* Zebu cattle are from India where they have developed resilience to hot climatic conditions, poor nutrition and exposure to disease. They are generally slow growing, medium maturing with moderate frame size and carcass.

The strengths and weaknesses of the production traits for each breed group are summarised in Table 3.1 (next page).

Figure 3.15: Limousin bull (Indonesia) and Angus beef cattle (China).

Table 3.1: Production traits of major cattle breeds

TRAITS / BREEDS	STRENGTHS	WEAKNESSES
 Tropical breeds *Bos indicus* (medium maturing)	Survival, Yield (medium carcass)	**Growth Rate, Meat Quality**
 British breeds *Bos taurus* (early maturing)	Fertility, Growth Rate, Meat Quality (marbling)	**Survival, Yield (small carcass)**
 European breeds *Bos taurus* (late maturing)	Growth Rate, Yield (large carcass)	**Survival, Fertility, Meat Quality**
 African breeds *Bos Taurus africanus* (medium maturing)	Survival, Fertility, Yield, Meat Quality	**Growth Rate**
 Bali cattle *Bos javanicus* (early maturing)	Survival, Fertility, Yield, Meat Quality (very lean)	**Growth Rate, Mothering Ability**

Emergence of Brahman (Bos indicus): During British and European colonial eras, temperate cattle breeds were transported to regions all over the world by pioneer settlers; however, the cattle did not perform well in tropical areas. From the 1850s, ranchers in southern USA imported Zebu-type *B. indicus* bulls from India and joined them with the local *B. taurus* (mainly Shorthorn) breeder herds. After several generations of natural crossbreeding, many local herds had become almost pure *B. indicus* in genetic content. This new breed was called the American Brahman, which exhibited the improved traits for both survival rates and productivity that the ranchers were seeking, for beef production in the tropical regions of the USA [4] (see Figure 3.16).

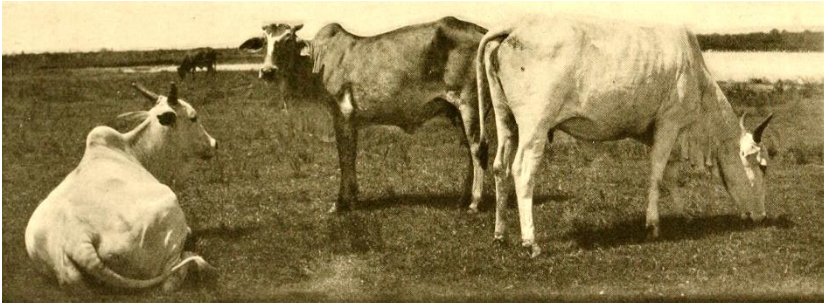


Figure 3.16: American Brahman, photo from American Breeders Magazine (1913).

Figure 3.17: A high grade Australian Brahman herd in Sabah, Malaysia.

Commercial cattle from northern Australia: American Brahman bulls were introduced into north Australia following their importation into Queensland in the 1930s. After decades of natural mating of Brahman bulls with Shorthorn and Hereford breeder herds that were originally brought to the north by the pioneer settlers, the descendants of those herds now have high (±7/8) Brahman content and are well adapted to extensive grazing of native pastures in northern Australia's harsh tropical environment. They are also the main source of Australian commercial cattle for live export to SE Asia (see Figures 3.17 (previous page) and 3.18 (below)).

Figure 3.18: Australian commercial feeder awaiting export to SE Asia

Crossbreds and Composites: Breeding programs were conducted in northern Australia in the 1950s to produce a tropical cattle breed of high fertility and disease resistance. This was done by careful selection of the beneficial traits of *B. taurus* and *B. indicus* to produce the Droughtmaster, Santa Gertrudis and Belmont Red breeds. More recently, composite breeds with traits from three or more breeds have been developed by cattle companies and the former Northern Territory Department of Primary Industry (NTDPI)[10]. While these crossbreeding programs were primarily aimed at increasing the resilience of cattle to northern Australia's harsh environmental, the infusion of *B. taurus* genetics is also key to improving productivity and meat quality for both domestic and export markets.

[10] Now called Department of Industry, Tourism & Trade (DITT) since year 2020.

Table 3.2: Northern Australian beef cattle crossbreeds.

Crossbreeds / Breed source	Drought -master	Santa Gertrudis	Belmont Red
Brahman (*B.indicus*)	½	⅜	-
Afrikander (*B.indicus*)	-	-	½
Shorthorn (*B.taurus*)	½	⅝	½ or ¼
Hereford (*B.taurus*)	or ½	-	or ½ ¼

The Droughtmaster, which combines both *B. indicus* traits of resilience to disease and tropical conditions with good fertility and meat quality of *B. taurus*, is a popular breed for the live export market. However because of its significantly lower *B. taurus* content (50%) than Australian Brahman cattle, the Droughtmaster performs best in the sub-tropics and cooler, elevated areas of SE Asia (see Table 3.2).

The Santa Gertrudis breed was established in USA, and imported into Australia in the early 1950s. Although the breed contains 63% *B. taurus* and 37% *B. indicus*, Santa Gertrudis has a *B. indicus* appearance, is heat tolerant and tick resistant, and renowned for its premium meat quality [5] (Table 3.2).

The Belmont Red was developed by CSIRO from the mid-1950s, to improve growth rate, tick resistance, and fertility, using *B. taurus* traits with 50% Afrikander (Table 3.6), which enhanced productivity and docility, although tick resistance was lower than Brahman [6] Table 3.2.

The above crossbreds are shown in Figure 3.19.

Figure 3.19: Northern Australian crossbreds: (left to right) Droughtmaster, Santa Gertrudis Bulls, and Belmont Red.

Table 3.3: Northern Australian beef cattle composites.

Composites / Breed source	AACo	Brunette	DITT*
Brahman	-	3/8	9/16
Afrikander	-	1/8	1/8
Santa Gertrudis.	1/2	-	-
Tuli	-	-	1/8
Senepol	1/4	-	-
Charolais	1/4	1/8	1/16
Shorthorn	-	5/16	1/16
Hereford	-	1/16	1/16

*Formerly NTDPI.

Table 3.3 gives the breakdown of different breeds that make up the multi-breed composites developed by cattle companies and DITT. Comparison trials between the DITT Composite and Brahman suggest better fertility in the composites and similar growth rates to Brahman [7]. Another study by DITT found that meat quality and performance of Brahman x Senepol[11] crossbred, when slaughtered as terminal F1, had higher weight gains, carcass yield and better meat quality compared with Brahman [8] (see Figure 3.20).

Figure 3.20: NTDPI Composite bull.

Senepol x Brahman (FI Senepol) steer in Indonesian feedlot.

[11] Senepol is a stable crossbreed between N'Dama (African *B. taurus*) and Red Poll (British *B. taurus*), developed in the West Indies: https://www.senepol.com.au

Cattle maturity types: This relates to age and weight of cattle around puberty, which roughly coincides with the onset of the fattening phase of growth (see Figure 3.21), and time of maturity is different between breed and sex. Once fattening starts, the rate of fat deposition is largely determined by nutrition. These factors are important to know when planning to meet market requirements, and to maximise production efficiency. In relation to breed effects, early maturity types (e.g. British breeds) generally begin storing fat sooner at a lighter weight (smaller skeletal frame) than later maturity types (e.g. European breeds). Bulls, steers and heifers on feedlot rations have different rates of fat deposition from the onset of fattening, with highest to lowest rates being heifers, steers and bulls respectively. Nutrition can trigger the early onset of fattening, such as when fattening diets are fed to cattle from an early age (e.g. weaners), causing accelerated growth rate of bone and muscle phases, followed by early fat deposition, resulting in a lighter finished animal at an earlier age, with a smaller frame and reduced carcass size.

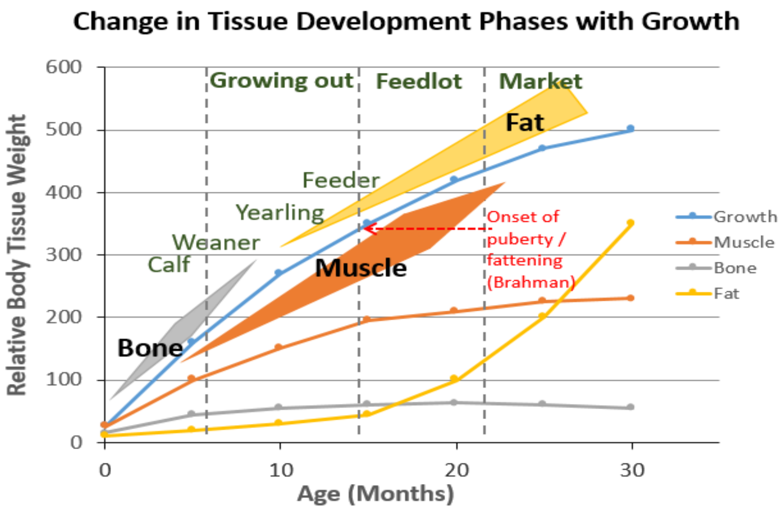


Figure 3.21: Relative growth phases of tissues (bone, muscle, fat) and onset of fattening in cattle.

Australian commercial feeder cattle (>75% Brahman) are medium maturity types. They are ready for export at 300-325 kg LW after backgrounding on pasture to optimise the growth phases of bone tissue and skeletal frame. In the feedlot, they should be given rations specially formulated to target the muscle growth phase, before the fattening phase. Slaughter stock are usually finished at around 425 kg LW (±24 months of age) which provides a relatively lean carcass for SE Asian market requirements. Fatter carcasses can be produced by continuing to feed cattle in the feedlot for a further month or more according to market requirements.

Cattle selection for export: General criteria for selection of different classes of cattle for importation into SE Asia are as follows:

- Any animal with poor temperament should not be considered for selection, as they are likely to be a hazard during transportation and cause ongoing handling problems.
- Imported cattle (feeders, breeders) should have 75% or more *B. indicus* content (e.g. Braham crossbred) for adaptation to tropical conditions[12]. Exceptions are imported cattle with high *B. taurus* content (<75% *B. indicus*) that are destined for cooler elevated areas or sub-tropical regions with cool winters. *Note:* Shipments of *B. taurus* breeds of cattle for slaughter during the cooler season of tropical regions, must also traverse the equator during the coolest season and the animals processed before the onset of the hot season (see *Some standard export criteria for cattle and buffalo*, page 197).
- Imported in-calf breeders should be pregnancy tested and imported during mid-term pregnancy (2nd trimester), and the breed content of progeny should be compatible with the destination climate.
- Breeding bulls should be performance tested (i.e. growth, fertility, libido) and be structurally sound. Bulls raised as part of a commercial herd are likely to perform better in different environments than stud bulls.
- Feeder cattle imported for lot feeding (backgrounding and finishing) should be in backward to store condition (see Appendix 1) to maximise added value potential. *Note:* Feeder cattle entering the feedlot in forward condition are likely to finish (fatten) ahead of similar aged feeder cattle in store condition.
- Slaughter cattle in backward condition can be reconditioned with appropriate forage based rations for up to 45 days before going on to fattening rations. Importation of old culled cows and heavy culled bulls for slaughter should be avoided due to their higher rates of stress and leg injury during transportation and shipping.

[12] Approximate temperature comfort zones for tropical and temperate cattle breeds: *B. indicus* (10-30°C), *B. taurus* (5-25°C), from various sources.

3.4. Cattle nutrition

The need for feed: Cattle stockfeed contains nutrients that are utilised for living processes:

- Maintenance and growth of body tissues (bone, muscle and fat).
- Movement (muscle contractions).
- Pregnancy and growth of foetus.
- Milk production.
- Health and immune system.

Infobox 3.4:

NEED FOR FEED

- Source of nutrients
  - *>Nutrient requirements*
- Nutrients in feed
  - *>Types of feed*
- Digestion in cattle
  - *>Ruminant digestion*
- Digestion of feed
  - *>Partitioning of energy*
  - *>Protein availability*
  - *>Microbial requirements*
  - *>Release of nutrients*
- Value of nutrients
  - *>Energy and protein metabolism*
  - *>Minerals and vitamins*
  - *>Drinking water*

Source of nutrients: Feed is the source of energy for the metabolic processes in the body that are needed for body function and growth. Feed is also a source of protein and minerals, which are used as structural materials for building and repairing tissues (i.e. bone, muscle, skin, teeth, etc.) and for producing enzymes and hormones. Vitamins (or their precursors) are essential for all the above body processes, and are mostly sourced from feed. Fresh feedstuffs provide an additional source of water, which can reduce the need for animals to drink water. The metabolic process of producing energy also produces water (H_2O), e.g.:

$$C_6H_{12}O_6 \text{ (Glucose)} + 6O_2$$

$$\downarrow$$

$$6CO_2 + 6H_2O + \text{Energy}$$

Water (2.82 MJ)*

*Megajoules (MJ)

Infobox 3.5

NUTRIENT REQUIREMENTS

The nutrient requirements of cattle are higher at critical points in the production cycle (see Figure 2.10: *Production Cycle of Cattle Breeding Herds*, page 15), depending on their physiological state, i.e. at certain stages of reproduction and during early growth. Figure 3.22 (below) illustrates the requirements for protein and energy by cattle during different physiological states. The lines measure the proportion (%) of protein and energy nutrients required above body maintenance requirements (0%). The critical points for nutrient demand are as follows:

- *Early to late growth*: The need for extra protein and energy above body maintenance declines with age.
- *Pregnancy:* There is a gradual increase in demand for extra nutrients, particularly for energy, as the foetus develops in the 3rd trimester.
- *Lactation:* The first 2-3 months has greatest demand for extra nutrients especially protein.
- *Nutrient deficit:* This can occur in cattle on very low planes of nutrition or when starving, leading to the break down muscle tissue (catabolism) to provide a source of energy when adipose (fat) tissues are depleted.

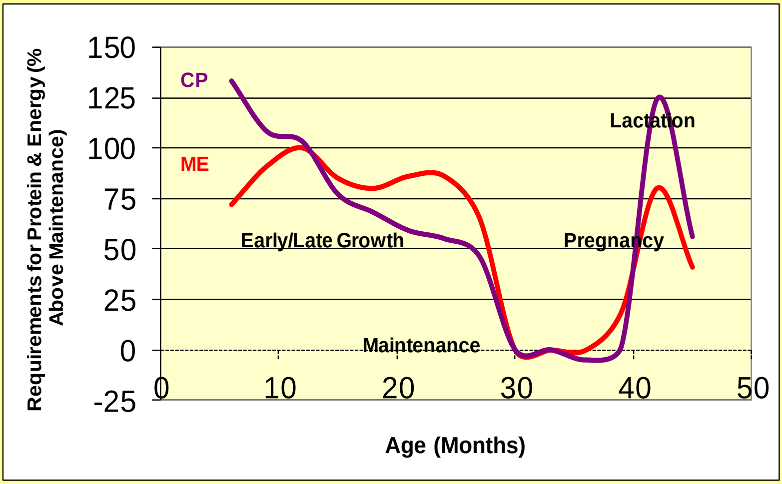


Figure 3.22: Energy and protein requirements for different physiological states

The requirements of major nutrients for different classes (or physiological states) of cattle can be found in the literature, however values can vary according to methodology used and breed-type. Table 3.4 presents indicative requirements of major nutrients for different classes of Brahman cattle in SE Asia. See also *Various book values for nutrient requirements of cattle*, Appendix 5.

Table 3.4: Nutrient Requirements of Cattle Classes	**DMI (% LW)**	**CP (% DM)**	**ME (MJ/kg DM)**	**Ca (%)**	**P (%)**
Dry Cow (425 kg)	1.8-2.0	6-8	8.0	0.2	0.2
Late Pregnancy (450)	2.3	8.5	8.5	0.2	0.2
Breeder + Calf (425)	2.5	10	8.0	0.3	0.2
Bull (500 kg)	2.5	8.5	9.0	0.2	0.2
Weaners (200 kg)	2.3	10	10.0	0.5	0.4
Yearlings (300 kg)	2.4	10-12	9.0	0.35	0.3
Feeder (350 kg)	2.3-2.4	10-12	10	0.35	0.3

Nutrients in feed: The source of major nutrients for cattle are plant materials, which comprise of dry matter (DM) and water. The DM consists of organic matter and ash. The organic matter is the major nutrient source of energy (carbohydrates, fats) and protein. The ash (i.e. remains of burning DM) contains minerals that are required by animals, such as calcium (Ca), phosphorus (P), and trace elements. The diagram below (Figure 3.23) illustrates the nutrient composition of feeds.

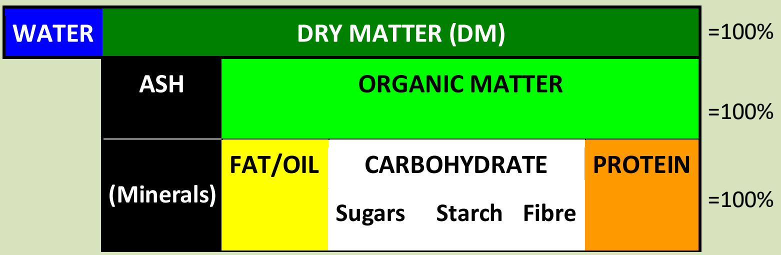


Figure 3.23: Nutrient composition of feed.

Types of feed: Stockfeed can be categorised according to the nutritive value. Roughages (>20% Crude Fibre) include fresh green or dry forages (e.g. Elephant grass, sugarcane tops, silages and roughages (hay, straw, and stover)). They mainly provide carbohydrates (sugar, starch and fibre) as a source of energy and fibre.

Infobox 3.6: TYPES OF STOCKFEED

- **Roughages**
  - grasses, corn chop
  - straw, hay
- **Concentrates**
  - corn, pollard
  - copra, rice bran
- **Minerals/Vitamins**
  - salt, limestone
  - dicalcium phosphate
- **Supplements**
  - molasses, urea
- **Additives**
  - Starbio (probiotic)

Concentrate feeds can be labelled as energy or protein concentrates according to which has the higher content of either nutrient. Energy concentrates are feeds such as grains and onggok (tapioca waste). Protein concentrates (meals) include copra, palm kernel cake (PKC), and soybean meal. Rice bran and wheat pollard are considered energy and protein concentrates due to an abundancy of both nutrients. Agro-industrial byproducts like pineapple pulp, banana rejects and brewers spent grains, are also considered as both roughage and concentrate feeds.

Minerals include macro-minerals (e.g. calcium, phosphorus, salt etc.), and trace-minerals (e.g. cobalt, zinc, selenium etc.). Vitamins are mostly absorbed from feed sources or synthesised in the bovine forestomach. Macro-minerals are normally included in ration formulations, whereas trace minerals and vitamins can be supplemented as a premix, especially if there are known deficiencies.

Fertiliser grade urea is commonly mixed with molasses (as a carrier) to supplement protein requirements, as an additive in the concentrate mix or as a separate supplement (i.e. lick block).

Additives also include ionophores, buffers, antibiotics, antitoxins, and probiotics, all of which can manipulate the rumen to function more efficiently.

Infobox 3.7

DIGESTION IN CATTLE

Microbial digestion of feed nutrients

The main difference between the way feed is digested by ruminants (i.e. cattle, buffalo, sheep and goats) compared with other livestock such as horses and pigs (i.e. monogastrics) is that ruminants have a forestomach (reticulorumen), in which consumed feedstuffs are broken down (digested) by colonies of microorganisms, thereby releasing essential nutrients required by the animal.

The forestomach contains multibillions of bacteria and millions of protozoa and fungi, all of which digest most of the feed into smaller particles, helped by the grinding action of the back teeth when the animal is ruminating (or chewing the cud). Ruminant animals chew their food twice; once just after eating, and then later when lumps of food (boluses) are regurgitated from the stomach into the mouth for further chewing.

The rumen bacteria digest the carbohydrate component of feeds by a process called anaerobic (oxygen-free) fermentation, for their energy requirements. The end products of this process are volatile fatty acids (VFAs), which are the main energy sources for cattle.

The protein components of feed are mostly hydrolysed by rumen microorganisms, releasing amino acids and ammonia nitrogen (N), which are converted into microbial protein.

Microbial digestion in the rumen supplies most of the nutrient requirements of a productive animal, from:

- Energy-yielding VFAs derived from fermentation of feed carbohydrate.
- Microbial protein, derived from amino acids and ammonia released by microbial digestion of feed proteins.

Passage of nutrients for animal's body function

The energy-yielding fatty acids pass through the rumen wall into the blood stream and are transported to the body tissues via the liver. Dietary lipid (oils and fats) are hydrolysed in the rumen and are mostly absorbed from the lower gut.

Microbial protein passes into the small intestine as part of the digesta, which is continuously evacuated from the rumen by contractions. The protein is digested by gastric juices in the small intestine and absorbed across the intestinal wall into the blood system, and carried to the body tissues via the liver.

Some feed protein (and small amounts of starch) may also reach the small intestine without being completely digested (or degraded) by the rumen microorganisms. This fraction (called bypass nutrients) provides the animal with extra protein, starch, and fat in a more direct form. Figure 3.24 shows a schematic diagram of the process of digestion in the ruminant.

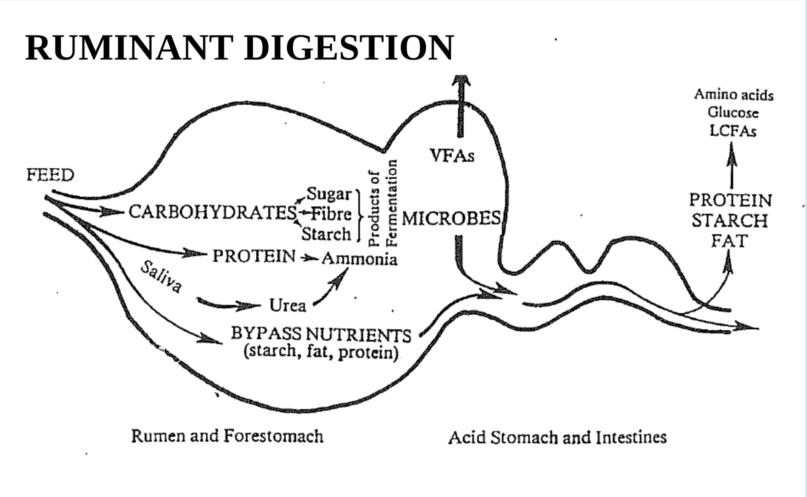


Figure 3.24: Process of ruminant digestion.

A key to formulating high performance rations with tropical feedstuffs comes with knowing the extent to which nutrients are digested in the rumen and small intestine. The supply and balance of feed nutrients can then be directed towards maximising the growth of microorganisms in the rumen as well as providing bypass nutrients to maximise the animal's production potential.

In practical terms, achieving high productivity in cattle requires continuous supply of a balanced diet containing adequate roughage, protein, energy, and minerals, to meets the physiological demands of the animal, together with access to clean water.

Digestion of feed: An animal consuming 8 kg DM of feed with 63% DM digestibility (DMD) will absorb 5 kg DM of nutrients and produce 3 kg DM of faeces. Rumen microorganisms break down most of the digestible portion of feed DM and make available about 70% of a productive animal's requirements for energy and protein and other nutrients. Further digestion of feed DM by gastric juices occurs in the small and large intestine. The supply of nutrients depends on feed dry matter digestibility and the extent to which nutrients are made available in the rumen and intestine (see Fig. 3.25, 3.26).

<u>*Partitioning of energy*</u>: Not all energy in feed dry matter is available to cattle as there are losses in faeces, urine and belching of methane gas from the rumen (see Fig. 3.27). Gross Energy (GE) of feed, minus the energy lost in faeces, becomes Digestible Energy (DE). The process of digestion produces urine and methane gas, both of which incur further losses of energy. When these energy losses are taken into account, the result is a more accurate measure of the energy that is available in feeds; i.e. Metabolisable Energy (ME).

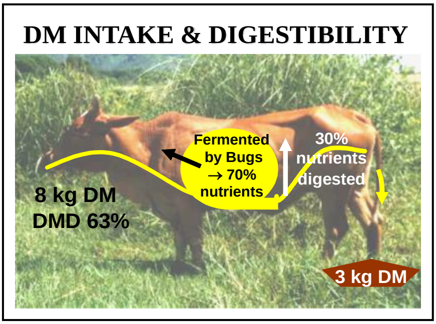


Figure 3.25: Illustration of ruminant digestion

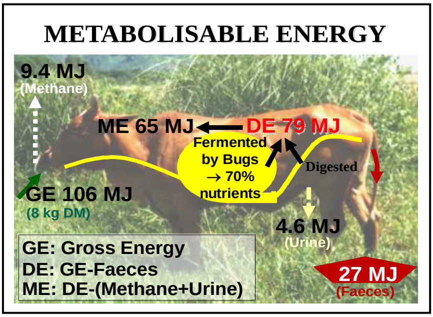


Figure 3.26: Illustration of partitioning of feed energy in ruminants.

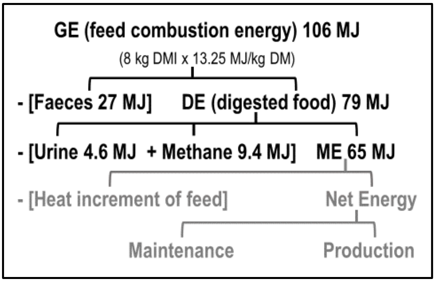


Figure 3.27: Summary of feed energy partitioning from Fig. 3.26. Further separation of energy (in grey) as Net Energy (NE) for maintenance and production, enables more fine-tuning of feed formulations according to the physiological phase of cattle.

Feed protein availability: Protein in the feed dry matter is mostly broken down into amino acids and nitrogen (N) and resynthesised by the microbes in the rumen for their protein requirements. Saliva also contributes up to 10% of available N from recycled urea. As digesta churns around the rumen with millions of bacteria attached to feed particles, digested feed particles are pushed towards the reticulo-omasal orifice by contractions. If the particles, together with attached microbes, are small enough, they are ejected through orifice into the omasum (O) and abomasum (A), and towards the small intestine (SI). Here, the feed protein and microbial protein is digested and absorbed into the animal's blood stream (see Figure 3.29, page 55)

Requirements of rumen microorganisms: The efficiency of microbial digestion depends on the availability of sufficient digestible feed DM and water, and optimal rumen conditions. Water from fresh feed, drinking, and saliva, all contribute to the fluid in the reticulorumen, together with plant fibre to stimulate rumen motility, and the mixing and churning of the rumen fluid. Conditions in the rumen are anaerobic (oxygen-free), temperature is maintained at about 38ºC, and rumen fluid acidity ranges from pH 5.5-6.5, which is buffered by phosphate and bicarbonate in saliva.

Surface enzymes on the microbial cell digest feed carbohydrates and protein, and the resulting sugars and amino acids are absorbed into the cell. Fermentation of these nutrients takes place in the cell to produce energy for protein synthesis and other cell processes. Other products produced in the fermentation process are VFAs, methane (CH_4), and ammonia (NH_4), which are all excreted into the rumen fluid, see Figure 3.28.

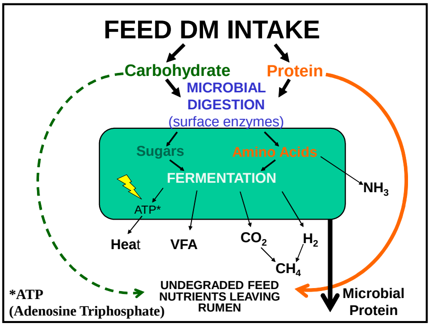


Figure 3.28: Microbial digestion of feed and excretion of nutrients use by the ruminant.

The degradability of Rumen Digested Protein (RDP) from ingested feed generally ranges from 60-80% for forages and 20-60% for concentrate feeds (see Table 3.10, page 76). The degraded feed protein releases N, which is taken up by microbes at a rate of about 30 g N per kg of Fermented Organic Matter (FOM) and converted to (30g N/16% CP =) 188g microbial protein

(MP). For example, cattle grazing 8 kg DM of grass per day, containing 85% FOM, would yield (6.8 kg OM x 188 g MP =) 1,278 g microbial protein. However, only about 2/3 of MP (i.e. 850 g) and UDP is digested in the small intestine and the remainder is lost in faeces. Figure 3.29 illustrates the availability of protein from ingested feed used for the synthesis of microbial protein.

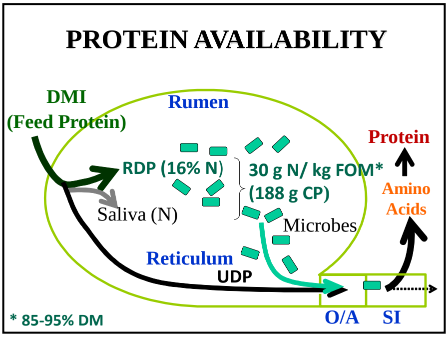


Figure 3.29: Feed protein digestion in the reticulorumen and N requirements by microbes. *Legend:* Omasum/Abomasum (O/A), Small Intestine (SI). Undegraded protein (UDP)

Value of nutrients: Feed values for cattle depends on the nutrient content of feed and the amount of DM consumed and digested by the animal (see Figure. 3.25, page 53). As feed DM digestibility (DMD) increases so does energy (e.g. hay (55% DMD and ME 8 MJ/kg DM) to grain (80% DMD and ME 12 MJ/kg DM) (see Figure 3.30). Feeds with low digestibility (e.g. rice straw) should only be used in an emergency or as a source of fibre in low fibre diets.

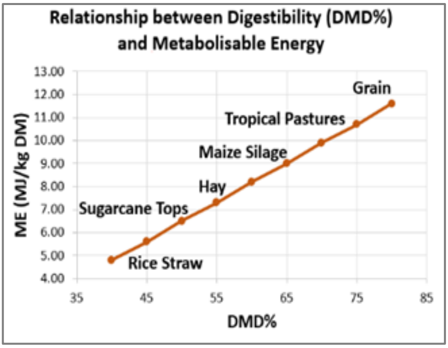


Figure 3.30: More energy available in better quality feeds.

The digested components of feed organic matter (carbohydrate, fat, protein) are sources of the energy, and have an average ME value of 18.5 MJ/ kg DM. Glucose is the primary energy nutrient to be released from carbohydrates (cellulose, starch, sugar). Fat is a concentrated source of energy, and protein can provide energy in an emergency, i.e. at the point of starvation.

Proteins are made up of amino acids absorbed from gastric digestion in the small intestine. They are used in every aspect of body metabolism, including growth and repair of body tissues (i.e. muscle, skin, hair. hooves etc.), milk production, movement, and function of enzymes and immune system.

Plant fibre (from course roughage) physically stimulates rumen contractions and is important for maintaining rumen function, particularly for stressed animals with inappetance (e.g. transportation stress).

Feed DM also provides a source of minerals (Ca, P, K), trace elements (Fe, Zn, Se), and vitamins or their precursors (e.g. carotene → Vitamin A). Most of the B vitamins are produced by the rumen microorganisms. Fresh forages contain up to 75% water, which contributes to the fluid in the rumen. Feedlot cattle may take in 7-8 L of water from the forage component of the ration, which is about 20% below their water requirements, therefore drinking water should always be available. The *Value of feeds* is summarised in Infobox 3.8, and the nutritional value of a range of feedstuffs is presented in Table 3.10, page 76.

Infobox 3.8: **VALUE OF FEED**

Dry Matter Digestibility: (>60%)

Fat+Carbohydrate+(Protein) → Energy[1]

Carbohydrate: - Starch → Sugar
- Fibre → Cellulose } **Energy**

Protein: - Amino Acids & N (muscle, milk etc.)

Fibre: (<25%), Rumen motility

Minerals/Vitamins: Ca/P, Carotene → Vitamin A

Water content → Rumen fluid, Body water (70%)

1. Gross Energy (GE) =18.5 MJ/kg DM)

Energy and protein metabolism: The energy-yielding volatile fatty acids (acetate, propionate, butyrate), which are the products of microbial fermentation of feed material in rumen, are absorbed through the gut wall into the portal blood vessel and transported to the liver. Butyrate however is mostly converted to a ketone (β-hydroxybutyrate) as it passes through the gut wall. The ketone and acetate temporarily gather in the liver until required as energy sources for tissue cell function. Propionate remains in the liver where it is converted into glucose and stored as glycogen for energy reserves. Glucose from the liver and circulating in the blood also accumulates as glycogen in muscle tissue as a source of active energy (see Figure 3.31, page 57).

Natural lipids are an important energy nutrient because their energy concentration is 2.25 times more than carbohydrates. They make up about 3% of cattle diets, mainly in the form of triglyceride and glycolipids. These are hydrolysed and converted to saturated free fatty acids in the rumen before passing, together with microbial phospholipids, into the small intestine. From here, they are absorbed into an adjacent lymph vessel, after reforming together as triglyceride-rich lipoprotein (TRL). They cross into the blood stream and circulated around the body tissues as a source of energy, fatty acid synthesis and fat storage (see Figure 3.31, page 57).

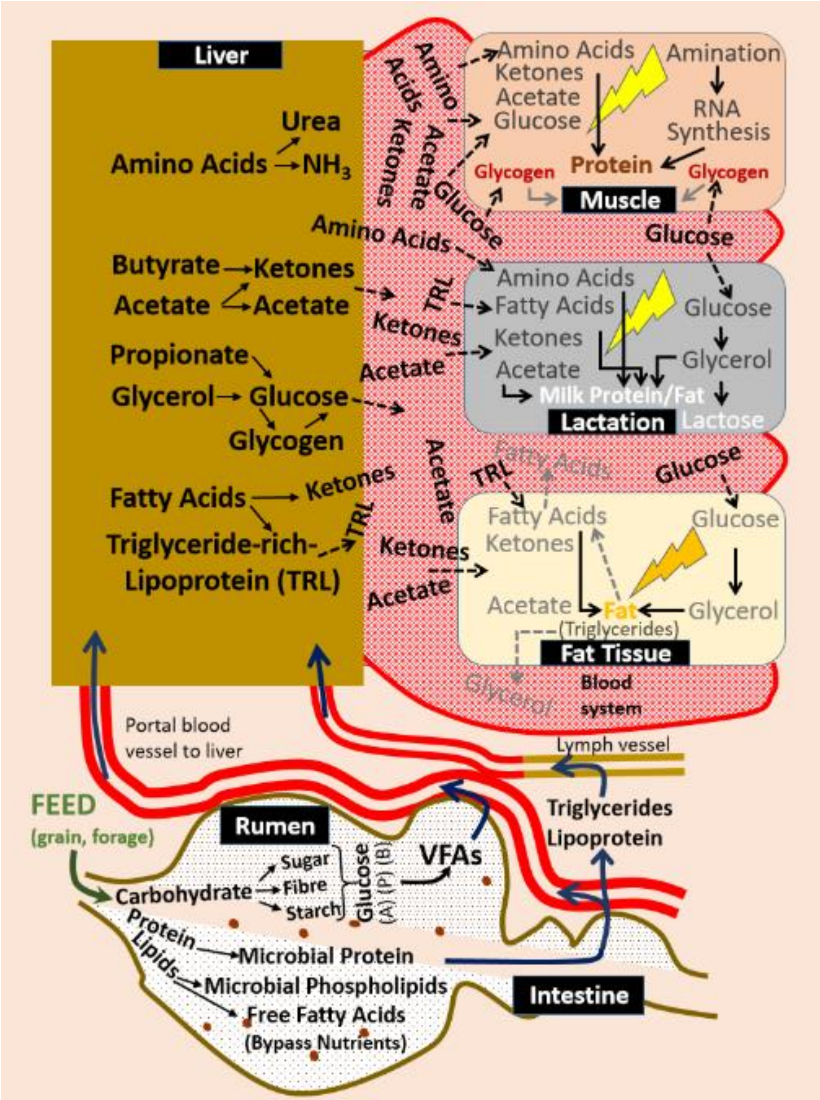


Figure 3.31: Illustration of flow and metabolism of absorbed nutrients via the liver to tissue cells as sources of energy and tissue growth.

Cattle obtain about 60% of their protein requirements from microbial protein digested in the small intestine, plus feed protein that has not been fully degraded in the rumen. Gastric enzymes break down the protein into amino acids, which are absorbed from the intestine and circulated in the blood stream to body tissues (e.g. muscle) and the liver. Cell proteins are constantly rebuilding and a lot of energy is needed to transfer amino acids into cells against an osmotic gradient[13], in order to synthesise specific cell proteins. During lactation, there is great demand for the amino acids circulating in the bloodstream, from which they are absorbed by the mammary gland to produce milk protein.

In circumstances where there is an oversupply of amino acids in the body or starvation, they are metabolised to provide energy for glucose production in the liver. A byproduct of this emergency source of energy is the release of ammonia in the blood, which can be toxic in large amounts. Under normal conditions, ammonia is absorbed from the rumen and transported to the liver where it is converted to urea and excreted in urine or is recycled back to the rumen in saliva.

Minerals and Vitamins: Calcium (Ca) and Phosphorus (P) are essential in young animals for skeletal growth, and comprise about 36% and 17% of bone ash respectively [9] at a 2:1 ratio. Ca is also essential for the nervous system and muscle contraction. P is important for energy transfer in adenosine di-/tri-phosphate (ADP, ATP) to drive biochemical, osmotic and mechanical work in the body, and crucial for the formation of nucleic acid of DNA. It is also involved in protein synthesis in body tissues, and microbial protein in the rumen (see Infobox 3.9).

Infobox: 3.9

Importance of Phosphorus

- **ATP**
  - **Biochemical Work**
  - **Osmotic Work**
  - **Mechanical Work**
- **DNA (deoxyribonucleic Acid)**
- **Phospholipids (membranes, nerves)**
- **Protein synthesis (rumen bact., muscle)**

All livestock need salt (NaCl) to replace sodium (Na) which is lost in sweating. Na is important for osmosis regulation[13], and for maintaining acid-alkaline balance of bodily fluids. Potassium (K) is active inside the cells with a similar role as Na. Nerve and muscle excitability is also stimulated by K.

[13] Osmosis is the natural movement of fluid through cell membranes to balance the concentration of solute on each side of membrane (e.g. water flows from a high to low concentration of salt until the concentration is the same on both sides).

Sulphur (S) is needed for synthesis of essential amino acids in the rumen for producing microbial protein. It is also required for production of biotin and thiamine (vitamins B_{1}) in the rumen, and is important for hormone, insulin and enzyme function in the animal. S is retained in microbial protein, which is absorbed into the body of the animal from the small intestine.

Magnesium (Mg) is mostly located in bone, and sourced for enzyme and other metabolic functions. Manganese (Mn) is also associated with enzyme function.

Iron (Fe) is mostly found in proteins, especially haemoglobin, and is a component of many enzymes. More than half of Fe is stored in body organs.

Table 3.5: Major/trace mineral and vitamin deficiency symptoms and treatments.

Ca/P:	Weakened bones, slow growth, emaciation, stiffness, chewing rocks, wood etc. Feedlot cattle need 30 g (Ca), and 15 g (P)/hd/day at 2:1 ratio.
Mg:	Tetany (low Mg i.e. <1.0 mg Mg/100 ml blood) esp. in lactation. Inject.
Mn:	Reproductive failure, slow growth etc. Feed rice bran, green forage.
K:	General ill-thrift, nervous disorders etc. on feedlot rations. Feed bananas.
NaCl:	Licking soil and animal sweat, esp. in hot weather. N need 25-35g salt/d.
S:	Reduced microbial protein synthesis from NPN. Add 8g S/hd/d to feed
Fe:	General anaemia in calves from continuous whole milk diets. Add forage
Zn:	Scaly, dry skin; hair loss, stiff joints in grazing cattle. Feed rice bran.
Cu/Mo:	Cu deficiency and Mo toxicity cause ill thrift, scours, paleness of skin, hair. Add copper sulphate in premix (5 mg/kg dry feed).
Se	Arched back, muscular dystrophy. Partly relieved by vitamin E inj./sup.
I:	General weakness due to goitreous feeds (e.g. soybean meal). Avoid.
Co:	Unthriftiness in grazing cattle. Give B_{12} injection or feed copra.
Vit. A:	Night blindness, scaly, rough skin; watery eyes, infertility. Inject. Vit.A
Vit. E:	Muscular dystrophy, elevated breathing in young cattle. Inject. Vit.E

Copper (Cu) is required for skin, hair and fur pigmentation, and is necessary as a component of blood proteins and for haemoglobin formation. It is also critical for many enzyme systems. Zinc (Zn) also has a high presence in animal skin, hair, and fur and is contained in or activates a number of important enzymes. Molybdenum (Mo) is an essential component of a few selective enzymes; however, high levels in pasture have caused ill thrift and scours, which can be controlled with copper sulphate supplement.

Iodine (I) is used in the thyroid gland for the synthesis of hormones, and Cobalt (Co) is required for the synthesis of vitamin B_{12} by rumen bacteria.

The function of Selenium (Se) and Vitamin E are linked in protecting cell membranes from chemical damage that can cause muscle disorders (myopathy) and reproduction failure. Both elements are sourced from green forage and cereal grains, which for Se depends on its presence in the soil.

Vitamin A is produced in the ruminant's intestinal wall or liver from plant carotenoids in rations containing green forage or yellow maize. It is also necessary for eyesight, especially in the dark, and for the formation and maintenance of epithelial tissues and mucous membranes.

See Table 3.5, page 59, for summary of mineral and vitamin deficiency symptoms and treatments.

Drinking water: This is the most important nutrient as it is essential for biological functions and the chemical process in the body (metabolism), such as:

- Digestion of feed and absorption of nutrients,
- Maintaining body fluids,
- Circulation of nutrients in the blood,
- Transferring nutrients across tissue cell membranes (see Footnote 13, p. 58)
- Milk production,
- Control of body temperature (thermoregulation), i.e. sweating and panting.
- Elimination of waste materials in urine and faeces.

The body of an adult cow contains about 70% water, and a 10% loss of total body water without replenishment can be life threatening. On a hot day, loss of water in urine, faeces, sweat, and respiration can amount to about 15% of live weight (see Table 3.6, next page).

Dying from thirst is quicker than starving to death!

Water requirements for cattle vary according to breed, feeding system, water quality and climatic conditions. Allowances[14] can be determined from dry matter intake (DMI) using the consumption index (CI), which ranges from 1.8-2.0%/LW for pasture and 2.3-2.5%/LW for feedlot rations, with younger cattle having a higher CI than adults (see Infobox 3.10, next page).

[14] Calculated water allowances should be treated as approximate.

Table 3.6: Sources of daily water loss from cattle in summer temperatures.

BODY WATER LOSS	
Liveweight / Temp.	350 kg / 30°C
Faeces	10.5 litres
Urine	6.0 litres
Sweating	22.0 litres
Respiration	11.0 litres
Daily Water Loss	49.5 litres (14% LW)

Cattle need about 15%[15] of body weight of water daily.

Infobox 3.10

CALCULATION OF WATER ALLOWANCE

Estimated Consumption Index (CI) of high Roughage or Concentrate rations (based on 350 kg LW).

		<350 kg>	
Roughage CI:	2 %	<1.9 %>	1.8 %
Concentrate CI:	2.5 %	<2.4 %>	2.3 %
Ambient Temp.:	25 °C	<30 °C>	35 °C
Litres/kg DMI:	4.5 L	6.0 L	8.0 L

400 kg LW lot-fed steer in mid-summer:
DMI (400 kg x 2.3%) = 9.2 kg DMI
Water/day at 35°C (9.2 kg x 8.0 L) = 74 L

Feed intake (DMI) can be used to estimate water requirements of *B. indicus* cattle, according to outside temperatures. This is calculated as follows: 4.5 L/kg DMI at 25°C, rising to 6 and 8 L/kg DMI at 30°C and 35°C respectively (see Infobox 3.10, and Tables 3.7, 3.8, next page). Temperate cattle (*B. taurus*) need about 25% more water than tropical breeds [10].

Note: Animals fed diets based on fresh forage will imbibe the water contained in plant material and therefore drink less water. Cattle on dry feed will need to drink all their water requirements.

Other factors affecting water intake by cattle are high temperatures with elevated humidity levels, and water salinity above 2,000 mg/L, which in both cases increases thirst.

[15] A water allowance of 15% of body weight can be used as an easy-to-remember, rule-of-thumb for summer temperatures of 30°C or less.

Table 3.7: Water allowances for tropical cattle breeds (*B. indicus*)

WATER ALLOWANCE Liveweight & Lactation	Temperature Range[1]		
	25ºC	30ºC	35ºC
250 kg LW x (2.0-2.5% CI[2])	23-28	30-38	35-50
300 kg LW x (2.0-2.5% CI)	27-34	36-45	43-60
350 kg LW x (1.9 -2.4% CI)	30-38	40-50	50-67
400 kg LW x (1.8-2.3% CI)	32-41	43-55	58-74
Pregnant (450 kg LW) (2.3%)	47-61	63-81	84-108
Lactating (12 L milk) (2.4%)	59-73	75-93	96-120

1. Varying from dry pasture (lowest value) to concentrate feed (highest value) and weight (age). 2. Consumption Index (CI) (see *Feed consumption A*, page 72*)*

Table 3.8: Guidelines for water consumption (L w/day) [11, 12*]

Body Weight (kg)	Average Consumption (L w/d)
50	6-7
70	7-9
90	10-11
120	14-16
150	18-20
190	20-25
350	25-35
450	35-45
540-730 (dry cow)	20-40
540-730 (Lactating)	45-110

*Increase water by 25-30% for buffalo (in direct sun).

As a guide for feedlots in Queensland, the drinking requirements of a 450 kg animal is about 35 L w/day in cold weather and 70 L w/day in hot weather, and annual consumption averages about 5 L w/50 kg LW for planning purposes (13). In summertime, water may be consumed at a rate of 4.8-5.6 L/head/hour during the middle of the day, out of a total of 50-65 L/day. About 90% of total water usage for the feedlot operation (i.e. cleaning, etc.) is water consumption by the cattle in the feedlot (14).

There are many tables and methods in the literature that provide water allowances for cattle, however in reality they are only guidelines for establishing a cattle enterprise. The cattle themselves will drink what they want if water is always available, and feedlot managers and stockmen should monitor the seasonal water consumption rates of their cattle, and ensure that there is always enough water available according to these rates.

3.5. Feedlot Operations

Lot feeding in SE Asia is largely based on the availability of a range of agricultural byproducts, whereas in North America, South Africa, Brazil and Australia, cereal grains such as corn (maize) and sorghum make up the bulk of the feedlot ration. Agricultural byproducts tend to be more variable in terms of their feed value compared with cultivated cereal grains. The challenge therefore for feedlot operations in SE Asia is how to feed and maximise productivity from a range of different feedstuffs that are locally available. This includes finding a consistent supply of stockfeed that are likely to be seasonal, thereby needing to change the ration ingredients during feeding periods. Feedlot operators therefore must have a good understanding of cattle nutrition in order to formulate different rations, at the same time maintaining cost effectiveness and nutritional balance to achieve performance targets and quality beef products. Other prerequisites of feedlot operations covered in this section are waste management plans, general animal husbandry and an animal health program.

Availability of stockfeed: Knowledge of peak availability and relative cost of stock feeds during the calendar year will help forward planning of ration formulations and advance purchase of concentrate feeds. Rations using fewer ingredients tend to be more problematic when seasonal shortages and price fluctuations occur than rations containing smaller amounts of a wider range of ingredients. The ability to produce a basic ration ingredient on-farm such as fresh and/or ensilaged forage is not only cost effective but also has a feed security advantage.

Roughages: These are fibrous bulky feeds (crude fibre >20% DM) mainly in the form of green forages and dry hays or straws. Crop residues (e.g. pineapple pulp) and silages are also included in this category. Elephant grass, corn chop and fresh stover[16] are extensively used as a source of roughage in SE Asian feedlot rations, and are mostly cultivated on-farm. They are generally available as fresh forage all year round, although supply may be limited without irrigation in areas where dry seasons are more prevalent. Supply may also be restricted during wet seasons due to inaccessibility. Feedlot operators that cultivate their own forage tend to use more in the ration and are more likely to conserve forage as silage, than operators that rely on

[16] Stover is a harvested crop plant (e.g. stems and leaves) left in the field. The nutrient quality of stover is best just after harvesting when still green.

contract-grown forage. (See Infobox 3.12, Forage Maize Silage, page 67).

Sugarcane tops are available for about 6 months during milling in dry season. Rice hay is also abundant after harvesting up to two crops a year. Other sources of roughage are corn cobs and bulk byproducts such as pineapple pulp and leaves, and sugarcane bagasse.

Feedlot operators who are thinking about purchasing fresh forage outside the local area should carefully consider the cost of water content of the forage prior to purchase (see Infobox 3.11).

Infobox 3.11

COST (DM BASIS) OF FORAGE

The nutritional value of fresh feed is in the DM content and the remainder is water. Check feed costs based on DM before considering purchasing feed sourced a long distance away. DM of freshly cut forage is usually around 25%, while forage that is wilted for a day or so is about 45% DM; thereby reducing cost of water by $10/t (see below) and increasing of DM by 20%.

(a) Cost of fresh forage (delivered) = $50/t
- DM content = 25% ($12.50)
- Moisture content (100-25 =) 75% ($37.50)

(b) Cost of wilted forage (delivered) = $50/t
- DM content = 45% ($22.50
- Moisture content (100-45 =) 55% ($27.50)

Figure 3.32: (Left to right) Forage maize/corn chop (Philippines); Elephant grass (Vietnam); sugarcane (Swaziland).

Concentrates: These feedstuffs contain high levels of protein and energy nutrients. They include energy feeds such as cassava (tapioca) chips, onggok[17] (tapioca waste), grain millings (e.g. corn bran, rice bran, wheat pollard), and protein meals derived from oilseed extraction processes (e.g. palm kernel cake, copra meal and groundnut meal). Seed meals (e.g. soybean, cotton, and kapok), and crushed cocoa shell are also used as protein meals. Grain milling byproducts (e.g. cracked grain, brans, grits, pollards) and farm-grown corn chop (i.e. corn/maize forage harvested with grain at dough stage) are generally cheaper options as high quality energy feeds than purchasing corn grain itself. Chopped dried corn cobs (without the grain) are also an excellent source of energy and digestible fibre in the ration. The availability of rice bran is seasonal, following the rice harvest after the wet season, whereas supply of wheat pollard is less predictable, depending on demand for imported wheat to supply the bakery industry. Cassava can be cultivated and harvested all year round as a cheap source of energy. The tubers must be chopped and sun (or air) dried, or soaked in water to neutralise prussic acid in the plant (see *Prussic acid poisoning*, page 163) The process of starch extraction from cassava tubers renders the tapioca byproduct harmless, after which it is dried before feeding to cattle.

Copra meal and palm kernel cake (PKC) are the most commonly used protein meals for cattle feed, however PKC is less palatable for cattle than copra. Soybean meal is usually in high demand for pig and poultry rations, making it costly as a cattle feed, but soybean hulls (13% CP) are a cheaper alternative. The availability of groundnut (peanut) meal and cottonseed (whole seeds and meals) will depend on their production in the region.

Opportunity feeds: Byproducts such as brewers spent grains, pineapple pulp and banana rejects, are examples of cheap opportunity feeds for cattle rations. However, intense competition for these byproducts from piggeries and dairies in the vicinity can inflate costs and become too expensive for larger feedlot operations.

Brewers spent grains are high in protein (DM basis). They are a major bulky byproduct used by lot-feeders located near the breweries, with most operations receiving deliveries two or three times a week. During national festivals when beer production is at its peak, excess amounts of brewers spent grains can be conserved as silage (See Figure:3.47, page 94).

[17] Onggok (tapioca waste) is a byproduct of starch production from cassava tubers.

Figure 3.33: Dried pineapple waste in Thailand

Pineapple pulp and leaves are a major byproduct of canning industries in Indonesia, Philippines and Thailand. The waste is a good energy and fibre source, and a major bulk feed for cattle feedlots that are integrated with the canning industry. The pulp and leaves are dried (see Figure 3.33) or piled up into a heap to ferment for a few days before feeding (See Figure 3.49, page 96).

Banana plantations create a byproduct of reject bananas that can be consumed by cattle as a source of energy. Other feedstuffs in this category include discarded cocoa pods, biscuit or breakfast cereal waste, and passion fruit skins, which are all suitable ingredients for cattle rations (see Figures 3.50 and 3.52, page 96-97).

Other feedstuffs: Molasses, which is a byproduct of sugar mills, is added to feedlot rations to improve palatability. Its price is strongly influenced by demand from the alcohol industry. Leucaena leaf meal (Ipil-ipil) is used in rations as a protein source; and to produce yellow fat (Philippines). Its use is limited to 10% of the ration (dry basis) due to the toxin mimosine that can adversely affect imported cattle (see *Leucaena leucocephala,* page 142).

Conservation of forage and bulky feedstuffs: Cultivated forages and bulky byproducts can be preserved as silage with minimum loss of nutrients. The natural process involves the fermentation of plant material in the absence of air, which releases preservatives in the form of acids. Preparation entails cutting fresh forage and wilting it to 60-70% moisture (30-40% DM) before chopping the plant material into a heap on the ground or into a silo. In between layers of plant material, rice bran, onggok or molasses may be added as an energy source to boost the anaerobic fermentation process. The chopped material is then compacted to eliminate air from each layer, using the weight of a tractor. When the pile of compacted silage reaches the top of the silo, it is sealed with plastic sheeting and weighed down with old tyres (see Infobox 3.12 and Figure 3.34, next page). High moisture bulky by-products (e.g. pineapple pulp) are best preserved with salt (5-10% w/w) without compaction, otherwise there will be excessive nutrient seepage if compacted.

Infobox 3.12: <u>Forage Maize Silage</u>

Aim

- Silage is ideal for conserving feed,
- Suitable crop – forage maize (Corn Chop),
- Minimal loss of nutrients.
- Lactic acid fermentation (best), tricky in tropics.

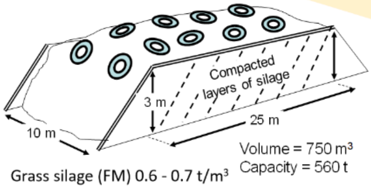
Critical points

- Maturity of maize cob – cut at early dough stage,
- Dry matter at cutting – 30-40% DM,
- Chop size – 5-7 cm,
- Rapid filling of silo in layers,
- Compact each layer – to expel oxygen,
- Allow for water drainage.

Good quality features

- Sweet acid smell,
- Low incidence of surface mould,
- Even khaki green colouration,
- Leaf and stem detail visible,
- Silage feels moist but not wet,

pH <4.5 (lactic acid)
pH 5.0 (acetic acid)
pH >5.0 (butyric acid)
pH↑ Lower Quality



Grass silage (FM) 0.6 - 0.7 t/m³
Maize silage (FM) 0.7 - 0.85 t/m³

A bunker silo with a volume of 750 m³ has the capacity to store 560 tonnes forage maize silage. This is sufficient for feeding 380 cows with calves for 3 months.

Figure 3.34: (From top right) Silage compaction as cut grass arrives (NT); silage sealed during fermentation process (Vietnam); water seeping from silage into drain (Vietnam); silage ready for feeding (Indonesia).

Storage of concentrates: A well ventilated shed and concrete floor is needed to store enough concentrate feed for 1-3 months (up to 0.5 t storage capacity per head), plus enough floor space to process forages and grains, and to mix feed ingredients. Mouldy and rancid feed can become an issue if kept in hot and humid conditions for any length of time (>1-2 months), particularly high fat and processed grains (e.g. wheat pollard, rice bran). Other susceptible feeds are copra and tapioca meals. Whole grains tend to store longer than processed grains, and the shelf life of bagged feed is likely to be more enduring than bulk feed stored in open bays. *Note:* Vermin and insect infestations need to be controlled to minimise feed spoilage.

Figure 3.35: Feed bunkers (left) and feed bag storage (right).

Equipment: In contrast to Western feedlot operations, much of the work in SE Asian feedlots is done manually. Small to medium sized operations (>1000 head) usually have one or two stationary forage choppers and a tractor and trailer to deliver bagged feed to the cattle pens. Larger feedlots will have grain processing machinery, a total mix ration (TMR) feed wagon to deliver feed to cattle pens, and a front-end loader (FEL) for loading feed into the mixer (and another FEL to clean the pens).

Figure 3.36: (Left to right) Manual loading forage chopper; TMR feed wagon, front end loader (FEL) to remove manure, at Vietnamese feedlots.

Feed requirements and consumption: For feedlot production systems, the emphasis is on skeletal frame development in young cattle prior to lot feeding. This is optimised by moderate growth on pastures or a roughage based ration. At feedlot entry, muscle development becomes the most important value-adding component of the operation and requires protein-rich rations. As muscle growth peaks, the growing ration is gradually replaced by an energy-rich fattening ration to enhance fat deposition and marbling, depending on market requirements for fatness (see Figure 3.37 below, and Figure 3.21, page 45). These strategies target the specific nutrient requirements for each stage of production (see Figure 3.38), while maximising the growth potential of the cattle.

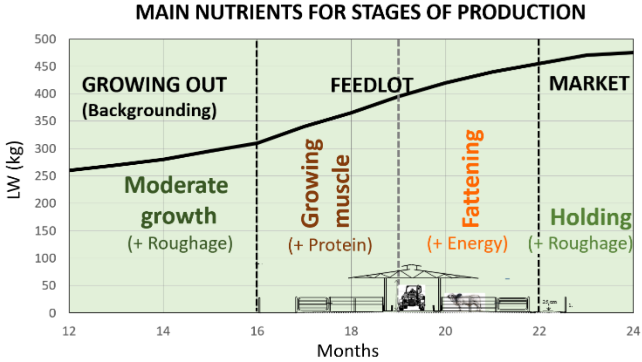


Figure 3.37: Stages of production and feed requirements of Australian cattle exported to SE Asian feedlots.

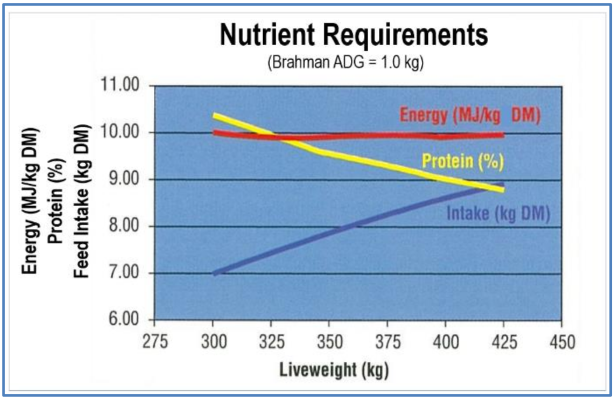


Figure 3.38: Different energy, protein and DMI requirements of lot-fed cattle.

<u>Backgrounding (growing out) stage</u>: This refers to the preparation of yearlings in Australia prior to shipment as feeders (±325 kg LW) for the SE Asian feedlot industry. They are raised on pasture (plus mineral supplementation) with moderate gains on native pasture (ADG ±0.5 kg), or more on improved pasture. This level of productivity ensures good development of skeletal frame size to 'hang the meat' and maximise carcass yield. In reality, this depends on the climatic conditions through the wet and dry seasons of northern Australia, which can be quite variable.

Weight for age of feeders is an important factor determining slaughter weight and carcass quality because of its relation to frame size and body condition. For example, young Brahman crossbred cattle fed high performance rations after weaning (150-200 kg LW) will end up with smaller skeletal frames. They will tend to finish with the same fatness as the bigger framed animals (i.e. 9-12 mm fat at P8 site), but at a lighter weight and smaller carcass (172 kg dress weight (DW)) compared with properly backgrounded feeders (221 kg DW) (see Figure 3.39). It is therefore recommended to keep young underweight feeder cattle on background (forage-based) rations until reaching the standard feedlot entry weight of around 300-325 kg.

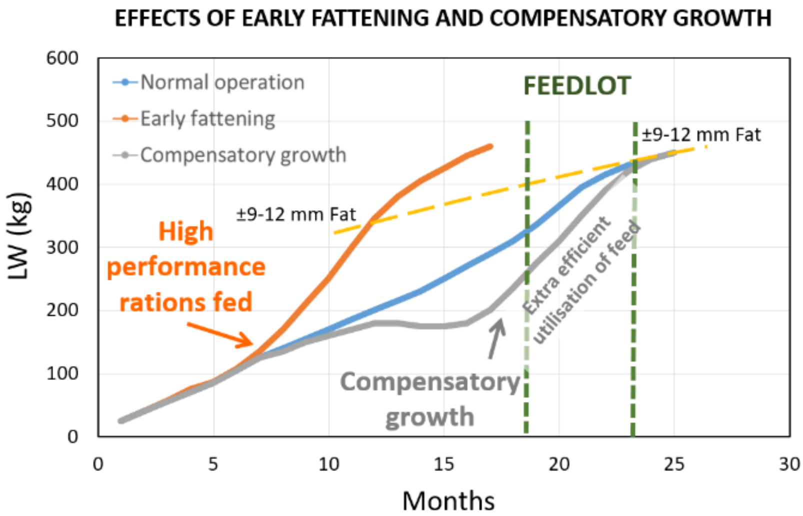


Figure 3.39: Illustrations of early fatness when feeding high performance rations from an early age, and the advantage of compensatory growth in feedlots.

Compensatory growth: Yearling cattle that have lost weight during a harsh dry season in northern Australia, can end up with a body condition of backward store (BCS=2) when selected for export as feeders. They are able to catch up with their better conditioned (BCS=3) contemporaries due to extra-efficient feed utilisation and higher growth rates (see Figure 3.39; page 70). This is actually an advantage for feedlot operators as there are cost savings to be made on feed due its efficient utilisation. The best opportunity for procuring consignments of backward store feeders is during and towards the end of the dry season in northern Australia.

Growing and finishing stages: Achieving the performance targets of feedlot cattle requires maximising feed intakes with an adequate supply and balance of feed nutrients as follows:

- Optimising the growth of rumen microorganisms to digest feedstuffs in the animal's forestomach to provide most of the energy and protein requirements of the growing animal.
- Providing extra feed nutrients (mostly bypass protein) which are digested in the small intestine, and used directly for the animal's full growth potential.

The feedlot rations are based on protein and energy concentrates to deliver these targeted nutrients for growth and fattening, together with enough roughage to stimulate churning of rumen contents. Concentrate feeds also have good feed conversion efficiency (FCR) (see ***Feed conversion ratio (kg DMI/kg LW)***, page 194), resulting in high growth rates and quicker turnoff of finished cattle.

When growing feeders arrive at the feedlot, they are fed high protein rations containing bypass protein to optimise the muscle development and growth. After this phase peaks the requirement for protein (relative to energy) decreases as the cattle put on weight as fat (see Figure 3.38, page 69). At this stage, some feed proteins can be replaced in the finishing ration with non-protein nitrogen (NPN) in the form of urea (fertiliser grade). The major minerals (e.g. salt, Ca, P) and trace minerals/vitamins are provided to cover any deficiencies, especially in high concentrate rations.

Ideally, the two-staged feedlot ration strategy should be implemented to better direct the supply and balance of nutrients for the requirements of growing and finishing stages of a fattening operation. This strategy will increase feed efficiency and reduce feed costs of production. The reality is that smaller feedlots prefer to stay with one fattening ration for the whole feeding period.

Holding rations: On reaching slaughter weight, it may take several days to a few weeks for cattle to leave the feedlot. It is recommended that finished animals be given holding rations to maintain their body condition and carcass quality according market specifications. Holding rations need sufficient nutrients to repair body tissues and maintain live weight. This could be sustained, for example, by feeding good quality roughage supplemented with 2-3 kg of the concentrate feed that is used for fattening rations (see Table A9.11, Ration 3, page 261).

Feed consumption A: Fresh feeds contain variable amounts of moisture, which makes it difficult to compare the relative values of different feeds, and to formulate rations. Feed values and ration formulation are therefore based on the nutrient content of feed dry matter (DM). The proportion of nutrients available to the animal depends on the amount of ration DM consumed and the digestibility of the feed DM (DMD).

The amounts of feed needed for each stage of production is determined by dry matter intake (DMI) of rations containing the nutrients requirements of cattle according to their physiological state. For example, younger animals need more protein for growth and have higher consumption rates relative to their live weight (LW) compared with older animals. It is important to ensure there is always enough feed available to formulate balanced rations for maximise production potential. Estimates of DMI by cattle and fresh matter (FM) feed requirements are as follows:

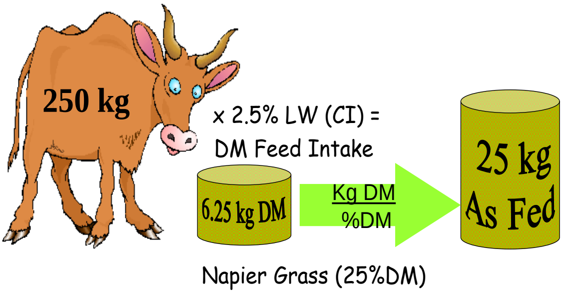
- *DMI:* On forage (or roughage) based diets cattle generally have daily DMI of feed between 2.3-2.5% LW. For high concentrate feedlot rations, DMI of feed can range from 2.7% LW for younger cattle to 2.3% for mature animals (see Table 3.4: Nutrient requirements of cattle classes, page 49).

  The feed DMI requirements of cattle can be estimated using an average Consumption Index (CI) of 2.5% LW for feedlot cattle (see Infobox 3.10, next page). Monitoring feed consumption of a fattening operation (i.e. amount fed minus leftovers) will enable a more accurate estimate of feed intake.

- *DM → As fed (FM):* To convert DM to fresh feed, the DM value is divided by % DM content of the feed. FM of green forage usually contains about 75% water and 25% DM. (see Infobox 3.13, next page)).

Infobox: 3.13

HOW MUCH TO FEED?



Example equations:

>Dry Matter Intake (DMI) = 250 kg LW x 2.5% CI = 6.25 kg DM

>Fresh Matter (FM) as fed = 6.25 kg DM / 25% plant DM = 25 kg FM (as fed)

Matching nutrient requirements with available feed nutrients: The estimation of daily DMI provides the basis for formulating rations with quantities and balance of nutrients available in stockfeed. The next step is to determine the energy and protein requirements of the productive animal from a range of feed tables (see Table 3.4, page 49 and Appendix 6 in this notebook, or from other sources). The animal's energy and protein requirements for production are additional to requirements of maintenance (i.e. lying down or standing and doing nothing). Most feed tables provide estimates of production requirements that include the maintenance component.

The art of ration formulation is the ability to match collectively the main nutrients of available (and cheapest) feedstuffs as closely as possible to the requirements of the productive animal (see Infobox 3.14, next page). In this example, the total ration ingredients for energy (+1 MJ) was close, but for protein there was a surplus of 116 g CP. Should we be worried about this discrepancy?

Feed tables are based on the results of many studies on nutrient requirements of cattle, as are feedstuffs, which are analysed for their nutrients content. Measurements of biological systems is not an exact science, and can only be measured in terms of probability. A high probability (±90%) of 350 kg steers with 1 kg growth rate requiring 93 MJ ME, could only come about with a very

Infobox 3.14

ENERGY AND PROTEIN AVAILABLE VERSUS REQUIREMENTS

350 kg feeder (ADG 1 kg):
DMI (kg/d): = 8.05

Energy requirements[1]:
A. ME for Maintenance: 44 MJ (no growth)
B. ME for Production: 49 MJ (ADG 1 kg)
Total ME required = 93 MJ (A + B)

Total Protein requirements:
C. CP for Maintenance: 460 g (no growth)
D. CP for Production: 370 g (ADG 1 kg)
Total CP required = 830 g (C+ D)

Ration (DM):	**DMI (kg)**	**ME (MJ)[2]**	**CP (g)[2]**
30% Corn chop:	2.42	24.2	94
[70% Concentrate:	5.64(100)[3]	68.8	636]
15% Corn (rolled):	1.2 (21)	15.1	21
15% Corn bran:	1.2 (21)	15.1	116
10% Rice:	0.8 (14)	10.1	113
25% PKC:	2.0 (36)	24.6	382
5% Molasses	0 4 (7)	5.0	20
TOTAL	**8.06**	**94**	**946**
		+1	+116

1. See Appendix 5, Steer (E), 350 kg LW, USA.
2. See Table 3.10, p. 76 for ME, CP values
3. Bracketed values: % of Concentrate (100%)

high degree of uniformity in terms of breed, prior history, ration, environment, climate etc., and data from a large number animals. Likewise, the analysis of nutrients from similar feedstuffs (e.g. corn) would be quite variable, unless they came from the same location under standard cropping operations to attain a high probability of a comparable nutrient profile that would only be related to that location.

Formulation of rations is a work-in-progress towards the lot-feeder's targets, as follows:

- Use a standardised ration based on pre-set amounts of ingredients according to feed category (i.e. roughage, energy and protein feeds) to formulate a basic ration. Once the ration is formulated, DMI and fresh matter quantities of feed can be estimated (see *Standardised ration*, page 75).
- The next stage of ration development is to look more closely at the energy and protein requirements of the feeders and determine whether the basic ration is meeting these requirements. Adjustments can be made to reduce oversupply (or increase undersupply) of nutrients in the ration. It is also an opportunity to incorporate cheaper feedstuffs or blend similar feeds together in case of seasonal fluctuations of availability (see Infobox 3.18, page 89).
- The final stage of development is fine-tuning the ration according to measurements. By this time, estimations of DMI during the feeding period have been measured, and the stockfeed from established suppliers has been analysed for actual nutrient content. This data replaces table values, enabling better control of feed management and ration formulation.

Ration formulation: Tropical feedstuffs can be categorised by their nutrient values in terms of sources of energy, protein, fibre, and minerals. The basic components of a ration are roughage and concentrate feeds, topped up with additives, minerals and vitamins as required. Roughage is usually in the form of fresh green forage, which provides energy, and importantly, fibre for maintaining digestive function. Concentrates are a denser form of energy and protein feeds, which together with roughage, are designed to optimise the conversion of feed nutrients by rumen microorganisms to energy and protein sources to meet the needs of growing or finishing cattle. The nutritional value of common ration ingredients used for lot-feeding Australian cattle in SE Asia are shown in Table 3.10, next page (also see Appendix A9, page 250).

Standardised ration: The categorisation of feedstuffs into roughage, concentrates, and additives, is useful for formulating a basic feedlot ration for SE Asian feedlots (see Table 3.9). Although the proportion of ingredients in the basic ration may not be super-accurate in meeting exact nutrient requirements, it is precise enough considering the natural variability of biological systems (e.g. feed intake, nutrient values, rumen digestion, stage of growth, body condition, etc.). The basic formulation can be fine-tuned later.

Table 3.9: Guidelines for formulating a basic feedlot ration (head/day) for Asian feedlots

Forage Source	Roughage	Concentrates
Green forage DM% (FM %)[1]	±30% (65%)	±70% (35%)
Dry roughage DM% (FM%)	±15% (30%)	±85% (70%)
Concentrates (100%)[2]:	DM basis:	
Energy concentrate	55% (e.g. grains: corn 10%; bran/pollard 45%)	
Protein meal	40% (e.g., copra, palm kernel cake, cottonseed meal).	
+ Additives:		
Molasses	±5%	
Urea (+ water)	60-80g daily (i.e. ~1% Ration DM)	
Salt	35 g daily	
Minerals/Vitamins	100-200g (Ca, P, premix) daily	

1. Bracketed percentages represent approximate proportions (%) of roughage and concentrate in the ration (as fed).
2. Concentrate ingredients as a proportion of the concentrate (100%) on DM basis. (*Note:* Concentrate ingredients are mostly dry (90-100% DM), except fresh feeds e.g. pineapple pulp, brewers spent grains etc.).
3. ~ (approximately).

Table 3.10: Approximate feed value and level of ration ingredients used for lot-feeding Australian cattle in SE Asia (DM basis). See also Appendix A9.

FEEDSTUFF	DM (%)	CP (%)	RDP (%)	CF (%)	ME (MJ/kg)	Ca (%)	P (%)	Max Level[1]
ROUGHAGE								
Forage Maize (75 days)	25	8.00	53	30	9.9	0.34	0.23	35%
Forage Maize (Stover)	25	5.50	65	30	8.9	0.60	0.10	10-20%
Corn Cob (Without grain)	92	4.40	n.a.	35	6.9	0.14	0.07	40%
Sugarcane Tops	28	6.00	65	35	7.7	0.50	0.20	25%
Elephant (Napier) Grass (75 days)	25	8.50	65	34	7.5	0.50	0.30	30%
Rice Hay	85	5.90	60	34	6.5	n.a.	n.a.-	15-25%
Rice Straw	96	5.10	45	35	5.8	0.41	0.11	5-10%
ENERGY CONCENTRATE								
Corn (Cracked/Ground)	91	10.00	75	3	12.5	0.03	0.03	85%
Corn Bran	90	9.50	60	13	12.5	0.06	0.73	15-25%
Wheat Pollard	88	17.50	79	8	11.0	0.20	1.00	45%
Rice Bran (RB)	91	14.00	66	13	11.8	0.07	1.60	15-30%
Tapioca Chips	88	3.00	80	4	12.8	0.15	0.15	65%
Tapioca Waste (Onggok)	90	2.00	90	3	12.0	0.60	0.20	60%
Sago Rasps	89	1.50	75	5	10.0	0.04	0.02	30%
Green Bananas	22	5.75	80(?)	4	13.0	0.06	0.20	50%
Pineapple Pulp	12	3.30	75(?)	26	10.1	0.40	0.10	20%
PROTEIN MEALS								
Palm Kernal Cake (PKC)	89	19.00	74	13	12.2	0.30	0.70	<50%
Copra Meal	90	20.00	35	7	12.5	0.20	0.70	25%
Soybean Meal (SBM)	89	47.00	65	8	13.7	0.27	0.70	5-10%
Groundnut Meal	86	34.00	80	27	11.7	0.20	0.60	25%
Brewers Spent Grains (BSG)	22	24.00	73	15	10.0	0.33	0.13	15%
Cottonseed (Whole)	93	21.00	65	22	14.0	0.16	0.76	10-15%
Cocoa Bean Shell	91	22.60	45	14	12.6	0.15	0.27	10%
Kapok Seed Meal	90	31.00	45	30	8.7	0.50	1.30	10%
Fishmeal[2]	92	70.20	40	0	14.6	2.65	2.23	10%
Leucaena Leaf Meal	92	26.75	45	21	10.9	2.20	0.30	10%
ADDITIVES								
Molasses	75	5.00	100	0	12.5	0.60	0.10	5-10%
Urea	100	(287)	100	-	-	-	-	<1.5%
MINERALS (mix)[3]								(200 g)
Salt (NaCl)	100	-	-	-	-	-	-	35 g
Limestone	100	-	-	-	-	34.0	-	200 g
Monocalcium Phosphate (MCP)	100	-	-	-	-	16.0	24.5	100 g
Dicalcium Phosphate (DCP)	100	-	-	-	-	22.0	19.3	150 g
Tricalcium Phosphate (TCP)	100	-	-	-	-	39.0	20.0	125 g
Monoammonium Phosphate (MAP)	100	76 (N)	-	-	-	-	27.0	100 g

DM Dry Matter

CP Crude Protein

RDP Rumen Degradable Protein

CF Crude Fibre

ME Metabolisable Energy

MJ Megajoules

Ca Calcium

P Phosphorus

1. % of whole ration. 2. Fishmeal is 'restricted animal material' (RAM), banned in Australia and EU as a livestock feed. 3. Max. g/head/day for minerals, 200 g limit for premixes.

Roughage/Concentrate feeding rates (DM basis): The proportion of roughage and concentrate in the feedlot ration varies depending on the quality (digestibility) of the forage. As a rule of thumb, higher levels (30%) of the more digestible green forages may be fed than drier roughages (see Table 3.9, page 75). Corn chop (forage maize) can provide both roughage (30%) and energy concentrate (10%) in the ration DM from dough-stage corn cobs.

The variability in the feed value of growing roughages is not only seasonal, but also different in conserved roughages like silage and hay. Roughages such as straw, bagasse, and dried maize cobs (without grain) have little nutritive value but are useful as fillers (5-15% of ration DM) to stimulate rumen mobility and the churning of digesta when other forages are in short supply.

Figure 3.40: Bagasse (China)

Concentrate feeds range from 70-85% of the whole ration DM depending on the quality of roughage used. In the standardised ration, default proportions of energy and protein feed sources in the concentrate are 55% and 40% as a percentage of concentrate (100%). The remaining 5% is for the molasses/urea additive and salt, minerals and vitamins which are supplemented according the required amount (see Table 3.9, page 75).

Fresh forage and dry roughage: High quality fresh forage maize (corn chop) harvested at 75 days, and Elephant grass (cut at 6-8 week intervals) can comprise up to 30% (DM basis) or about 55-65% (FM basis) of the total ration. With corn chop, the dough-stage corn cobs also provides about 10% concentrate energy in whole ration. If availability is not a limiting factor and delivery costs (DM basis) are low (see Infobox 3.11, page 64), then it makes economic sense to feed the maximum amount of forage. The fresh green leaves of sugarcane tops (i.e. without stalk) can also be included in high performance rations at a rate of up to 25% of the diet (DM basis) or about 50% as fed. Lesser amounts of dry roughages[18] (±15%) are fed in feedlot rations because they may contain high levels of structural lignin with low digestibility.

[18] Dry roughages (90-100% DM) as fed, are considered as DM for ration formulation.

Infobox: 3.15

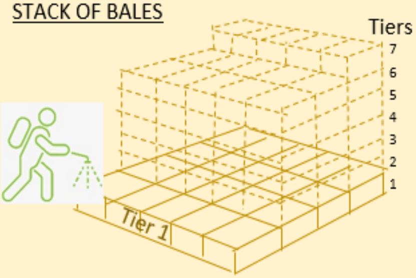
UREA TREATMENT OF RICE STRAW

UREA / AMMONIA

$$ \underset{\text{urea}}{(NH_2)_2C{=}O} + H_2O \rightarrow 2NH_3 + CO_2 $$

A. 4 kg urea (2.2% NH_3) per 100 kg straw.
B. Dissolve 4 kg urea in 50-60 L water.
C. Square bale (20 kg) x 5 = 100 kg straw.
D. Storage: 5 bales x 4 = 20 bales/tier; 7 tiers stacked
E. 5 bales x 4 =20 bales/tier; needs 16 kg urea/ 200 L water.
F. Lay first tier of 20 bales and spray urea solution (E) equally over the bales.
G. Stack the next tier and repeat spraying.
H. Cover stack of bales with plastic sheet.
I. Ready to feed after 5-7 days.

STACK OF BALES



Source: Walli *et al* 1995 [15]

For example, corn stover is the remains of a maize crop after harvesting, and usually consists of wilted leaves and dry stem of a low nutrient value, but useful as a source of fibre to stimulate rumen function. Rice hay may have unharvested grain still attached thereby adding to its nutrient value. However, rice straw, which is one of the most abundant feedstuffs in SE Asia, is also one of the lowest in nutritive value. Its use should be limited 5-10% of the ration DM as an emergency feed to maintain rumen function. The treatment of rice straw using alkaline agents such as sodium hydroxide (NaOH), ammonia (NH_3) or urea can increase the digestibility of the fibrous plant material by 10%, and can be fed up to 15-20% of the ration (see Infobox 3.15).

Corn cobs (without grain): The cobs are usually chopped or ground as fill for dairy rations. They are a good source of fibre and energy, and the ground cobs enhance the availability of these nutrients. The processed cobs can temporarily replace fresh forage in the ration if required.

Corn/Maize Grain: The grain contains 70% starch, which is a source of concentrated energy for microbial digestion; protein content however is relatively low at ±9% DM. Not all the starch is digested in the rumen and some escapes into the small intestine and is absorbed as glucose, which is the primary energy source for animal productivity and the formation of intramuscular fat (marbling). Yellow corn is also a good source of β-carotene precursor of vitamin A.

Corn grain, or its milling byproducts, which have similar feed value but higher fibre content, will generally boost feedlot performance when included in the concentrate at >10% DM or about 0.85 kg/head/day. The whole grain should be coarsely hammer milled (10-19 screens) or cracked by a roller to expose the grain contents. Another option is to feed 10-12 kg of freshly chopped corn forage with cobs and grain at dough stage (white), to provide the equivalent amount of grain, plus dietary requirements for forage. Similarly, chopped dried corn cobs (with grain) fed at a rate of up to 30% of the whole ration (DM basis) will also provide some concentrated energy, and bulk fibre as a substitute for roughage.

Other Energy Concentrates: The most commonly available feedstuffs in this category are byproducts of processing of cereal crops; e.g. rice bran (from rice polishing), wheat pollard (from flour milling), cassava chips (sliced and dried tubers), tapioca waste (after extraction of starch)), and sago waste (after flour production). Both rice bran (grades 1, 2) and wheat pollard (hard, soft) can be fed together as a mixture to benefit from the range of nutrients supplied by both, and to minimise the effect on rumen digestion when the availability of one of these ingredients is limited.

Rice bran: Grade 1 bran is less contaminated with hulls (<9% crude fibre) than the grade 2 bran, and is the best substitute for corn grain. Energy and protein content is higher (>10 MJ/kg DM); >10% CP) for grade 1 than grade 2. Rice bran contains relatively high levels of unsaturated oil and should not exceed 30% of the concentrate feed or 1% of LW (DM basis) to avoid excess deposition of soft fat, unless it is a market requirement.

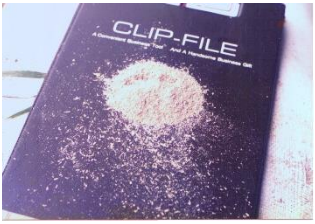


Figure 3.41: Grade 1 rice bran (Philippines)

Wheat pollard: The pollard, which is a bran and millings blend, is a very palatable energy and protein source for cattle, and is rich in phosphorus (P). The pollard may comprise 45% of the concentrate feed (DM basis), however cattle performance on pollard alone is not likely to be as good unless mixed with 15% corn or rice bran.

Cassava chips and tapioca waste: The dried chips and waste are fed as the main energy source for feeder rations up to 60-65% of concentrate feed (DM basis). As with wheat pollard, it is advisable to substitute 10-15% of the cassava with corn or other grain byproducts. Since cassava is very low in protein, a source of NPN needs to be added to the ration (e.g. 2.5% urea/kg cassava, see Infobox 3.16, page 82), or provide a protein source that is readily degraded in the rumen (see Table 3.10, page 76, protein feeds with high RDP, e.g. PKC).



Figure 3.42: (Left to right) Cassava tubas (Vietnam); sun-drying tapioca chips (Philippines); tapioca waste from starch extraction process (Malaysia).

Sago waste: This is a good source of concentrated energy, but low in CP content (±1.5% DM). It can be fed up to 30% in the concentrate (DM basis).

Figure 3.43: Chunks of sago pith before crushing (Indonesia).

Other energy feeds include bulky by-products such as pineapple pulp, green bananas, and biscuit factory waste (see ***Bulky industrial byproducts***, page 94).

Protein concentrates:

Copra and palm kernel cake (PKC): These are major sources of concentrate protein feeds, used in feedlot rations in SE Asia. Copra is a better feed than PKC in terms of quality (bypass protein) and palatability. PKC can make up to 50% of the local ration ingredients (DM basis), but this level of feeding is not recommended for Australian stock due to nutritional issues. Both copra and PKC should be limited to 40% of the concentrate feed.

Brewers spent grains (BSG): This byproduct also serves as a suitable protein source especially for feedlots located near to breweries. However, the wet byproduct contains about 80% water and subject to nutrient losses if not fed within 2-3 days. These losses can be reduced by sun drying and or ensiling (see *Brewers Spent Grains*, page 94). Copra, PKC and BSG (dry) are interchangeable as protein sources in the concentrate feed and can be combined at a rate of up to 40% of the concentrate feed (DM basis).

Other protein sources include soybean, groundnut and cottonseed meals, which are all high in protein. Soybean meal provides a high quality protein source whereas groundnut meal is a more nutritionally variable product.

Cottonseed meal (CSM): Both the whole seed and meal contains gossypol, which is a toxic compound if fed to cattle at high levels, made worse with possible chemical residues from crop spraying. Its inclusion in feedlot rations should is limited to a safe level up to 15% of the concentrate feed (DM basis). See also Appendix A9 *Cottonseed meal,* page 250.

Leucaena: Dried Leucaena leaf meal is a labour-intensive product, but ideal as a source of good quality protein for smallholder cattle fattening operations. The fresh leaves contain the toxin mimosine, which cannot be degraded in the rumen by imported Australian cattle that have not been previously exposed to leucaena (see *Leucaena leucocephala,* page 141*)*. It is therefore restricted to 15-20% of the concentrate feed (DM basis). Filipino farmers add value by substituting corn with dry leucaena leaf to produce beef with yellow fat.

Kapok seed meal: The Silk Cotton tree produces seeds protected by long cotton-like fibres. Oil extracted from the seeds (±25%) and the fibre have commercial value. The seed meal is high in protein (30%), about half of which bypasses the rumen. There is some limitation to feeding (10-15% of concentrate) due to the high oil content even after extraction (see Figure 3.44).

Figure 3.44: Kapok seed meal

Cocoa bean shell: Although the waste from processing cocoa is a good source of energy and protein for ruminant diets, levels in the concentrate feed are limited to 10%, due the presence of the toxin theobromine.

Fishmeal: Fishmeal has the highest protein content of around 65%, and has high levels of Ca and P. It is commonly mixed with rice bran (50:50) as a creep feed for calves to boost bone development. Fishmeal is covered by Australia and Europe's Restricted Animal Material (RAM) legislation that bans its use as a livestock feedstuff.

Infobox 3.16:

MOLASSES/UREA

MIXING UREA WITH WATER AND MOLASSES

EXAMPLE: 1

- 1% Urea/Ration DM (see *Urea* below)

A. 300 kg feeder x 2.4% (CI) = 7.2 kg DMI
B. Urea (7.2 x1.0%) = 72 g
C. Dissolve 72 g Urea in ≥ 70g water
D. Conc. (7.2 x 70% Ration DM) = 5.0 kg
E. Molasses (5.0 x 5%) = 250 g DM
F. MIX Urea/Water with Molasses
G. Molasses (250/75%) = 333 kg FM
H. Molasses/Urea (22%) w/w = (72/333)%

EXAMPLE: 2

- 2.5% Urea/kg DM Tapioca Waste (TW)
- 35% TW in Conc. (70% of ration DM)

A. 350 kg steer x 2.3% (CI) = 8.05 kg DMI
B. Conc. (8.05 x 70%) = 5.64 kg DMI
C. TW (5.64 x 35%) = 2.0 kg DMI
D. Urea (2.0 x 2.5%) = 50 g Urea
E. Dissolve 50 g Urea in ≥ 50g water
F. Molasses (5.64 (B) x 5.0%) = 280 g DM
G. MIX Urea/Water with Molasses
H. Molasses/Urea (14%) w/w = (50/373)%

Molasses: This is a byproduct of the sugar industry and contains 50% soluble sugars and a wide range of minerals. Its primary function as a feed additive (restricted to ≤10% of concentrate feed) is to increase the palatability of the ration and serve as a carrier for urea (e.g. molasses/urea (22%) w/w) (see Infobox 3.16, Example 1, H.). This relatively small amount of molasses as an energy source also stimulates microbial activity in the rumen, but too much molasses inhibits digestion of plant material in the forestomach.

Alternatively, molasses based rations can be fed with a source of fibre, feed protein, NPN and S (see Figure 46, page 84, and ration at Appendix A9, *Sugarcane*, p.56).

Urea (46%N): Small amounts of fertiliser grade urea (about 60-80 g urea or ±1% of ration DM) diluted in water, then mixed with molasses, will provide supplementary nitrogen (N) for microbial protein synthesis, especially needed when feeding highly digestible energy sources like cassava waste (onggok), or when feed protein levels are low in the whole ration. The addition of 70 g urea (32 g N) in the ration concentrate should raise the protein equivalent in the ration by (6.25 x 32=) 200 g CP as microbial protein which is then digested in the small intestine of ruminants.

Urea is poisonous to cattle if not mixed properly. To avoid this, it is advised that the quantity of urea needed in the concentrate (e.g. 70 g/head/day) is dissolved in about the same amount of water (w/w), before mixing the urea solution into molasses. It is less risky to gradually introduce the urea/molasses into the ration, or to place urea lick blocks in the feed trough.

Infobox 3.17:
SALT FOR 325 kg STEER

- DMI# (kg): (325 x 2.5%) = 8 kg DMI
- Salt (Na 39%, Cl 61%).

A. Feed tables: 0.1% Na/kg DM
(0.1% x 8 kg) x 1000 = 8 g Na, (8/39%) = 21 g salt

B. Tropics: 0.15% Na/kg DM
(0.15% x 8) x 1000 = 12 g Na, (12/39%) = 31 g salt

#DMI (Dry Matter Intake)

Salt (NaCl): Recommended intake of salt for cattle is generally around 0.1% sodium (Na) per kg DM feed intake, but in hot climates it should be raised to 0.15% (or more) because of increased sweating. Therefore, it is advised to feed 30-35 g salt per head daily in the tropics (see Infobox 3.17).

Calcium (Ca); Phosphorus (P): Feeder cattle require 35g Ca and 25 g P daily. The Ca:P bone ratio of 2:1 is used as near as possible in ration formulation even if there is excess of both minerals. Adding combinations of limestone, mono-ammonium phosphate (MAP) or mono-calcium phosphate (MCP) can meet this requirement. 100 g of MAP also provides 12g N, which is equivalent to 26 g urea. Alternatively, 150 g of dicalcium phosphate (DCP), or 125 g of tricalcium phosphate (TCP) will provide the needs for both Ca and P.

Sulphur (S): This element is necessary for the formation of microbial proteins by rumen microorganisms, particularly in rations containing urea. 13 g of elemental sulphur or 100 g of ammonium sulphate per head added to the daily ration will meet requirements. The ammonium sulphate will also provide 10 g of N (equivalent to 22 g urea).

Macro mineral mixes: These generally cover the needs of lot-fed cattle for major minerals nutrients, at a daily rate of 200g/head, as a loose mix or 3.5% of concentrate feed (see Figure 3.45).

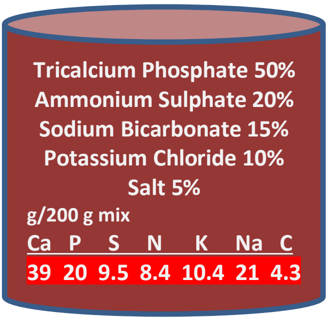


Figure 3.45: Example of macro mineral mix for feedlot cattle provided at a rate of 200 g/head concentrate feed.

Other feed additives: Monensin (Rumensin®) and lasolocid are examples of ionophores used to enhance propionic acid production in rumen fermentation[19], thereby increasing efficiency of energy availability to the animal by about 10%. In addition, ionophores reduce incidences of bloat and acidosis, and have coccidiostat properties. Mix into a carrier (e.g. rice bran) to dilute the dosage before mixing into a ration, as it can be toxic to cattle.

Sodium bicarbonate (baking soda): This is used in feedlot rations (25 g/head/day) to help feeders adapt to high grain rations by stabilising acid levels in the rumen.

Seaweed: Kelp meals have long been used as a source of minerals and vitamins in dairy rations. More recently, red seaweed (*Asparagopsis taxiformis*) has been promoted as an additive (~35 g freeze-dried/head/day) for suppressing methane production by cattle and significantly increasing productivity [16].

Trace minerals and vitamins (Premix): Cattle feeding on high concentrated rations need Vitamin A and E, but this is less critical in rations based on green forage or contain fresh yellow corn. These vitamins can be administered to feeders by injection at entry into the feedlot. Alternatively, vitamins and trace minerals can be supplied in the form of commercial premixes or lick blocks (see Table 3.11, next page). For deficiency symptoms of important vitamins and minerals, see Table 3.5, page 59.

Figure 3.46: Trough and bucket of molasses (Philippines and Swaziland) associated with molasses based diets (see Appendix A9.6, page

[19] Ionophores reduce rumen microbial populations that produce the less energy efficient VFAs and methane in the fermentation process. This allows populations of propionate producing rumen bacteria to expand and flourish, thereby converting more readily available energy from feed for absorption by the animal.

Table 3.11: Example of premix for feedlot cattle

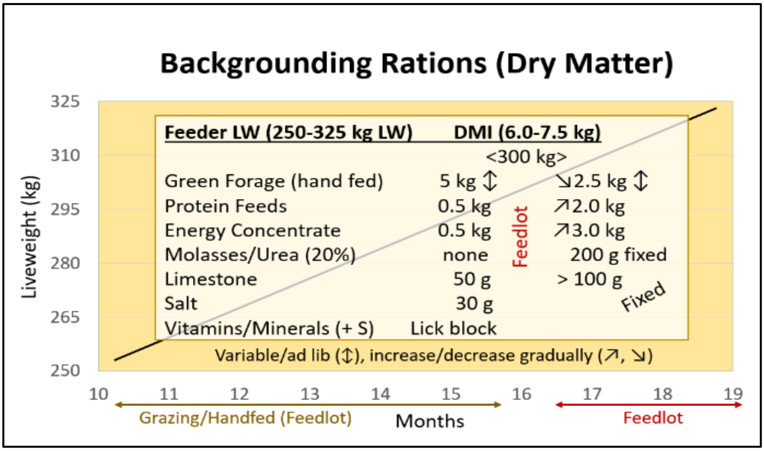
Nutrient/ Additive	Requirements (per kg feed DM)	Source Material	Amount of source material (mg)	Amount of source material (% mix)	Nutrient content (per kg mix
Vitamin A	2,500 iu	Carotene-β	4.5	0.23	1,250,000 iu
Vitamin E	20 iu	Di-α-tocopherol acetate	13.3	0.67	10,000 iu
Magnesium	500 mg	Magnesium Oxide	833	37.5	225,000 mg
Manganese	20 mg	Manganese Sulphate	55	2.75	10,000 mg
Iron	30 mg	Ferrous Sulphate	149	8.69	17,500 mg
Copper	5 mg	Copper Sulphate	20	0.98	2,500 mg
Cobalt	0.15 mg	Cobalt Sulphate	0.5	0.02	75 mg
Zinc	25 mg	Zinc Oxide	31	1.56	12,500 mg
Selenium	0.1 mg	Sodium Selenate	0.2	0.01	50 mg
Ionophore	25 mg	Sodium Monensin	25	1.25	12.5 g
Antioxidant	2 mg	Butylated hydroytoluene (BTH)	1	0.05	1,000 mg
Carrier	-	Calcium Carbonate	926	46.3	463 g

Note: Add 2 kg premix per tonne of dry feed.

***Basic rations*:** Using categorised feedstuffs and specified proportions of ingredients to formulate a basic ration (see *Standardised ration*, Table 3.9, page 75) is an easy way to get started with a feedlot ration. However, it is advised, at a later stage, to review the ration formulation regarding opportunities to use cheaper ingredients and fine-tune the nutrient balance of the ration. There is an example of fine-tuning rations in Infobox 3.18, page 89, or consult a livestock nutritionist for assistance.

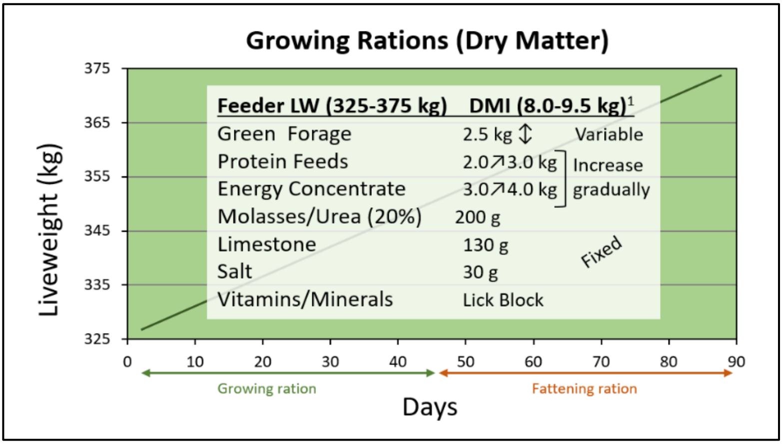
The following rations (1-3) are examples of basic formulations for pre-entry into to the feedlot (backgrounding), and growing and finishing rations in the feedlot. The formulations are based on dry matter, and will need to be converted into fresh matter (as fed). See example in Table 3.12, page 88.

Ration 1: Generic backgrounding ration based on roughage (kg/head/day)*.



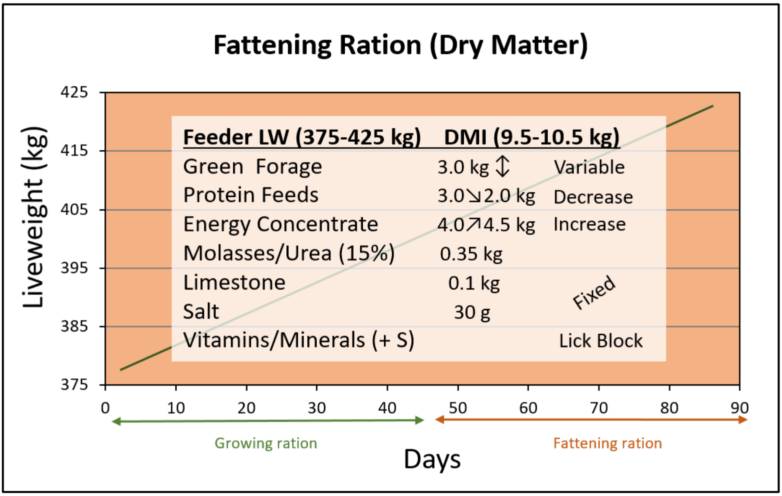
* DMI based on 2.4%/LW. Green forage is set at 80% of ration (DM basis), or 100% if grazing improved pastures. Hand fed animals are fed a concentrate (±1 kg/head/day) of processed corn grain or a wheat pollard/rice bran mix, and copra meal/PKC mix, at rates of 10% ration DM for both energy and protein concentrates. Young feeders reaching 300 kg LW (±15 months old) are gradually introduced to the feedlot's growing ration over a 2-3 week feeding period, with total urea in ration of 55 g (20% in molasses FM).

Ration 2: Generic growing ration based on concentrate feeds (kg/head/day)*.



* Green forage is set at 30% of ration (DM basis) but may vary according to adjustment of feed leftovers; gradually increase concentrates as consumption rises over the feeding period. [1]*Note:* (a) DMI based on 2.5%/LW; (b) Includes processed corn grain up to 10% of concentrate mix.

Ration 3: Generic fattening ration based on concentrate feeds (kg/head/day)*.



* Increase forage in ration over a period of a week to the 'fixed' amount according to leftover adjustments; as consumption rises, decrease/increase respective concentrates gradually over the feeding period. Total urea in ration is 70 g (15% molasses FM).

Table 3.12: Converting Rations 1, 2, 3 (pages 86-87) from DM to FM (as fed).

Ration (DM→FM)	Forage (~25% DM)	Concentrates (~90% DM)	Molasses (75% DM)	Total (kg FM)
Backgrounding:	(DMI/25%)	(DMI/90%)	(DM/75%)	+ additives
<300 kg LW	20 kg	1.1 kg	-	21.1 kg + 80g
>300 kg LW	10 kg	5.0 kg	0.27 kg	15.3 kg + 130 g
Growing:	10 kg	5.6→7.8 kg	0.27 kg	15.9→18.1 kg + 160 g
Fattening:	12 kg	7.8→7.2 kg	0.47 kg	20.3→19.7 kg + 130 g

Note: Ration 1: e.g. (5 kg forage DMI/25% DM in forage) = 20 kg forage as fed.

The above Table 3.12 is a 'back-of-an-envelope' calculation to convert the generic Rations 1-3 from dry matter (DM) to fresh matter (FM). A more detailed ration formulation would convert each ingredient from DM to FM before calculating total fresh matter of the ration (see Infobox 3.18, Table E, page 91). The price and amounts of each ingredient (as fed) is needed to calculate the cost of the ration, for example:

A. If the price of fresh Elephant grass is $10/t and was used as the forage in all the above rations, then the forage component of the ration would cost (($10/1000 kg x 20 kg (or x 10 and 12 kg) =) $0.20 (20c), 10c and 12c/head/day, respectively.

B. If the protein (copra) and energy (corn and rice bran) feed costs, in turn, are $40 and $200/t, and the concentrate contains has 40% protein and 60% energy feeds, then the mean cost of the concentrate is 13.5c/kg. For Ration 1, the cost is (1.1 x 13.5 =) 15c and 68c/kg respectively. For Rations 2 and 3, the average daily cost per head is ((5.6+7.8)/2) x 13.5 =) 91c and 104c.

C. If the molasses is worth 170$/t or 17c/kg, then its cost in the ration is (0.27 x 17 =) 4.5c and (0.47 x 17 =) 8c for growing and finishing rations.

D. Total daily cost/head of the main ingredients (A+B+C) for each ration averages 35c and 82.5c (Ration 1), $1.06 (Ration 2) and $1.25 (Ration 3).

Infobox 3.18 on the next page provides a detailed example of ration formulation, starting from a basic ration, reviewing and fine tuning, to meet nutrient requirements of the animals and to reduce feed costs.

Infobox 3.18: Basic feedlot ration formulation

Step 1: Determine the nutrient requirements of cattle (Table A), and list the feedstuffs available, nutrient values and current prices (Table B).

Tables A & B: Nutrient requirements of growing feeders, and nutrient values and prices of available feedstuffs.

A: Cattle requirements	**DMI (kg)**	**CP (%)**	**ME (MJ/kg)**	**Ca (g)**	**P (g)**
Nutrients needed for 325 kg feeder, intake 2.5% LW, growing 1 kg/d					
Total requirements	8.13	12.0	10	26	19

B: Nutrient values, prices of available feedstuffs (See Table 3.10, p.76)	**DM (%)**	**CP (%)**	**ME (MJ/kg)**	**Ca (%)**	**P (%)**	**Price US$ ($/t)**
Roughage:						
Elephant grass	25	8.0	8.5 (64)*	0.34	0.23	9
Energy feeds (EF):						
Corn (cracked)	91	10.0	12.5 (78)	0.03	0.30	320
Rice bran (G2)#	90	12.7	10.1 (74)	0.07	1.38	75
Wheat pollard	88	17.6	11.0 (70)	0.20	1.00	200
Protein meal (PM):						
Palm kernel cake	89	19.0	12.2 (76)	0.30	0.70	80
Copra meal	90	20.0	12.5 (78)	0.20	0.70	40
Additives:						
Molasses	75	5.0	12.5 (78)	0.60	0.10	170
Urea	100	(287)	0	0	0	200
Salt	100	0	0	0	0	75
Limestone	100	0	0	36.0	0	60
Vitamins/minerals						

* Bracketed values are TDN% (Total Digestible Nutrients) where: TDN = MJ/kg ÷ 0.15104
# G2 (2nd Grade) = 12-20% Crude Fibre (CF), versus G1 (1st Grade) = 4-11% CF

Infobox 3.18: (cont.)

Step 2: Determine dry matter intake (DMI) of feed categories according to the basic ration parameters (Table C); formulate a ration from available feedstuffs and calculate total nutrients from ration ingredients (Table C), e.g.:

(a) Rice bran (RB) = 22.5% x 5.69 (kg DMI Conc.) = 1.28 kg RB #
(b) CP Rice bran = 1.28 kg RB x 12.7% CP (Table B) = 0.16 kg CP #

Tables C, D & E: Ration formulation and costs according to nutrient requirements of growing feeders and parameters of the basic ration.

C: Parameters of the basic ration (see Table XXX)	% in ration and conc. (DM basis)	DMI (kg)	CP (kg)	ME (MJ)	Ca (g)	P (g)
Feed intake (DMI)	100	8.13	0.98	81	26	19
Roughage (R)	30	2.44				
Concentrate (C)	70	5.69				
Concentrate mix:	70 (100)[1]	5.69				
Energy feeds (EF) (Include corn <10%)	39 (55)	3.13				
Protein meals (PM)	28 (40)	2.28				
Additives (A)	4 (5)	0.29				

D: Ration formulation and total nutrient values (based on B and C)	% in ration and conc. (DM basis)	DMI (kg)	CP (kg)	ME (MJ)	Ca (g)	P (g)
Elephant grass	30	2.44	0.20	21	8	6
Concentrate:	70 (100)[1]	-	-	-	-	-
Corn (cracked)	7 (10) a	0.57	0.06	7	0	2
Rice bran	16 (22.5)#	1.28#	0.16# b	12.9	1	18
Wheat pollard	16 (22.5)	1.28	0.23	14	3	13
PKC	28 (40) c	2.28	0.43	28	7	16
CPM	0	0	0	0	0	0
Molasses	2 (3.0)	0.17	0.01	2	1	0
Urea	1 (1.4) d	0.08	0.23	0	0	0
Salt	0.4 (0.6)	0.03	0	0	e 0	0
Total	70 (100)	8.13	1.31	85	20	54

1. Ingredients as % of concentrate (100%).
Red letters refer to options for fine-tuning ration (see Step 3 below)

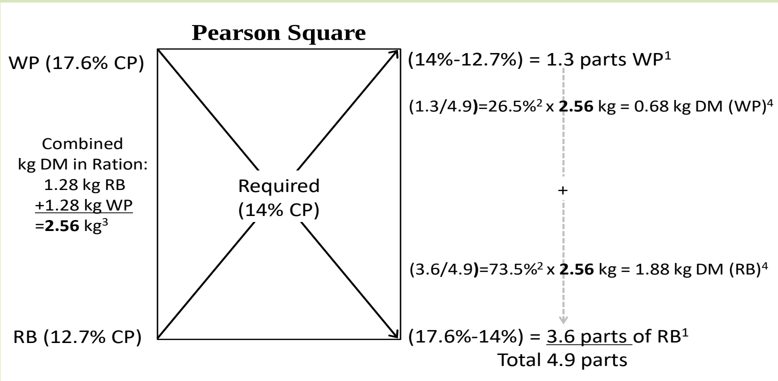
E: Cost of ration 1 (DM→FM x $)	**DM (%)**	**DM (kg)**	**FM (kg)**	**As fed cost ($ FM)**
Elephant grass	25	2.44	9.76	0.09
Corn (cracked)	91	0.57	0.63	0.20
Rice bran	91	1.28	1.41	0.11
Wheat pollard	88	1.28	1.45	0.29
Palm kernel cake c	89	2.28	2.56	0.20
Molasses	75	0.17	0.23	0.04
Urea	100	0.08	0.08	0.02
Salt	100	0.03	0.03	0.002
Intakes, costs (head/day)		8.13	16.15	$0.95
				6c/kg as fed
				12c/kg DM

Step 3: Review Ration 1 (Table D) for better nutrient balance and cheaper feedstuff options. As it stands, the ration exceeds requirements for protein and energy nutrients by 35% and 9%; rice bran and copra meal are the cheapest energy feed (75 US$/t) and protein meal (40 US$/t); and the Ca:P ratio is too low (i.e. 1:3), and should be 2:1 (or 2 >1:1 is acceptable).

Changes to the ration:

(a) Reduce corn to 5% of ration DM due to high cost of this feedstuff.

(b) Reduce high cost wheat pollard (WP) and increase low cost rice bran (RB), but keep average of 14 CP% (or near as possible) using the Pearson Square (PS) to calculate a new amount (kg) of each ingredient in the ration (see below) [17]).



Infobox 3.18: (cont.)

(b) (cont.) Superscripts at the end of the PS equations indicate calculation sequence, as follows:

1. 14% CP (Required) - 12.7% CP (RB) = 1.3 parts (WP);
   17.6% CP (WP) - 14% CP (Required) = 3.6 parts (RB)
2. Total parts 4.9
3. Combine 1.28 kg (RB) + 1.28 kg (WP) = 2.56 kg DM (in ration)
4. Parts: 1.3 (WP)/4.9 Total = 26.5%,
   3.6 (RB)/4.9 Total = 73%
5. 26.5% x 2.56 kg DM = 0.68 kg (WP)
   73% x 2.56 kg DM = 1.87 kg (RB)

The amount of rice bran and wheat pollard in the ration is now 1.87 kg and 0.68 kg, with a combined CP level of 14%.

(c) Substitute ½ PKC with cheaper copra meal (CPM) (US$40/t), so that 20% of each protein meal is included in the ration. CPM will also improve the palatability of PKC.

Note: The use of multiple energy and protein ingredients in rations facilitates feed management when adjustments to ration formulae have to be made due to availability issues or high price of ingredients.

(d) Remove urea from the ration due to excess protein in the formula. There is sufficient rumen digestible protein (RDP) from the energy and protein ingredients in the concentrate for optimal microbial protein synthesis.

(e) Add Ca (in the form of limestone) to lift the Ca:P ratio to 1.3:1. This is particularly important for optimising skeletal development of younger feeders.

Step 4: Reformulate ration with proposed changes and costing (see below Table F & G).

Table F & G: Reformulation of ration, nutrient values, and cost of ration.

F: Revised ration/ Nutrient values	% in ration and conc.[1] (DM basis)	DMI (kg)	CP (kg)	ME (MJ)	Ca (g)	P (g)
Elephant grass	31	2.44	0.20	21.0	8	6
Concentrate[1]:	69 (100)[2]					
Corn (cracked)	4 (5)	0.29	0.03	3.5	0	0
Rice bran	24 (34)	1.87	0.24	19	1	26
Wheat pollard	9 (12)	0.68	0.12	7.5	1	7
PKC	14 (21)	1.14	0.22	14	3	8
CPM	14 (21)	1.14	0.23	14	2	8
Molasses	2 (3)	0.17	0.01	2	1	0
Urea	0	0	0	0	0	0
Salt	0.4 (0.5)	0.03	0	0	0	0
Limestone	2 (2.7)	0.15	0	0	54	0
Total	70 (100)	7.91	1.05	80.9	71	54
Requirements:		8.13	0.97	80.1	26	19

1. % adjusted to change total DMI. 2. Ingredients as % of concentrate (100%).

G: Revised ration (DM→FM x $)	DM (%)	DMI (kg)	FMI (kg)	As fed cost ($ FM)
Elephant grass	25	2.44	10.0	0.09
Corn (cracked)	91	0.29	0.31	0.10
Rice bran	91	1.87	2.19	0.16
Wheat pollard	88	0.68	0.81	0.16
Palm kernel cake	89	1.14	1.28	0.10
Copra	90	1.14	1.26	0.05
Molasses	75	0.17	0.23	0.04
Salt	100	0.03	0.03	0.002
Limestone	100	0.15	0.15	0.01
Intakes, cost (head/day)		8.05	16.3	0.71c
				4c/kg as fed
				9c/kg DM

The revised ration has brought nutrient values closer to requirements, including Ca:P ratio of 1.3:1. Feed costs are also down by 25c/head/day. Further reduction in feed cost could be made by using less wheat pollard and/or palm kernel cake in the ration. Total replacement with the other cheaper ingredients is not advised, unless prohibitively expensive or not available at all. If this is the case, seek out a similar replacement to maintain at least two sources of protein and energy concentrate ingredients in the ration.

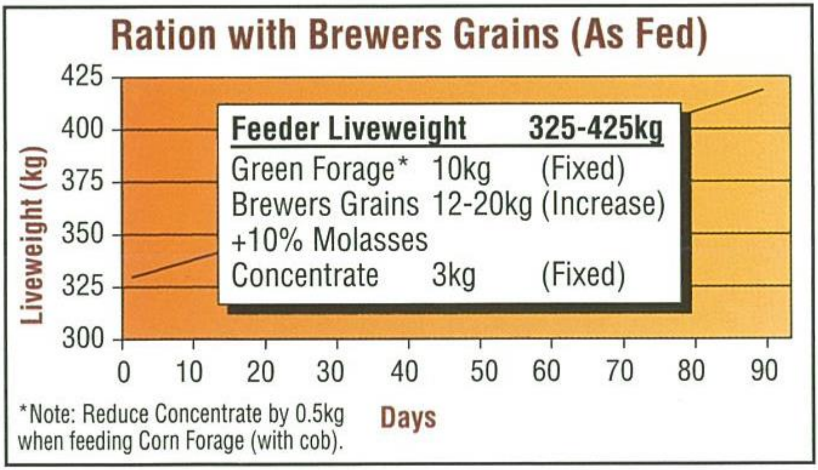
***Bulky industrial byproducts*:** Common byproducts are from breweries, fruit canning and biscuit factories, bakeries and banana plantations. In SE Asia, there are an abundancy of these sorts of waste products that can be consumed by livestock, which invariably leads to the establishment of livestock industries nearby these sources to take advantage of the cheaper feeds.

Brewers Spent Grains: The fresh byproduct consists of mashed grain (mainly barley and rice) leftover from the fermentation process used by breweries to produce beer. The leftover spent grains are usually in great demand by local pig producers and dairy farmers as a cheap source of digestible bulk feed, providing energy and high levels of protein, thereby reducing the need for concentrate feeds. The byproduct also contains yeast residues that are rich in B vitamins. The disadvantage of the fresh byproduct is that it contains around 80% water and therefore expensive to transport beyond short distances from the source.

Fresh spent grains are very palatable to cattle and are well suited for fattening rations. They can be fed up to 15% of the ration DM, or about 45-50% of the ration as fed. There are also advantages in mixing part of the spent grains with the forage component of the ration and leaving it to ferment overnight before

Figure 3.47: (Clockwise) Brewers spent grains; mixing forage with spent grains; ensiled spent grains (Philippines).

feeding out the following day. Wet spent grains should be fed within 3 days of delivery, or sun dried to 10% moisture and preserved with salt (5%). Alternatively for longer term storage, it can be ensiled with molasses (10%) and salt (5%). See photos in Figure 3.47 (previous page) and Figure 3.48 (below) for a ration example.



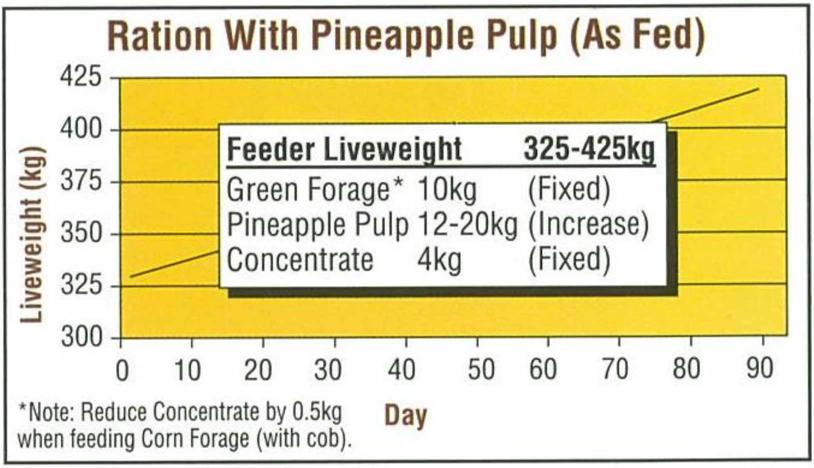


Figure 3.48: Rations with brewers spent grains and pineapple pulp.

Figure 3.49: Pineapple pulp (Indonesia)

Pineapple pulp: The pulp consists of the outer skin and the inner core of the fruit, which contains citric acid and large amounts of sugar. This feedstuff is an excellent energy source for cattle, limited only by its relatively high fibre content. It is therefore considered as part of the roughage component of a ration and can be fed up to 60% (as fed) of total intake together with chopped pineapple leaves. The fresh pulp is very wet containing up to ±85% water and when left standing, sugars rapidly convert to lactic acid. Because of the acidic nature of the fresh pulp, it should be gradually introduced to new cattle with a daily addition of 50 g/head of sodium bicarbonate in the concentrate. It is recommended to feed chopped leaves and concentrate mix, separately on top of the pineapple pulp. See Figure 3.48 ration (previous page) and Figure 3.49 pile of pulp (above).

Green bananas: Rejected green bananas (see Figure 3.50) are an excellent source of starch energy (± 73%), but the protein content is low. Rations containing high levels of bananas should be supplemented with urea (as molasses/urea (10% w/w), offered free choice, or lick block) or a readily degradable feed protein such as palm kernel cake or soybean meal. Cattle and buffalo relish bananas and no processing is required. *Note:* Long-term feeding of bananas to livestock increases horn and hoof growth; this needs to be monitored to avoid foot problems.

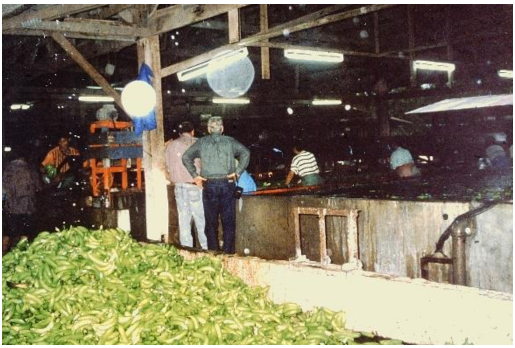


Figure 3.50: Rejected green bananas (Philippines).

<u>*Biscuit factory waste*</u>: This includes bakery waste such as bread and pastry products as well as biscuits. The waste is coarsely ground and is a good source of energy (±14.5 MJ/kg DM) due to high levels of carbohydrate, sugar, and oil (5.5%), crude protein (±9.5% DM), and is suitable for fattening rations. The waste product can be included up to 10 % in the ration (as fed), or 20% in the concentrate (DM basis). Some bakery products and pastries are high in fat (>6%) and these products should be further limited in the ration so that total fat levels in the concentrate DM are no more than 6%. *Note:* Biscuit and bakery waste may be contaminated with plastic packaging, which will need to be removed before feeding.

Figure 3.51: Biscuit factory waste (Philippines)

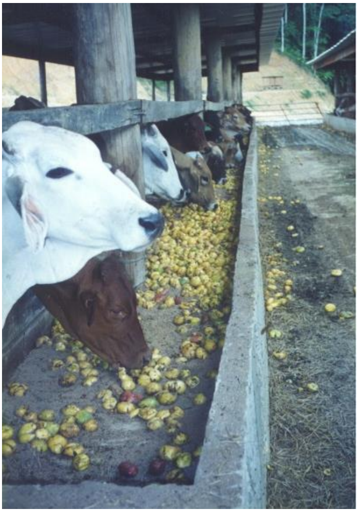


Figure 3.52: Cattle eating passion fruit (Malaysia).

Examples of seasonal opportunity feeds are fruit crop rejects like mangoes and passion fruit (Figure 3.52), both of which can be fed as the main source of energy in cattle rations for a month or two during the harvest period. These types of feedstuffs are inexpensive or even free, and give feedlot managers an opportunity to reduce overall feed costs. However, transitioning from the normal feedlot ration to a temporary opportunity feed needs careful nutritional management to avoid an adverse effect on rumen digestibility during ration changes. The key is to introduce a replacement ingredient gradually while slowly withdrawing the outgoing feedstuff over a period of several days or more.

Feed management: The aim is to provide clean water and fresh palatable feed containing a balance of nutrients in sufficient quantities to meet the requirements for healthy and productive cattle. The feeding operations need to have a plan for each cycle of cattle shipments entering the feedlot well before their arrival. This includes information about the following:

- Number of heads.
- Cattle classes.
- Feedlot cattle liveweight ranges.
- Target slaughter weights.

Data from the above information would allow the following planning:

- Ration options (feed availability, price, etc.).
- Average daily gains (depending on ration formulations).
- Feeding period.
- Total ingredients required.
- Feed cost projections.

The above information would enable forward planning to have at least a month's supply of ration ingredients in storage prior to arrival of a cattle shipment, as well as pre-ordered supplies for the following months. On-farm cultivated forages should also be synchronised for harvesting during the feeding period. Larger feedlot operations may be targeting a number of different markets, each with a different feeding plan and stock feed inventories.

Feedlot staff that are responsible for preparing rations and feeding out, should be well trained in their duties, including the following:

- Maintenance of forage choppers, grinders, feed trailers, TMR wagons etc.
- Monitoring of feed quality, storage spoilage, and vermin control.
- Accurate mixing of rations from written formulations.
- Recording of daily amounts of feed provided and leftovers.
- Cleaning feed and water troughs.
- Checking water consumption and cleanliness.
- Recognition and reporting of health issues (e.g. inappetance, diarrhoea, downers, etc.), temperament of cattle, and repairs to facilities.

Feed consumption B: A major goal of feed management is to maximise the intake of feed (DM basis) by cattle, as this is closely related to animal productivity. In US and Australian feedlots, where highly digestible cereal grains such as corn/maize, wheat and sorghum, make up the bulk of rations, DM intakes of 3% LW can be achieved. In SE Asia, lot feeding is based on cultivated forages and agricultural/industrial byproducts, which have a high degree of variability in terms of feed value compared with grains. This means that DM intakes tend to be lower at 2.3-2.5 % LW. Other factors such as cattle breed, age, climate, and feedlot management, also affect feed intakes. For example, intakes are lower in grazing cattle, and for cattle on forage based rations, also older cattle tend to eat less than younger animals (see *Feed consumption A*, page 72).

Preparation: The aim is to maintain a consistent supply of ration components for cattle and minimise selective consumption of preferred ingredients by individual animals. Ideally, all the ration ingredients are mixed together, and while this is easier to do with dry feeds, it is more difficult in rations based on fresh forage. Good practices for feed preparation are as follows:

- Fresh forage and dry roughage are best chopped into 3-5 cm lengths with a forage chopper. Chopped dry forage or smaller amounts of chopped fresh forage can be mixed in with the concentrate feed.
- Corn grain is cracked or hammer milled to increase digestibility by 5-10%
- Salt is mixed first with an ingredient of similar texture, such as wheat pollard or copra meal, to ensure its even distribution in the concentrate component of the ration.
- Urea (dissolved in water) is mixed with molasses (see *Urea (46% N)*, page 82) before adding the molasses to the concentrate mix, or manually poured on top of the feed in the trough, using a watering can.
- Ration ingredients should be changed as little as possible or gradually over time (7-10 day). Sudden changes in the proportions or types of ingredients in the ration can upset the digestive function of the rumen microbes, leading to a sharp drop in feed intake and productivity, and large amounts of feed leftovers in the trough.
- If mechanical premixing equipment is not available, concentrate and roughage components of the ration can be fed individually three times during the day (see *Manual feeding,* page 101).

Daily feed supply: Up to now, rations have been formulated on paper based on feed dry matter (DM) and the estimated daily dry matter intake (DMI) of a single animal. For example, the feedlot manager has formulated a growing ration (DM basis) for a new batch of feeders averaging 325 kg LW with an estimated daily feed intake of 8.13 kg DM/head (i.e. CI=2.5%). In reality, actual feed supply is the total amount of fresh matter (FM) needed to be fed to group of penned animals. The staff that prepare the feed has to convert each DM amount of ration ingredient into the fresh matter (FM) to estimate the daily requirements of the total ration (as fed) required per head. This amount is multiplied by the number of cattle in the group (see Table 3.13 below). In larger feedlots, daily rations are normally mixed by the ton.

Table 3.13: Converting a ration (DM basis) to fresh matter (FM) for mixing the daily ration as fed for a group of cattle.

Growing Ration (DM→FM x 55 head)	**DM[1] (%)**	**DMI (kg/hd)**	**FMI (kg/hd)**	**Daily supply (kg/d/55 hd)**
Elephant grass	25	2.44 (30%)	9.76 (61%)	537
Concentrate:		5.61 (70%)	6.26 (39%)	(344)
Corn (cracked)	91	0.28	0.31 [5%][2]	17
Rice bran	91	1.99	2.19 [35%]	121
Wheat pollard	88	0.71	0.81 [13%]	45
Palm kernel cake	89	1.14	1.28 [20%]	70
Copra	90	1.14	1.26 [20%]	69
Molasses	75	0.17	0.23 [3.7%]	12.7
Salt	100	0.03	0.03 [0.5%]	1.7
Limestone	100	0.15	0.15 [2.4%]	8 3
Totals		8.05	16.02 [100%]	881

1. Dry matter content of ration ingredient (DM%): DMI kg/feed DM% = FMI (as fed).
2. Square bracketed percentages (%) are ingredients as percent of concentrate (as fed).

Another way of calculating daily feed supplies based on total live weight of cattle group and percentage of roughage and concentrate in the ration is shown in Infobox 3.19, next page.

Feeding out: The aim is to provide the feed requirements of each group of cattle in pens without over or under feeding. Moreover, feed troughs should never be empty for more than a few hours as this destabilises rumen digestion and affects productivity.

Infobox 3.19:

CALCULATING DAILY FEED SUPPLY

(Another method using parameters from Table 3.13)

(a) Total LW of 325 kg feeders (55 head) = 17,875 kg
(b) Total feed required (2.5% x Total LW) = 447 kg DM
(c) Ration composition and daily supply (DM basis):
    Roughage 30% (x b) = 134 kg DM
    Concentrate 70% (x b) = 313 kg DM
(d) Dry matter content of feedstuff:
    Roughage 25% (Elephant grass)
    Concentrate 90% (5.61 kg DM/6.26 kg FM)
(e) Daily supply of ration components (kg FM) to 55 hd:
    Roughage (c/d) = 536 kg (61%)
    Concentrate (c/d) = 348 kg (39%)

The best practice for feeding out is as follows:

- *Continuous feeding:* Feedlots without enough trough space to feed all the cattle at the same time should use a continuous feeding regime. In this situation, cattle take turns to feed as the troughs are topped up with feed during the day and night.
- *Interval feeding:* Where there is enough trough space to feed all the cattle at the same time, it is recommended to feed out a proportion of the daily ration 3 times a day, at the same times each day. This routine will ensure optimal conditions for rumen digestion.
- *Manual feeding:* In the absence of mechanical premixing equipment, the roughage and concentrate components of the ration (particularly forage based diets) can be fed as follows:

  AM: One third (⅓) of chopped forage is fed first thing in the morning to all the cattle, followed by feeding ½ of the concentrate mix on top of the remaining forage.

  PM: In the afternoon, another ⅓ third of the roughage and the other ½ of the concentrate mix is fed out, in the same way as in the morning feed.

  PM+: The remaining ⅓ of the forage is fed in the evening.

  Note: Salt and mineral supplements should be mixed into the concentrates before feeding and molasses may be poured over the forage (using a watering can) as it is fed out into the trough.

- *Set feeding times:* Provide feed in the morning as early as possible (by 7 am) in tune with the natural behaviour of cattle. Thereafter, feed at approximately 5-hour intervals over the rest of the day (around midday and evening). If very hot at midday, just a small amount (⅓) of forage component can be given, with the rest of the ration being fed out when it is cooler later in the afternoon or evening. Some feedlots also provide a night feed of hay in separate hayracks, particularly for buffalo.
- *Feed preparation:* The morning feed is usually prepared late afternoon on the previous day.
- *Cleaning:* Feed troughs are cleaned before feeding out in the morning. This involves removing leftover feed from each pen. The leftovers are bagged, weighed and recorded for feeding adjustments. Feed troughs should also be checked during the day for manure contamination and foreign objects that may have fallen into the trough.

Feed adjustments: Consumption should be monitored daily and adjusted weekly according to the amount of feed leftovers. If there are consecutive days of significant leftovers then total feed offered should be reduced accordingly, and if there are consecutive days without leftovers then feed should be increased accordingly (see Infobox 3.20).

Infobox 3.20: Monitoring feed consumption and adjusting feed supply

FEED SUPPLY RECORDING SHEET (As Fed)

Pen No. 1 (10 head)

Date (dd/mm/yy)	11/06/19	12/06/19	13/06/11	14/06/19	15/06/19	16/06/19	17/06/19
Daily Feed Supply)	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
Roughage (kg) - fixed	165	165	165	165	165	165	165
Concentrate (kg)	45	45	45	45	45	45	45 + 5
Leftovers (kg) (est. % roughage (R))	13 (75% R)	10 (75% R)	9 (90% R)	3 (R)	0	0	7 (90% R)

Leftovers were mainly roughage and decreasing amounts of concentrate until zero leftovers. The red circle indicates that ration was adjusted by increasing 5 kg concentrate per 10 head.

Water consumption: Penned cattle always need access to cool clean drinking water. Their water requirements will increase as temperature rises during the day particularly on hot summer days. Allowances of drinking water for tropical breeds of cattle (including Australian Brahman crossbreds) are summarised in Table 3.14 below (see also ***Drinking water,*** page 60, for more detail).

Water troughs are checked daily for manure contamination, and are emptied and cleaned regularly. Consumption is monitored closely for abnormal intakes possibly caused by the following issues:

- *Low intakes:* Poor water quality (dirty, high mineral/salt levels, etc.), high water content of ration, erroneous dosage of electrolytes (if used).
- *High intakes:* Unpalatable feed (mouldy, salty, high urea level, etc.), dry dusty rations, heat wave conditions (especially hot and humid) and heat stress.

Any water issues should be investigated and rectified as soon as possible.

Table 3.14: Summary of water allowances for tropical cattle breeds at different live weight and daily temperatures.

Cattle Liveweight	Water Intake (L/day)		
	25°C	30°C*	35°C
250 kg	25	35 (35)	45
300 kg	30	40 (42)	50
350 kg	35	45 (49)	60
400 kg	40	55 (56)	75
450 kg	45	60 (63)	80

* Bracketed values = 14% of LW

<u>*Feeding new arrivals*</u>: New consignments of feeders are not offered high levels of concentrate feed until digestive function has normalised following shipment and transit to the feedlot. This can take up to 2 weeks. Best practice is to introduce the feedlot ration gradually to new arrivals over a period of 10 days. This induction process minimises the impact of transition from previous diets (ships pellets, hay etc.) to the feedlot ration. The following steps are recommended (see also Infobox 3.21, next page):

- On arrival at the feedlot and before processing[20] the animals, provide ships pellets (if available), or unchopped forage, for at least one feed cycle (thereafter chop the forage). Ensure that there is access to plenty of clean water.
- Concentrate feeds are gradually introduced into the induction ration to allow the microbial populations to adapt to the new sources of feed. This will minimise nutritional disorders and production losses.

[20] Processing new arrivals (1-3 days) involves, checking (ID, health, etc.), weighing, vaccinating, and sorting into groups, prior to settling into allocated feedlot pens.

Feeding fresh whole forage is the best way to reduce transport stress and to stabilise digestion in cattle.

Infobox 3.21: Example of induction program for new arrivals			
Days:	**Roughage (% FM)**		**Concentrate (kg)**
Pre-Processing	100%	Induction	0
4-6	85%	Ration	2
7-9	70%	↓	4
10+	Feedlot Ration		

<u>*Poor (shy) feeders*</u>: It is very important to observe all new arrivals closely during the first few weeks in the feedlot (or holding yards) to ensure that they are feeding normally. Animals that do not appear to be eating well, or have stopped eating, should be moved into low density pens and fed good quality roughage. Intermittent feeding and changes in diet during and after transportation is likely to be main cause of inappetance (lack of appetite), amongst other possible causes listed below:

- General transportation stress causing inappetance,
- Weak from an underlying disease and pushed aside by healthier animals,
- Rapid changes in diets affecting rumen function,
- Unpalatable feed e.g. mouldy feed ingredients,
- Characteristically nervous or temperamental in a new environment.
- Overcrowded pens and missing out on a full feed.
- Inherently poor eater.

Avoid widespread inappetance by providing plenty of clean water and fresh palatable feed containing a balance of nutrients in sufficient quantities to meet requirements. If poor feeders do not respond to treatment (e.g. roughage diet plus appetite stimulants) and have ill thrift (i.e. losing weight and weak), there are limited options other than sending them to the abattoir for processing. Large numbers of animals in the feedlot with inappetance is a sign that there is something wrong with the ration, or an infectious disease has spread through the herd, or caused by heat stress from a heatwave.

Overcrowding: High pen densities and inadequate trough space will disadvantage a number of animals in the group, especially if feed is provided intermittently during the day. The more aggressive eaters will selectively consume the more natural feed components such as fresh forage and other fibrous feeds, leaving insufficient amounts of less desirable concentrate ingredients for the remaining animals. These animals often stand out as poor feeders with an 'empty gut', and because of overcrowding, they tend to remain standing, while well-fed cattle are lying down ruminating and taking up the floor space.

Overcrowding of holding pens should be avoided, unless for short periods between feeding times for pen maintenance. The recommended density is 2.5-3.0 m^2 for 325 kg LW feeders and 3.5-4.5 m^2 for 350 kg LW (or more) for fattening cattle. Headspace for the feed trough is 30 cm for lighter feeders and 50 cm for cattle over 350 kg LW. Ideally, the feed trough can accommodate all animals in the pen at the same time for interval feeding, or ¾ of the pen group with continuous feeding.

Electrolyte supplements: Cattle become stressed when their routine and environment are changed. The livestock export process compounds the stress factor when the animals are transported long distances by truck and spend several days on a ship. During transit, they can be subjected to different diets, standing up for hours, high heat and humidity, poor ventilation, and motion sickness. These conditions are a precursor to heat and nutritional stress, resulting in inappetance and dehydration, which leads to weakness, reduced immunity, and respiratory trauma.

Table 3.15: Generic composition of an electrolyte supplement (ES). [18]

Ingredients (%/kg ES)	Dosage: 1 kg ES/ 100 L w
Sugars:	
White sugar	50%
Glucose	30%
Salts:	
Salt (NaCl)	5%
Sodium bicarbonate	5%
Potassium chloride	5%
Magnesium sulphate	3%
Monocalcium phosphate	2%

These stress related symptoms cause imbalances in the acid-base balance of fluids in animal's body. For new arrivals, it is recommended to add electrolytes into the water troughs for several days to hasten recovery from stress. Electrolyte supplements are available commercially or can be prepared on site (see Table 3.15). The inclusion of sugar increases water consumption by cattle, which in turn rehydrates the body and stimulates animals to eat.

It should be noted that research findings on the benefits of electrolytes for alleviating cattle stress are inconclusive, but there does appear to be advantages in providing electrolytes to cattle prior to transporting slaughter stock to the abattoir, in terms of better quality of beef (18).

Figure 3.53: Suitable drainage for collecting effluent from holding yards.

Figure 3.54: Options for cleaning of holding yards, ranging from manual (Indonesia) to mechanical methods (Vietnam) (continued on next page).

Waste management: Cattle produce large amounts of wet manure (±12% DM) in the form of faeces and urine daily (i.e. about 5.5% of LW). For example, a 350 kg feeder eating 2.5% LW of feed DM daily with digestibility of DM 65% will produce about (8.75-5.69 =) 3 kg dry faecal solids and 6 L of urine per day. 500 head of feedlot cattle over 90 days, can produce 865 t wet manure, or 135 t DM and 270 kL urine. A good waste management system is therefore critical for maintaining hygiene and avoiding pollution. Management options range from drainage into settling ponds, to mechanical removal of manure and in both cases, either used on-farm or processed for sale as fertiliser. Some feedlots in Asia out-source pen cleaning and disposal of manure on a proportionate sales agreement.

Yard design: It is important that yard design facilitates the rapid drainage of effluent from the holding yards into settling ponds for treatment (i.e. re-cycled as liquid fertiliser) (see Figure 3.53). In high rainfall areas, a proportion of solid waste will also be drained from open yards and will need to be collected and treated in settling tanks. Holding yards with 50-75% roof cover make it easier for mechanical collection of manure solids for further processing.

Figure 3.54: (cont.) (Vietnam).

Cleaning cycle: Holding yards need be cleaned regularly to avoid smell, flies, foot problems and disease outbreaks. Bedding (usually a layer of sawdust) can be used to make cattle more comfortable on concrete floors. It also absorbs moisture from effluent and helps to extend the interval between cleaning. Dry manure and discarded feed leftovers, mixed with bedding can be cleaned out weekly or longer in dry weather. If the manure is excessively wet and building up in the pen after a few days then it should be manually or mechanically scraped and removed daily or within a few days (see Fig. 3.54)

Settling ponds: The aim of the ponds is to capture all the effluent (along with rainwater) and allow the solid fraction to settle on the floor of the pond. The liquid fraction is separated into another pond to evaporate and/or be used as liquid fertiliser in an irrigation system. The solid fraction is removed for stockpiling and used as fertiliser or processed for sale (see Figure 3.55).

The ponds should be located some distance from the feedlot. At least two concrete settling ponds are required so that the liquid can be emptied via sluice gates into the holding pond and the solids collected from pond A, while pond B is collecting effluent (see Figure 3.59, page 110). The size of each pond depends on feedlot capacity, average rainfall, roof area, and volume of water used for cleaning holding pens.

Figure 3.55: Effluent drain to settling ponds (Indonesia).

Storage and processing waste: Stockpiled manure should be located in a dry place (i.e. cover by a roof or tarpaulin) and away from the feedlot and watercourses. Dry material is processed into compost in manageable heaps, which are turned over daily for aeration. The action of microbes and fungi in the dry manure breakdown organic matter into a fine humus. The process takes 1-2 months before the product can be bagged and sold as compost or organic fertiliser (see Figure 3.56, next page).

Figure 3.56: Manure processing to make compost (Indonesia and Philippines).

The liquid waste that flows from the settling ponds into the holding pond has elevated levels of N from urine and can be used in an irrigation system to fertilise farm-grown crops. Before irrigating, the N levels in the liquid waste need to be determined and calibrated according to N requirements of the crop.

Biogas production: Under anaerobic conditions, microbial digestion of manure results in methane production, which can be harnessed to produce energy. This may be in the form of a gas flame (for cooking and light) or fuelling a generator for producing electricity (see Figures 3.57 and 3.58).

More recently in Italy, feedlot effluent from buffalo and cattle feedlots is separated into manure and liquid by extraction using a screw press; the products are usually recycled as fertiliser (see Figure 3.58, next page).

Figure 3.57: Cooking rice using methane from a biogas digester at a small holder dairy (Indonesia).

Figure 3.58: (Conterclockwise). Feedlot methane digester plants to generate electricity (USA and Vietnam); Manure press to separate liquid and solids from feedlot effluent for recycling as fertiliser (Italy).

Daily routine: Daily inspection of feedlot animals and holding pens is required to identify health and hygiene problems and the need for repairs to facilities. The key elements to look out for are as follows:

Health: Check all holding pens for sick or injured animals. Sick animals should be removed to a hospital pen for treatment, and in the case of mortalities, standard procedures for disposal of carcasses apply (according to local regulations). Fallen animals or downers need to be attended to as soon as possible (see *Downers*, page 168). During the summer and particularly in heatwave conditions, special attention needs to be given to signs of heat stress (see Heat stress, page169). Other signs to look out for include bullying and shy feeders, which will require appropriate action. See section **3.9 Husbandry and Health**, page 155, for more details on feedlot health.

Hygiene: Make sure that the waste disposal program is maintaining a proper level of hygiene in the holding pens. If the build-up of manure in pens is too high then get it cleaned and adjust the cleaning schedule if necessary.

Routinely check water troughs for contamination with feed, faeces or algal growth, and remove any rubbish (plastic bags, syringes, string, paper etc.) near the holding pens and around the feedlot.

Repairs: Observe the state of repair of each holding pen, and laneways, including water supply and leaks, loose wires and protruding objects, broken gates and cracked drain covers, etc. Repairs should be made as soon as possible.

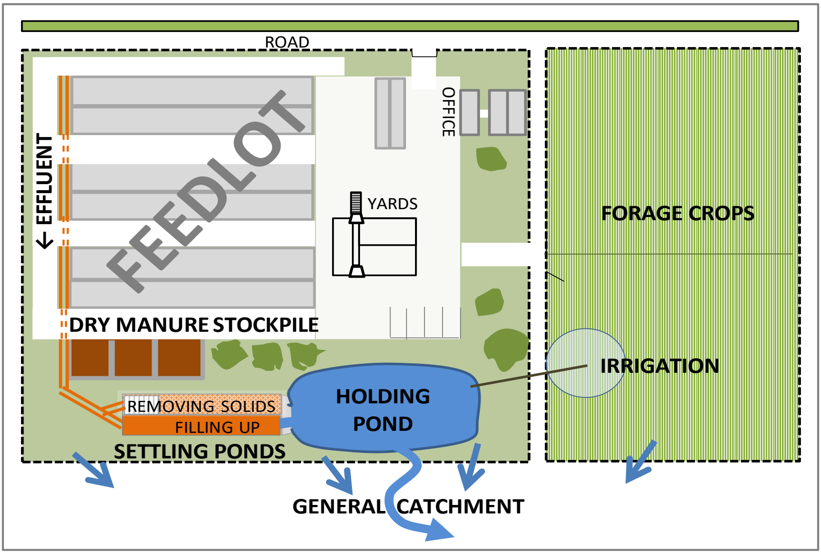


Figure 3.59: Illustration of a simple feedlot effluent disposal system with two settling ponds (1.5 m depth), allowing removal of solids from pond A, while pond B fills up with effluent. Up to 70% of solids settle within 10 minutes. Dry manure is stocked for sale or processing, and the holding pond water, which is high in nutrients is used for irrigating and fertilising forage crops [19, 20].

3.6. Husbandry of buffalo in cattle feedlots

Australian buffalo exported to SE Asian markets are normally held in cattle feedlots and managed similarly to cattle. However, there are physiological and behavioural differences between the two species that need to be taken into account to ensure best practice management and welfare of the buffalo[21].

Figure 3.60: Australian commercial swamp buffalo on board ship and discharging at port of arrival (Sabah, Malaysia).

Feedlot design (buffalo): Cattle yards, races and holding pens are generally suitable for both Swamp and Riverine young adult buffalo with tipped horns[22]. There are some different husbandry requirements to consider when holding buffalo in cattle feedlots, as follows:

Figure 3.61 Swamp (left) and Riverine (right) buffalo (NT).

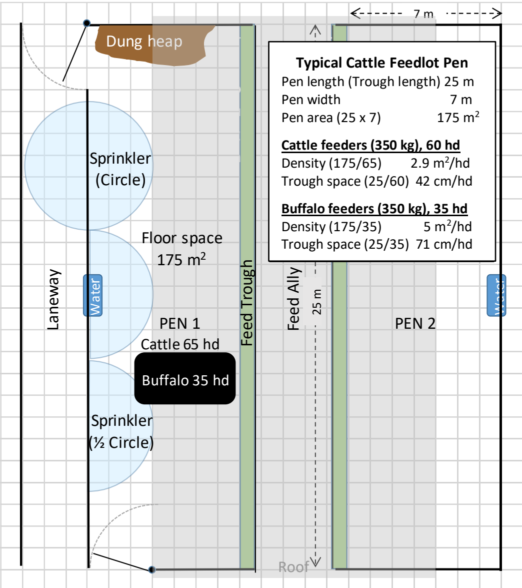
- Heavier bulls (>650 kg LW) are usually too large for standard cattle races (700 mm wide) and need a wider buffalo race of 750-800 mm width. [21]
- Groups of buffalo are easier to manage when given more space than cattle, therefore the re-commended pen density for buffalo in holding

[21] This section is from *Management of Australian Water Buffalo in South East Asian Cattle Feedlots (2018)*[22] , available at: https://dpir.nt.gov.au/primary-industry/primary-industry-publications

[22] Tipped horns are a requirement for live export of Australian buffalo.

pens is 5-7 m²/head[23] (compared to 2.5-3.5 m²/head for cattle). At this density, buffalo tend to defaecated in a common area, thereby reducing cleaning time.

- Access to shade and clean drinking water is essential, as buffalo are less tolerant than *B. indicus* cattle to direct sun during hot and humid summer days. A pressurised water hose should be on hand to manually spray animals that show signs of heat stress (see *Heat Stress*, page 169).
- Sprinklers are recommended for handling yards and holding pens where buffalo are routinely held for several weeks or more. These are commonly used to cool down dairy cows in the summer. The sprinklers should have a moderate droplet size. They are normally operated for 15 minutes each hour during the hottest part of the day (see Figure 3.62).



Evaporative cooling using sprinklers (for dairy cattle) or manual spraying of buffalo to alleviate heat stress.

Figure 3.62: Typical feedlot pen with floor space of (25 m x 7 m =) 175 m2, holding optimal numbers of feeder cattle or buffalo, and showing position of sprinklers and likely area of buffalo defaecation.

[23] Stock density for housed buffalo in Italy is ≥4.5 m²/head.

Unloading, transportation, feedlot entry (buffalo): Moving buffalo from A to B requires quiet and gentle handling, caution and patience. It is best carried out by well-trained buffalo handlers (see **3.2 Cattle and buffalo handling**, page 32). Good handling of buffalo takes a bit longer than cattle. Guidelines for moving buffalo from the ship to the feedlot and feedlot entry are as follows:

- Before discharge from ship, consult the ship's veterinarian or head stockmen about the health status of the buffalo, particularly loss of appetite and injuries during the voyage. Affected animals will need to be monitored at the feedlot. Standard operating procedures for loading, transportation, and unloading of cattle also apply to buffalo (see **4. Standard Operational Procedures (SOPS)**, page 200).
- Standard operating procedures for new arrivals of cattle at the feedlots also applies to buffalo, including induction rations. Premixed feeds and pellets containing Rumensin® (active ingredient Monensin) should not be fed to buffalo as they are intolerant to the additive and its consumption is often fatal.

Handling buffalo: The principles of low-stress handling of cattle also apply to buffalo, but there are some notable differences in behaviour between the species to be aware of, as follows:

- Experienced stockmen say that buffalo appear to learn quicker than cattle and have a better memory. Routine hand feeding and patient handling by the same stockman will hasten their domestication and trust towards that person.
- Buffalo should be given time to adjust to unfamiliar surroundings and management routines.
- Allow plenty of room in handling yards for buffalo to move around and avoid putting too much pressure on individual animals. When working in handling yards, a rule-of-thumb is to reduce numbers of buffalo by 1/3 of the numbers normally used for cattle.
- Avoid handling buffalo in yards during hot summer days as they can overheat more quickly than cattle. If necessary, schedule yard work for the cooler parts of the day, and spray the animals frequently with a water hose.
- Keep older bulls separate from younger bulls in holding pens and handling yards.
- Keep visitors at a distance from active handling yards to avoid 'spooking' and stirring up the buffalo.
- Be aware that processing of buffalo (particularly new arrivals) is likely to take longer than for cattle, and will be more efficient with a few experienced handlers that adhere to quiet, gentle and patient handling.

- Stockmen should take advantage where possible to use the herding instinct of buffalo to follow each other up and down ramps and along laneways. If necessary, cattle talkers can also be used to encourage buffalo to move forward in races.
- Buffalo can become aggressive if they have been upset by something (e.g. noise) or heat stressed, and will stand their ground or charge someone who comes too close. This becomes dangerous when dealing with an angry ¾ tonne animal. The best way to diffuse this situation is to back off quickly (i.e. reduce pressure) and leave the animal to calm down. A spray of water and some hay will hasten the calming process.

Figure 3.63: Australian swamp buffalo feeding (Vietnam).

Buffalo nutrition: Buffalo fed forage based diets generally have higher feed intakes than cattle, because they are more efficient at digesting forage. When forage based diets are supplemented with protein feeds, levels of rumen ammonia and blood urea are higher than in cattle, and recycled urea levels in saliva are much greater. Growth rates of Australian swamp buffalo do not seem to improve above 35% concentrate in a forage-based ration (DM basis), suggesting that this is optimal for buffalo growth on this type of diet (see Table 3.16 and Figure 3.63) [23].

Table 3.16: Basic composition of buffalo feedlot rations for optimal growth

Buffalo (300 kg)	Proportion of ration	Feed intake (kg DM/d)	As Fed (kg FM/d)
Total feed intake	100%	6.0	17.9
Forage (25% DM)	65%	3.9	15.6
Concentrate (90% DM)	35%	2.1	2.3
Energy feeds[1]	25%	1.5	1.7
Protein feeds[2]	10%	0.6	0.6

1. Such as, corn (crushed) wheat pollard, rice bran, or tapioca waste.
2. Such as, palm kernel cake, copra meal, and soybean meal.

Heat stress (buffalo): In the absence of shade or water (i.e. to immerse themselves), buffalo are more prone to heat stress due to physiological differences in body temperature control (thermoregulation) compared with cattle. Body heat loss through evaporation in buffalo is mostly by panting whereas cattle lose much of their body heat by sweating (see Table 3.17). Buffalo are poorly adapted to sweating because the skin has only 1/6th of the sweat gland density of tropical cattle. The black skin of buffalo readily absorbs solar radiation and the thin covering of hair is little protection against a hot sun.

Table 3.17: Relative contributions (%) of sweating and panting to evaporative heat loss in buffalo and cattle [24].

Method	Buffalo	Cattle
Sweating	12%	85%
Panting	88%	15%

Feedlots for holding buffalo need to have water hoses and sprinklers installed (see Figure 3.62, page 112).

Managers must be vigilant during hot summer days by monitoring the Temperature Humidity Index (THI) and look for signs of heat stress in buffalo. Breathing rates of 75-85 breaths/minute (BPM) should activate heat stress preventative measures, using water hoses and sprinklers (see Heat Stress, page 169).

Buffalo health: Common diseases of cattle that also affect buffalo, such as clostridia, external parasites and worms, are subject to health protocols treatments prior to shipment or on arrival at the feedlot (see **3.6 Husbandry and Health**, page 155). The acute viral infectious disease Malignant Catarrhal Fever, which spreads by contact with sheep, is a major risk to Australian buffalo exported to SE Asia as there is no available treatment and is fatal in affected animals [21].

Bladder stones: The formation of bladder stones[24] (urolithiasis) can become a problem in ruminants, especially in castrated males, causing blockage of the urinary track. Feral buffalo are likely to have a higher incidence of harmless stones because of mineral imbalances in feed and water due to their harsh nutritional and climatic conditions. When the animals are fed feedlot rations with mineral imbalances, this may lead to further growth of a stones until a blockage occurs in the urinary tract. Clinical signs are; observed abdominal pain, thrashing tail, straining to urinate, and dribbling bloodstained urine.

[24] Aggregates of mineral salts, which can obstruct the urinary tract.

Without surgery to remove the stone, the only alternative is to slaughter the animal and salvage the carcass.

Subclinical presence of bladder stones can be managed as follow:

- Provide 25 g calcium (Ca)/head/day in the ration and make sure its ratio with phosphorous (P) in the total ration is about (Ca:P) 2:1.
- Include ammonium chloride in the ration mix at a rate of 50-80 g/head/day.
- Provide 30 g/head/day of salt in the ration together with salt blocks in the feed trough to encourage animals to drink more water.
- Have drinking water analysed for high mineral content, and consider installing water filtration technology if high mineral levels are found.

Rumensin® intolerance: The active ingredient Monensin is often included in compound and pelleted feeds for cattle at a rate of 25 mg/kg, to improve feed efficiency, control coccidiosis, and reduce acidosis and bloat (see Figure 3.64). Buffalo have a much lower tolerance to Monensin than cattle, and should not be offered feeds containing this substance. Symptoms of poisoning with Monensin in buffalo include loss of appetite, muscular weakness, laboured breathing, lying down, and ultimately death within a few hours.

Figure 3.64: Cattle feed pellets containing Monensin (Vietnam)

3.7. Breeder Herds

Many factors need to be considered before determining size and composition of a breeder herd of Australian commercial cattle, the first being land constraints. Traditional cattle breeding on extensive pastures is not usually possible for commercial herds in SE Asia due to land availability, with the exception of plantations. Ideally, a semi-intensive system that combines a feedlot facility with limited cropping and pasture area, will reduce the extent of land required for breeding.

Herd size and composition: The size of the herd is determined by the carrying capacity of the farm and its feed resources and holding facilities. For example, rotational grazing of 50 ha of improved pasture could support 75 pregnant breeders (at stocking rate of 1.5 head/ha), compared with the same number on a cut-and-carry system from 5 ha of cultivated Elephant grass (*Pennisetum purpureum*), together with holding facilities and a few hectares of improved pasture for grazing (see Figure 3.2, page 27).

A breeder herd comprises of different classes of cattle (i.e. bulls, cows, calves, weaners, and yearling heifers and bulls). If carrying capacity of 50 ha of pasture for grazing (or 5 ha of Elephant grass for cut-and-carry) is 75 breeders, in reality there will need to be fewer breeders to have sufficient feed for the rest of the herd (i.e., bulls and progeny), unless other sources of feed are available. *Note:* In this example, stocking rates are high due to all-year-round rainfall.

Adult Equivalents (AEs): This is an animal unit measure for calculating carrying capacity of cattle operations (e.g. an extensive grazing area) over time. The unit measure is based on the comparative metabolisable energy (ME) requirements of different cattle classes according to their stage of growth and productivity. The AE values are formed by comparing the ME requirements of other cattle classes in the herd against that of a mature dry cow as the base unit. The AE values are used to estimate the size and composition of the herd according to carrying capacity of pasture, or other feed sources, in terms of energy available over a set period of time (usually a year). (see Table 3.18, next page, and Appendix A6, A7 for further details).

Table 3.18 shows estimated AEs for Brahman crossbred breeder herds used in SE Asia as standards for calculating carrying capacity of common grazing areas, plantation understories and semi- intensive cattle operations.

Table 3.18: Standard Adult Equivalents (AEs) used for Brahman crossbred breeder herds in SE Asia.[25]

Cattle Class	LW (kg)	ME needs. (MJ/d)	AEs	
Dry cow	425	61	1.0	
Late pregnancy	450	88	1.4	Breeder[1]
Breeder with calf	425	85	1.4	
Bull	500	113	1.8	
Weaner	200	46	0.8	
Yearling	300	65	1.1	

1. Annualised for the breeding cycle of a productive cow.

Infobox 3.22: **Estimation of Carrying Capacity (CC)**

- **Area (ha):** 50
- **Feed resource:** Pangola pasture
- **Yield (t/ha/y):** 10
- **ME value (MJ/kg DM):** 8
- **Cattle class (AEs)**: Late preg. /lactating breeders (1.4 AEs)
- **ME required (MJ/hd/d):** 87
- **Breeder nos. (hd)**: 75 (75x1.4= 105 AEs)
- **Stocking rate (SR):** (75 hd/50 ha) = 1.5 hd/ha (2.1 AEs/ha)
- **Available ME (MJ/ha/y):**
  (10,000 kg DM/ha/y x 8 MJ/kg DM =) 80,000 (80k) MJ
- **Trampling factor (TF=50%)#:** (50% x 80k =) 40k inedible + 40k edible (MJ)
- **ME required (MJ/SR (ha)/y):**
  (2.1 AEs x 61 MJ* x 365 d =) 46,757 (47k) [*1 AE = 61 MJ]

> SR of 1.5 hd breeders/ha/y (2.1 AEs) is (47k/40k), 18% above CC.
> Max. CC is 1.25 hd/ha/y (1.75 AEs), needing 39k MJ [i.e. 62 hd/50 ha].

 # *Note:* Trampled and soiled grass (i.e., 20-50% of pasture) is considered as inedible; e.g. 10,000 MJ ungrazed - (10,000 MJ x 35% TF) = 6,500 MJ edible

Herd projections: The breeder herd composition is calculated from production targets (Table 2.4, page 17) and the estimated carrying capacity of grazing area. Using the above example (Infobox 3.22), that 50 ha of improved pastures can only support 62 pregnant breeders or (62 hd x 1.4 AEs=) 87 AEs/ha, but actual herd composition (i.e. dry cows, bulls and progeny) increases total AEs from 87 to 157.5 (see Table 3.19, next page).

[25] These AE values for Australian cattle in SE Asia are slightly higher than Northern Australian standards due to operational and nutritional differences.

The daily ME requirement ([(157.5 AEs/50 ha] x 61 MJ x 365 d) =) 70k MJ/ha/y is almost twice that available (40k MJ/ha/y) from the 50 ha of pasture.

Table 3.19: Projected composition of with 62 breeders (157.5 AEs).

Year 1 Breeding Cycle[1]		Replacements/Mortalities (m) and Turnoff		Year 2 Breeding Cycle
Class	Composition [hd (AEs)]	Transfers/Losses (hd)	Sales (hd)	Leftovers [hd (AEs)]
Breeders	50 (70)	+12♀/-12♀	12c[2]	62 (87)
Dry Cows	12 (12)			
Bulls	2 (3.5)			2 (3.5)
Yearling	36 (40)	+20♀,+21♂	8♀/21♂	36 (40)
Weaners	40 (32)	+43♀♂/-2 m		40 (32)
Calves	47	-4 m		NEXT PROGENY
Total	140 (157.5)	+95/-18	41	140 (157.5)

1. Reproductive performance (Targets): Pregnancy rate (80%), Calving rate (75%), Weaning rate (65%), Culling breeders (20%), Mortality (mort.) (10%), Calving interval[26] (15 months). 2. c (culls).

When herd size and consumption becomes greater than pasture availability, there are a number ways to achieve a sustainable carrying capacity, such as:

- Provide additional feed to supplement grazing.
- Hand feed yearlings in pens to reduce SR on pasture.
- Reduce the number of breeders and raise herd productivity.

Additional feed: The shortfall of feed energy for the above breeder herd is 30,000 MJ/ha/y. This would require an additional 150 bales/ha of Pangola hay (or about 7,500 bales/50 ha (180 t) for the whole herd per year) which would not be viable for the above example.

Hand feeding yearlings: Separation of 35 yearlings (250 kg LW) into pens and hand feed for 120 days prior to transfer or turnoff would only increase annual carrying capacity of the pastures by 8% for grazing by rest of the herd.

Use less breeders and improve productivity: Reducing the number of breeders in the herd by almost half (from 62 to 35 head) would increase grazing to 90% of carrying capacity with a requirement of 45.5k MJ/ha/y (versus 40k). There

[26] Period between one calving to the next calving.

is also an opportunity to improve reproductive performance with a smaller herd, and feed cost are lower with more access to grazing. Supplementary feeding would require about 30 bales/ha/y, and lot-feeding 25 yearlings for 90 days would significantly increase pasture availability due to lower SRs and reduced trampling. Reproductive performance needs to exceed targets with smaller herds (e.g. 35 breeders) to produce a greater turnoff rate of yearlings per breeder (54%) than larger herds (e.g. 62 breeders; 44% turnoff) grazing 50 ha of pasture (see Tables 3.19 and 3.20).

Table 3.20: Projected composition of a smaller breeder herd with improved management (Total AEs 102).

Year 1 Breeding Cycle		**Replacements, Mortalities (m) and Turnoff**		**Year 2 Breeding Cycle**
	Composition	**Transfers/Losses**	**Sales**	**Leftovers**
Class	**[hd (AEs)]**	**(hd)**	**(hd)**	**[hd (AEs)]**
Breeders	30 (42)	+5♀/-5♀	5c[2]	35 (47)
Dry Cow	5 (5)			
Bulls	2 (3.5)	0		2 (3.5)
Yearling	25 (27.5)	+12♀,+12♂	7♀/12♂	>25 (28)
Weaners	26 (24)	+24♀♂/-1m		>26 (24)
Calves	28	-3m		NEXT PROGENY
Total	88 (102)	+53/-4m	24	111 (143.5)

1. Reproductive performance (Improved): Pregnancy rate (85%), Calving rate (80%), Weaning rate (75%), Culled breeders (15%), Mortality (m) (7%), Calving interval = 14 months. 2. c (culls).

There are significant gains in developing an efficient and profitable breeder herd over time through improvements in herd management. At the outset, culling of breeders with poor fertility and mothering ability are critical for stabilising calving rates and survival. The outcome will eventually result in a better output of progeny, with lower mortality and less culling of breeders, thereby maximising the reproductive efficiency of the herd.

Calving interval: Both herd composition tables above (Tables 3.19 and 3.20) are based on calving intervals between 14 and 15 months. Although annual calving is the ideal target, this is not easy to achieve and maintain. Usually heifers are not culled for fertility if they miss their second pregnancy within 18 to 24 months, but are culled if they do not fall within the average calving interval of the herd after their second calf (see *Segregation of heifers*, p.123).

Breeding strategy: The aim is to maximise conception rates and ensure optimal conditions for the breeding cycle as well as progeny growth and survival. Ideally, breeders should be mated and calves reared when nutrition is maximised with abundant forage during seasonal rainfall. A number of strategies are used to maximise breeding efficiency as follows:

Selection and Culling Criteria: Breeder herd productivity and composition is reviewed at least annually, when all the cattle are yarded and can be individually inspected. Breeder cows that are not considered productive anymore should be removed (culled) from the herd and sold. Culled cows may be replaced with their daughters as long as the herd bull is unrelated to the replacements.

General criteria for culling breeder cows:
- Age limit (i.e. 10 years).
- Failure to conceive or calve (1st calf heifers get a second chance).
- Failure to raise calf (poor mothering ability).
- Abnormal characteristics (i.e. bad temperament, physical defects, eye or teeth problems, poor body condition, udder deformities, etc.).

General criteria for selecting herd bulls:
- Bulls should be unrelated to breeder cows.
- High-grade tropical breed (>75% *B. indicus*). *Note:* Imported stud bulls may not perform as well under different environmental conditions.
- Peak performance during 3-5 years of age
- Sound body structure, especially hind legs.
- Normal penis/sheath structure.
- Meets fertility test standards:
  - > Scrotal size (circumference >32 cm with *B. indicus*) for higher fertility.
  - > Semen density, forward motility (>30%), and normal shape (>80%).
  - > Libido or serving capacity test using bull and teaser cow to observe mounting ability and frequency.
- High growth rate potential from performance records (see page 123).

Figure 3.65: Measuring scrotum size of young bull.

Note: Stress from poor nutrition, overfeeding, transportation, extreme weather conditions, etc., can affect bull fertility in the short-term.

Natural mating: Bull-to-cow ratios in breeding herds are usually 25%, therefore a breeding herd of 100 head would have 4 bulls. This ratio maybe increased in smaller herds to 30-40% for established bulls that are fully tested.

Continuous (natural) mating: In regions with all-year-round monthly rainfall and forage is abundant and continuously growing, bulls can run with the breeder herd throughout the year. It is good practice to separate bulls for 2-3 months from the herd to regain body condition and libido, or replace with different bulls to maintain the continuous mating system (see Figure 3.65, left circle).

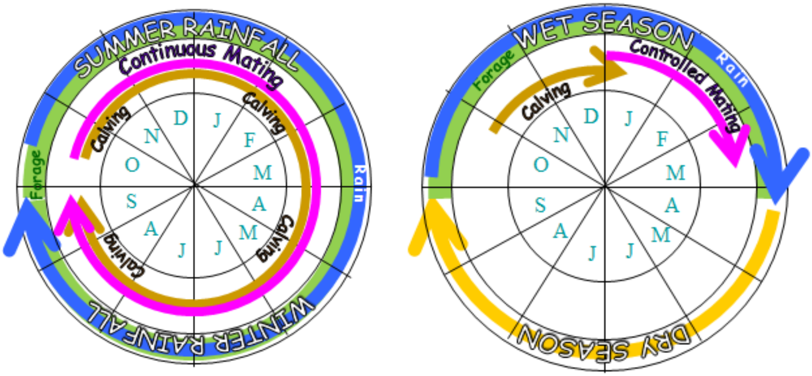


Figure 3.66: Calendars of Continuous and Controlled Mating according to seasonal rainfall and abundancy of green forage (Southern Hemisphere).

Controlled (natural) mating: In regions that have a seasonal dry period[27] during which green forage availability is limited and low in nutrition, the practice of controlled mating is recommended. Under this system, the bulls run with the breeder herd for 2-3 months only. This mating period is scheduled so that the calving period (i.e. 9 months later) occurs around the onset of the wet season when pasture growth and nutrition is optimal for reproduction, including calving, lactation, mating and conception (see Figure 3.66, right circle). The shorter the dry season, the longer the bulls can run with the breeder cows, resulting in an extended calving period.

[27] Northern Australia, East Java and Nusa Tenggara (Indonesia) are examples of regions with long dry seasons.

Controlled mating (natural or artificial insemination (AI)) can also be used for forward planning to target peak market demand such as festivals. For example, to supply 300 kg young Brahman bulls to the Indonesian Korban market requires controlled mating from about 30 months before the event (see Infobox 2.1, page 10).

Pregnancy Testing: The foetus can be detected 2 months after conception (or earlier with ultra sound). Cows can be pregnancy tested (PT) at least 2 months after removal of the bulls (controlled mating) or quarterly during the year when bulls are continuously run with the breeder herd (continuous mating). The fate of non-pregnant breeders is also decided at this time.

Weaning: From 120-150 kg LW or around 6-8 months of age, calves may be separated (weaned) from the dam (cow). This allows the pregnant dam to maintain body condition as the foetus develops. Wean all calves together in a controlled mating system; for extended mating periods, a second round of weaning is required to remove remaining calves that were underweight at the first round of weaning. Quarterly weaning is needed for continuous mating.

Segregation of heifers: Brahman heifers are ready to mate at 320-340 kg LW at BCS 3.5 [25]. After delivering their first calf, the young cows are notoriously difficult to conceive again within a reasonable calving interval. This is because of the strain on the young cow's body condition from birthing and nursing their first calf.

The chance of conception can be greatly improved by segregating first calf heifers from the main breeder herd just prior to birthing, and provide a higher plane of nutrition from better pastures and supplementary feeds (see *Supplementary feeding*, page 128). After a few months, the young cows return with their calves to the breeder group and herd bulls. This feeding strategy enables young breeders to regain body condition and return to oestrus, thus increasing the chances for a second pregnancy within a 12-14 calving interval.

Performance monitoring of progeny bulls: Apart from fertility, high growth rate potential of young bulls is an important attribute that breeders and buyers seek when selecting herd bulls. All the male progeny are monitored for their performance by keeping records of birth dates and live weights during their growth phase towards adulthood. The data collected from weaning to 20 months of age is used to rank the performance (and price) of bulls for sale (see Table 3.21, next page. and Figure 3.67, page 125).

Method: Guidelines for selecting superior bulls from breeder herd progeny:

- *Day 1:* Record date of birth and weight of all newly born calves, and eartag IDs of calf and mother cow.
- *Weaning (±200 d):* Select a group of male calves visually and from their live weights at weaning as candidates for performance monitoring. Ensure data is recorded correctly according to eartag IDs of selected weaners.
- *300 d old:* Record live weights of the young bulls in the selected group and determine the growth rates of each animal since birth. At this stage, animals with low growth rates (e.g. 20% or more, lower than top highest rates) could be removed from the group.
- *600 d old:* Record the live weights of remaining bulls in selected group and determine growth rates for 300-600 day period (see Table 3.21).

Table 3.21: Record sheet for performance monitoring for selecting bull selection.

Bull ID	Mother Cow	Birth Date	300 Days			600 Days		
			LW (kg)	Age (day)	ADG (kg	LW (kg)	Age (day)	ADG (kg)
A#221	A#611	1/11	95	305	0.39	250	480	0.74
C#221	C#511	1/10	105	335	0.39	265	510	0.77
C#222	C#611	1/7	120	305	0.48	300	575	0.57
D#222	E#311	1/6	115	305	0.46	325	590	0.65
D#223	E#411	1/5	130	310	0.50	340	600	0.64
D#224	No tag	1/6	105	290	0.45	320	590	0.63

ID (Identification); LW (Liveweight); ADG (Average Daily Gain or growth rate).

- *Graphic:* Create a graph of growth rates (ADG) for 1-300 days (X-axis) and for 300-600 days (Y-axis). For each animal, mark the point where the growth rates cross (see C#222 in Figure 3.67).
- Draw a reference line from the last measurement on the X-axis to the same measurement on the Y-axis (i.e. 0.6 to 0.6 in Figure 3.67).
- Use the reference line to draw parallel lines up through the clumps of data, until the last data point is reached (i.e. D#223 in Figure 3.67). This bull has the best performance in terms of both weaner and yearling growth rates, and would grade as a superior breeding bull for beef production. The other two bulls on the topmost parallel line would also be considered as herd bulls for replacements or sale.
- The middle parallel line in Figure 3.67 passes through a cluster of lower performing bulls that would be considered for lot feeding and slaughter.

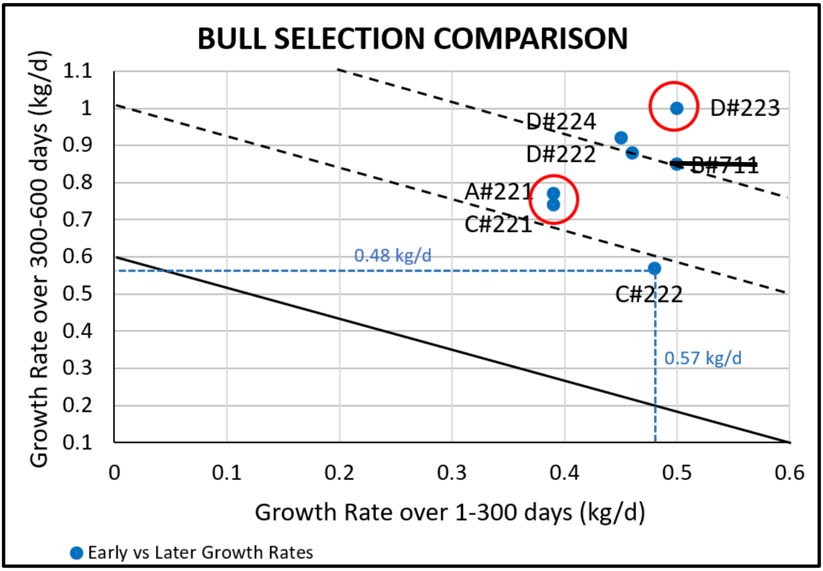


Figure 3.67: Bull selection for growth rate.

Estimated Breeding Values (EBVs): A bull's breeding value depends on what 'above average' performance traits are most important for the profitability of a breeding operation. These traits range from milk production and ease of calving (in daughters), to fertility, growth and carcase quality (in sons). The aim is to identify bulls with the desired traits to pass on to their progeny. Any performance traits that are above a herd average can be quantified as an Estimated Breed Value. This allows cattle breeding operators to obtain bulls or semen according to their EBVs of desired performance traits to improve the productivity of herd.

Table 3.22: Example of EBVs of a bull for sale (*Note:* + value is above average performance).

TROPICAL BULL	EBV
Calving ease	+0.5
Gestation length (d)	–0.1
Birth weight (kg)	+0.1
200 days weight (kg)	+19
400 days weight (kg)	+18
600 days weight (kg)	+24
Mature cow weight (kg)	+25
Milk (kg)	+4
Scrotal size (cm)	+1.3
Carcass weight (kg)	+14
Eye muscle area (cm^2)	+0.8
Rib fat depth (mm)	–0.1
Rump fat depth (mm)	+0.0
Intramuscular fat (%)	+0.1

EBVs are generated from computer software called Breedplan, which is a data input program for registered cattlemen who are improving their herds or selling high performing bulls. The data for each animal in the herd is entered into the program regularly and sent to the Agricultural Business Research Institute (ABRI)[28], which developed Breedplan. ABRI's services to cattle breeders is to help select genetic traits to improve the performance of stud bulls and profitability of their breeding herds over time. Their services also extend to beef producing countries around the world, including Thailand and Philippines in SE Asia.

Maintaining herd integrity: There are a number of options for expanding the breeding operation, and maintaining or improving the performance of a breeder herd imported from of northern Australian, as follows:

- Import more bulls (or semen for artificial insemination) to put over female progeny from the herd.
- Import more in-calf heifers, and use selected bull progeny from the breeder herd.
- Upgrade native breeder cattle with a Grading Up breeding program using purebred Brahman bulls (or semen) to mate with consecutively upgraded (i.e. F1 to F4) local cows. This requires at least four generations of breeding to achieve an upgrade of more than 90% Brahman genetic content in the offspring, which is considered a purebred (15/16 Bra.) (see Figure 3.68).

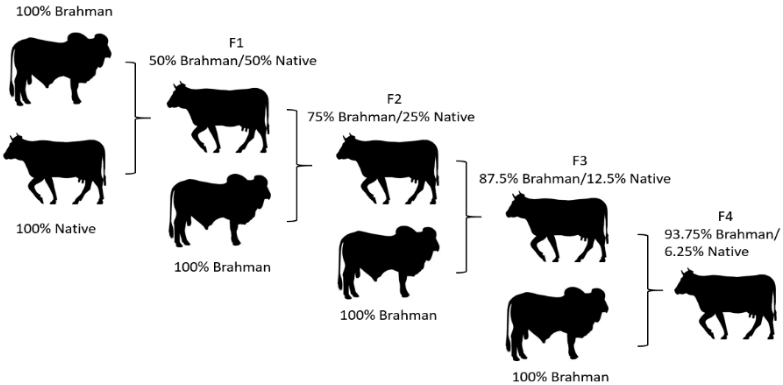


Figure 3.68: Grading Up breeding program to upgrade native cows into high grade Brahman breeders.

[28] Breedplan, c/o ABRI, University of New England, Armidale NSW 2351; https://breedplan.une.edu.au/products/breedplan/

<u>*Record keeping*</u>*:* All breeder herd calves are weighed at birth and given an eartag identification (ID) number (ear tagging may be left a few days until calf has settled). Records of each animal in the herd should include breed, sex, live weights (dated), body condition score, reproductive status and health treatments. This data needs to be updated during the year (at least 6 monthly) to monitor the performance of individual animals and the herd (see **3.11 Records**, page 181, for more details).

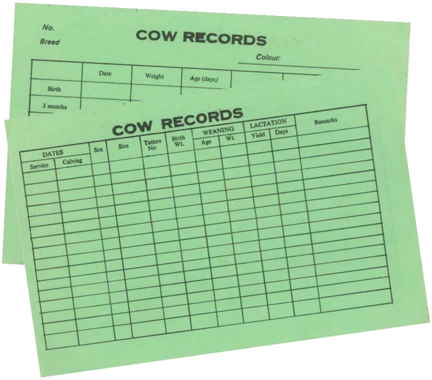


Figure 3.69: Cow records.

<u>*Operational planning calendar*</u>*:* A breeding strategy (see Table 3.23) and feed availability versus total AEs (see Appendix 8) are examples of planning calendars for implementing breeder operational planning options.

Table 3.23: Breeding strategy calendar for controlled mating (e.g. northern Australia) and continuous (i.e. Sabah, Malaysia) in Australian beef cattle herds.

Controlled Mating

J	F	M	A	M	J	J	A	S	O	N	D
Wet/Growing Season				Dry Season (cooler)				Wet Season (hot)			
Cows	Mating Period								Calving Season		
Calf				Wean			Wean				
Heifer				PT			PT	Segregate PT^{+} Heifers			

Continuous Mating

J	F	M	A	M	J	J	A	S	O	N	D
Winter			Summer (less rain, hotter)					Winter (more rain)			
Continuous Mating											
Calving Season											
Wean				Wean				Wean			
PT	Segregate PT Heifers			PT	Segr. PT Heifers			PT	Segr. PT Heifers		

Pregnancy tested (PT)

Supplementary feeding: Breeder herds require a consistent supply of good quality forage to maintain productivity, whether it is improved pasture, understorey forages in plantations or cut-and-carry for stalled cattle. However, forage based diets also need supplementation at various stages of reproduction to ensure the best outcomes. Equally important is the availability of ample cool clean water for grazing cattle, particularly for lactating cows.

Late pregnancy, early lactation, and body condition for mating, are physiological stages that have increased demand for nutrients. Extra feed (or spike feeding) is required for segregated groups of young cows nursing calves, and breeder herds during the short period with the bulls in controlled mating systems. If forage nutrition deteriorates towards the end of a dry season or during a drought, then additional fodder and concentrates may be required to maintain body condition (see example at Table 3.24). Continuous mating breeder herds will also benefit from all-year-round access to a urea-based lick block containing Ca, P and S (see next section).

Table 3.24: Example of supplementary feed formulation for breeder groups (daily requirements per head)

INGREDIENTS	Late Pregnancy/ Early Lactation/ Joining (mating)	Creep Feed (Calves)
Corn	1.5 kg	250 g
PKC/Copra/CSM[1]	2.5 kg	250 g
Salt	25 g	
Minerals[2]	Urea base, plus Ca, P, S	

1. Protein meal options (use ½ amount for CSM): Palm kernel cake (PKC), Copra, Cottonseed meal (CSM). 2. Provided as loose mix or lick block (±100 g/d) (see Tables 3.25 and 3.26), page 129.

Important minerals for reproduction: In addition to the daily mineral requirements for beef cattle (see ***Minerals and vitamins***, page 58), breeders specifically need more Ca and P (e.g. 25 g/d for each), and N during their reproductive phase (3rd trimester, lactation, conception). Under controlled mating, delivery of these minerals are in the form of lick blocks or loose mixes as part of feed supplementation given during the reproductive phase, with emphasis on P in the wet season and urea (N) during the dry season. In the case of continuous mating, lick blocks or loose mixes are provided all-year-round, especially when forage quality is decreasing during periods of low rainfall. Examples of mineral supplementation are on the next page.

Table 3.25: Example of a Lick Block formula for breeder cattle.

Lick Block (Intake ±100 g/d)	Ingredient (%)	Mineral intake (g/100 g))	DR[1] (%)
Urea	20 %	9 (N)[2]	
Dicalcium phosphate	35 %	8 (Ca), 6 (P)	30 (Ca), 25 (P)
Ammonium sulphate	10 %	2 (N)[2], 2.5 (S)	19 (S)
Salt	35 %	35 (NaCl)	100

1. % of Daily Requirements (DR). 2. Total protein equivalent: 11 g N x 6.25 = 69 g CP (14% DR).

Table 3.26: Example of a Loose Mix formula for breeder cattle.

Loose Mix (Intake ±100 g/d)	Ingredient (%)	Mineral intake (g/100 g))	DR[1] (%)
Urea	15 %	7 (N)[2]	
Dicalcium phosphate	30 %	7 (Ca), 5.5 (P)	30 (Ca), 25 (P)
Ammonium sulphate	10 %	2 (N)[2], 2.5 (S)	19 (S)
Salt	35 %	35 (NaCl)	100
Protein meal e.g. copra	10%	0.4 (N)[2]	

1. % of Daily requirements (DR). 2. Total protein equivalent: 9.4 g N x 6.25 = 59 g CP (12% DR).

Water requirements for reproduction: In addition to daily water allowances for tropical beef cattle, a number of rule-of-thumb advisories for productive breeders are listed below:

- Productive breeders from late pregnancy require about 30% more water than dry cows.
- Additional allowance of 1 L water per L milk produced.
- Temperate cattle (*B. taurus*) require up to 25% more water than tropical breeds as temperature rises.
- High humidity together with high temperatures increases thirst, as does water containing salts at concentrations above 2000 mg per litre.
- A diet of fresh forage containing 75% water will only supply up to 30-50% of daily water requirements of productive cattle.

Seasonal water allowances for tropical beef cattle breeder herds grazing green pasture or consuming dry roughage are given in Table 3.27 (next page).

Table 3.27: Water allowances (Litres/day) for stock classes of tropical beef cattle breeder herds grazing green pasture (left-hand value) and dry pasture (right-hand value) at different seasonal temperatures.

WATER ALLOWANCE for Breeder herd stock classes (LW)	Temperature Range		
	25°C	30°C	35°C
Dry cow (425 kg)	15-35	30-45	45-60
Pregnant (3rd term) (450 kg)	35-60	55-80	85-110
Lactating (12 L/d) (425 kg))	50-75	70-95	100-120
Bull (500 kg)	30-55	45-75	70-100
Weaner (200 kg)	10-20	15-30	25-35
Yearling (300 kg)	15-30	25-45	40-60
Heifer (400 kg)	20-40	30-50	50-70

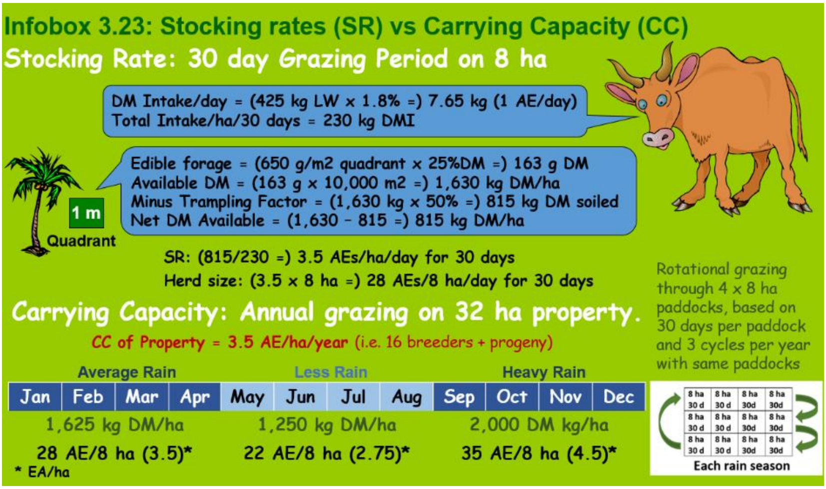
Grazing strategy: The aim is to optimise breeder herd productivity by grazing pasture as a sustainable feed source. To achieve this requires determining an optimal stocking rate and grazing pressure to maintain the feed source during the period of continuous and rotational grazing.

Stocking Rates (SR) vs Carrying Capacity (CC): The size of the breeding herd is limited by the area of pasture available (see ***Adult Equivalents (AEs)***, page 117). The number of cattle or AEs per hectare of land at any one time (or short term) is the SR. Different SRs are used during the year according to seasonal production of grass. CC is the average of fluctuating SRs over a longer period, usually annually.

> Stocking Rate = AEs/ha or head/ha (short-term)
> Carrying Capacity = AEs/ha or head/ha (long-term)

Infobox 3.23 (next page) shows an example of estimating the SR for a small breeding herd in a 30-day rotational grazing system and annual carrying capacity. There are four paddocks of similar size (8 ha) used for rotational grazing, which make up 32 ha of available pasture. Pasture production varies during the year due to seasonal rainfall, averaging 1,625 kg DM/ha with a capacity to support 16 productive breeders and their progeny for 30 days. During the drier season and heavy rain season, pasture production ranges from 1,250 kg to 2,000 kg DM/ha respectively. The CC for the year (i.e. average of SRs) is 3.5 AEs/ha. Options for the manager are:

- Maintain the herd size at 28-30 AEs and cut and conserve extra forage during the wetter season for lot-feeding and adding market value to yearling progeny during the dry season.



Trampling factor (25-50%) is subjective and depends on Stocking Rate.

- Cultivate 1 ha from the 32 ha pasture area to grow a high bulk forage such as Elephant grass, and incorporate lot-feeding into the breeding cycle. An extra 10 AEs could be add to the breeder herd.
- Establish a breedlot where breeders are lot-fed for more than half of the breeding cycle, using 22 ha of pasture for calving and lactation. The remaining 10 ha are cultivated for forage crops. The CC of this system triples the herd size to 100 AEs or about 64 breeders plus progeny. This would entail considerable investment in terms of facilities and machinery.

Carrying capacity, which takes into account variable stocking rates for different areas and seasons, and other management reasons, is the optimum SR (i.e. average AEs/ha) that can be maintained on a cattle property over time (usually annually), without adverse effect on pasture. Maintaining SRs for 2 or 3 months by buying in feed from outside sources is not used in calculating CC. The optimum range of SR/CC is determined as follows (see Figure 3.70, next page):

- Animal productivity per hectare (Gain/Unit Area) rises to a peak and then falls with increasing Grazing Pressure (SR), due to overgrazing.
- Animal productivity (kg Gain/Animal) decreases as Grazing Pressure (SR) increases, and is optimised at peak productivity per ha (Gain/ Unit/Area).
- Close to the point where Gain/Animal and Gain/Unit Area curves cross over in the graphic, this is the range for optimal stocking rate and productivity without over- or under-grazing the pasture. This crossover point will vary

during the year as pasture conditions change, resulting in a different value for CC (long-term measure) than for SR (short-term measure).

- Breeder herd productivity and SR can be measured as weaner live weight per herd breeder, or per ha. The preferred units are kg weaned per unit weight of breeder mated (or AEs) (Weaners/Breeders), and ha of pasture grazed (Weaners/Unit Area). See *Breeder herd efficiency*, page 225, for calculations.

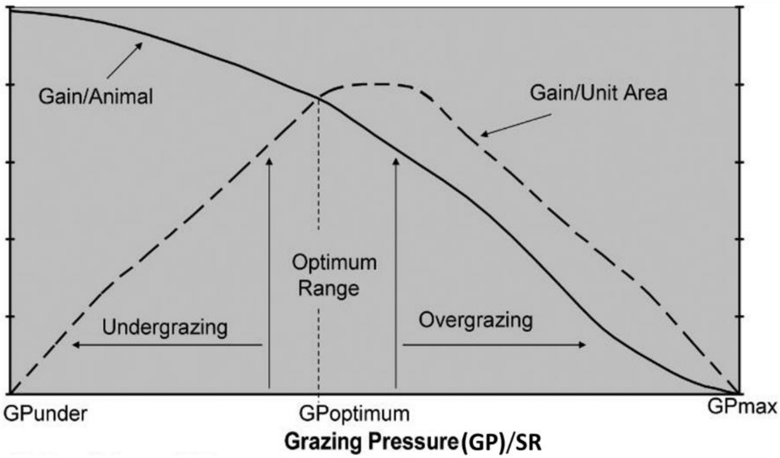


Figure 3.70: Optimum stocking rate/carrying capacity on pasture for animal production [26].

Grazing systems: Types of grazing management range from free-range to hand feeding (zero grazing) as listed below:

- *Free range:* Cowboys on foot or riding horses herd cattle to fenceless common grazing areas or under storey forage areas in plantations.
- *Herding/corralling:* This is free-range grazing with the herd brought back to a fenced enclosure at night,
- *Tethering:* Individual animals are tied to a tree or post with a long rope and left to graze the area according to the length of the rope. The animals are usually brought back to a stall at night.
- *Paddock grazing:* Fenced areas of pasture have many different grazing management systems, including the following:
  > *Continuous grazing/set-stocked:* Northern Australian cattle stations have very large paddocks for extensive grazing where a herd of cattle can remain in a fenced area throughout the year.

> *Rotational grazing:* A number of smaller paddocks are used to move cattle herds from one paddock to another every few months, allowing grazed pastures to recover, and breaking the life cycle of many cattle parasites.
> *Cell grazing:* Paddocks are small (e.g. 6 ha) and SRs are high with only sufficient pasture to support the herd for a few days before moving to the next paddock or cell. In wetter areas, there needs to be 15 or more paddocks to allow at least a 30-day rotation cycle and enough time for pasture in each cell to recover from grazing. This highly intensive management system requires careful monitoring of SRs each season.
> *Put and take:* Grazing pressure is carefully monitored and animal numbers varied to ensure that SRs preserve a desirable pasture mix.
> *Strip grazing:* Strip grazing features a moveable electric fence across the paddock. The fence is moved forward several metres each day to give cattle access to fresh grass. It is typically used for dairy cattle, allowing more control of pasture management.

Note: The more intensive the system, the more the grazing area becomes trampled and soiled with faeces, thereby reducing edible pasture. These areas recover quickly when cattle move on to the next cell or paddock.

• *Pasture spelling:* Cell and rotational grazing systems are designed to allow paddocks to recover after grazing with short-term spelling of 1-4 months. Intermittent pasture spelling is also used to invigorate paddocks that have been under continuous or rotational grazing for some years. The best time to spell a paddock is during the growing season for 6 months or longer to encourage the replenishment of the C4 grasses[29] in the tropics.

• *Zero Grazing/Cut & Carry:* This refers to feedlot, breedlot and stalled cattle operations that are mostly confined to holding pens. The breedlot and stalled cattle might have limited access to grazing, while cattle breeding enterprises may graze their herds on pastures for part of the breeding cycle (parturition and early lactation), and progeny yearlings are lot-fed using farm-grown or locally sourced forage mixed with concentrate feeds. The advantage of this system is the reduced pressure on the pastures grazed by breeding herds where grazing land is limited.

[29] Tropical (C4) and temperate (C3) perennial grasses have different photosynthesis pathways to capture CO2, giving tropical grasses more adaptability in warm climates.

Pasture Quality: Native pastures provide a basic level of nutrition but require supplementary feeding at critical points in the growth and reproduction cycle of cattle. Pasture grazing is improved by cultivating better quality grasses (e.g. Pangola, Guinea grass, etc.), which are often mixed with introduced legumes (e.g. Centro, Leucaena, etc.) to provide more protein for a better balance of nutrients for productive cattle (see ***Tropical grasses and legumes***, page 138).

Weed Management: Weeds can be a major problem in maintaining pasture productivity, particularly if overgrazed. Methods of controlling weeds are as follows:

- Hand pulling, hoeing (manual).
- Biocontrol (insects; i.e. Mexican beetle (Sida)).
- Spot spraying (herbicide).
- Slashing (machine).
- Boom spraying (machine/herbicide).
- Wickwipers/Carpet rollers (machine/herbicide).

Weeds of significance in Australia and SE Asia (see Figure 3.71):

Figure 3.71: (Left to right) Billygoat weed (*Ageratum conyzoides*); Lantana (*L. camara*); Siam Weed (*Chromolaena odorata*); Bellyache Bush (*Jatropha gossypiifolia*); Siamese Senna (*Senna siamea*); Candle Bush (*Senna alata*); Sida (*S. acuta*); Rats Tail (*Sporobolus pyramidalis, S. jaquemontii*).

Establishment and management of pastures and forage crops**:** The area of land designated for pastures should be flat or undulating, but not too steep. The area needs to be cleared of obstructions, such as large rocks, trees and dense scrub. However, it is recommended to retained small clumps of trees to provide shade for livestock. The next stage is cultivation of the cleared land, starting with ploughing, followed by harrowing until a seedbed has been formed. To avoid erosion on steeper slopes, plough across the slope (parallel to contours), and form contour bunds or ridges on steeper slopes (see Figure 3.72 below).

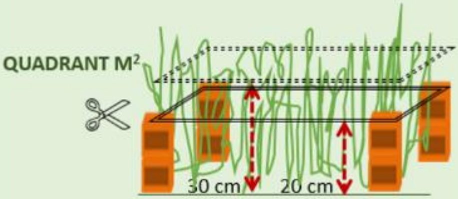
Figure 3.72: (Clockwise) Contour ploughing (across the slope) of cleared land to reduce erosion; seeding maize crop on contoured furrows; contoured lines of young Elephant grass across slope (Vietnam); bunding or ridging using a tractor implement (India).

If irrigation is not available, ensure that planting is done early in the wet season and the soil has sufficient moisture before sowing seed. Grass seed can be broadcast onto the seedbed by hand or spreader, or planted in rows 0.5-1 m apart, remembering to follow the contours of sloping land. The seed is pressed into the soil using a roller or light-weight harrow. Seed treatment or scarification may be required to improve germination (e.g. tropical legumes) by scratching the seed case, or hot water treatment. Sowing rates are about 5-10 kg/ha for grass seed and less for legumes. Grass and forage crop species that propagate vegetatively from stem cuttings, stolons etc., are transplanted into contoured furrows (see *Pennisetum purpureum* (Elephant grass), page 140).

Once grasses have established a well formed root system by the end of the first growing season, light grazing or cutting can commence. Cutting interval is usually around 40-50 days during the wet season, when the height of foliage above the ground is about 30 cm for low grasses and >90 cm for taller grasses. Respective cutting heights above the ground are 5 and 15 cm to encourage faster regrowth. Pastures of low grasses are ready for grazing when the sward reaches about 30 cm high, and is grazed down to 20 cm above the ground (approx. 20% of available forage), before moving cattle to the next paddock.

Infobox 3.24:

ESTIMATE GRASS (KG) BETWEEN 20-30 CM HEIGHT



Sites	Fresh (FM)	Dried (DM)	DM%
1.	735 g	184 g	25
2.	680 g	163 g	24
3.	473 g	123 g	26
4.	576 g	144 g	25
5.	624 g	150 g	24
		Average 152 g DM	

(152 x 10,000 =) 1,520 kg DM/>20 cm/ha

The amount of grass available between 30 and 20 cm height (ht) above ground varies depending on type of grass and density of growth. This can be estimated using an m^2-quadrant placed on two 10 cm high wooden blocks. The foliage above the 20 cm height is cut and collected, and this is repeated randomly five times around the paddock. The collected foliage from each site is weighed (as fresh), before drying (using sun, oven or microwave). The estimated amount of forage (i.e. kg DM/20-30 cm ht/ha) available from each site gives a sense of variability and average amount (e.g. 152 g DM/>20 cm ht/m^{2}); or 1,520 kg DM/ha of potential pasture for grazing (see Infobox 3.24).

Fertiliser and maintenance. Depending on soil fertility, pastures and cultivated forages respond well to nitrogen (N) and phosphorus (P) fertiliser applications of 50-75 kg N/ha/year (half at the onset of the wet season and half later in the wet season), and 20 kg P/ha/year (and every two years after first application). Feedlots normally apply cattle manure to on-farm pastures and forage crops instead of inorganic fertiliser. About 5-6 t of fresh manure per hectare is applied for equivalent levels of 50 kg N and 20 kg of P (see Table 3.28, next page).

Pastures and areas of forage production (e.g. Elephant grass) are prone to deterioration and weed invasion, if overused for grazing and cutting of tall grasses. Rehabilitation of these areas involve light cultivation of bad patches of overgrazing and rigorous weed control in the pasture, followed by over sowing with seed or runners of the existing grass or new species, and application of N-fertiliser. For cultivated tall grasses like Elephant grass, the area should be completely re-cultivated and replanted. A more sustainable use of these cultivated areas, together with weed management, will ensure a longer period of good productivity before requiring regeneration.

Table 3.28: NPKS values of common fertilisers and cattle manure.

Fertisers and manure	Nitrogen (N %)	Phosphorus (P %)	Potassium (K %)	Sulphur (S %)
N Fertiliser:				
Ammonium sulphate	21			24
Urea	46			
P Fertiliser:				
Monammonium phosphate (MAP)	12	22		
Diammonium phosphate (DAP)	18	20		3
Monocalcium phosphate (SSP)		9		11
Dicalcium phosphate (DCP)		18		
Tricalcium phosphate (TSP)		19		1.6
K Fertiliser (Potash):				
Potassium chloride (KCl/MOP)			52	
Potassium sulphate (SOP)			43	18
Feedlot manure (DM basis):				
Africa (35% DM) [27]	1.6-2.1	0.4-0.6	4.0-4.8	-
US feedlots: Pen, 34% DM, (stock-piled, 26% DM) [28]	2.4 (2.2)	0.8 (1.0)	2.6 (2.5)	-
Australian feedlots: Pen, 74% DM, (stockpiled, 63% DM) [29]	2.5 (2.2)	1.0 (0.8)	1.9 (1.9)	0.4 (0.5)
Abbreviations: Single Super Phosphate (SSP) Triple Super Phosphate (TSP) Potassium chloride (KCl), also called Muriate of Potash (MOP) Sulphate of Potash) (SOP)	*Notes:* P_2O_5 and K_2O (oxide form) are often used for P and K content in fertilizer. Multiply the oxide form by 0.44 (for P) and 0.87 (for K) to obtain the actual content of the element, e.g.: MAP; 50% P_2O_5 = (50 x 0.44) 22% P			

Source: Author

Tropical grasses and legumes: Advice is often sought by importers about improved pastures and bulk forages that can be used in the tropics for grazing, cut-and-carry or conserving as hay. Below is a list of grasses and legumes, with information on their cultivation and peak nutritional qualities, along with descriptions of suitable environments for their growth (sourced from Feedipedia [30], DITT Agnotes [31], and Phillips (1977) [27]).

Andropogon gayanus (Gamba grass): Tall (1.4-4 m), tufted, drought tolerant, with yields of 4-9 t DM/ha/y, 7-10% CP (young growth), and a high carrying capacity of livestock. Needs cutting before flowering to avoid unwanted seed spread by wind or transportation. Susceptible to locust swarms in Eastern Indonesia. [*Warning:* This grass is extremely invasive, difficult to eradicate and a fire hazard in dry seasons, if not managed properly.]

Urochloa (orig. Brachiaria) decumbens (Signal grass): Creeping, (60 cm height, with flowering stems 1 m tall), deep rooting, vegetative growth from rhizomes and stolons (see Figure 3.74, p.139), perennial grass. Yields from 10-30 t DM/ha/y depending soil fertility, grows well as an understorey grass in plantations. Other species of Urochloa (*U. brizantha, U. ruziziensis, U. humidicola*) are slightly different in terms of morphology and habitat, but are all good quality forages for grazing cattle. Average nutrition of green aerial parts (% DM): 27 (DM), 8.9 (CP), 7.7 (ME, MJ/kg DM), 0.3 (Ca), 0.3 (P).

Figure 3.73 Signal grass cultivated for feedlot rations (Indonesia).

Urochloa (orig. Brachiaria) mutica (Para grass): Also called Rumput malela (Indonesia); Cỏ lông tây (Vietnam). Closely related to *U. arrecta*. A perennial that thrives in wetland habitats and swamps (1 m water depth), with tall leafy stalks (1-2 m height) and long (up to 5 m) horizontal runners. Yields are 5-15 t DM/ha/year, or 30 t DM with fertiliser and irrigation. Apart from grazing when waters have receded, it is also suited for cut-and-carry, haymaking or silage. Average nutrition of green aerial parts (% DM): 28 (DM), 8.4 (CP), 35.5 (CF); 7.8 (ME, MJ/kg DM); 0.34 (Ca), 0.24 (P), 1.84 (K).

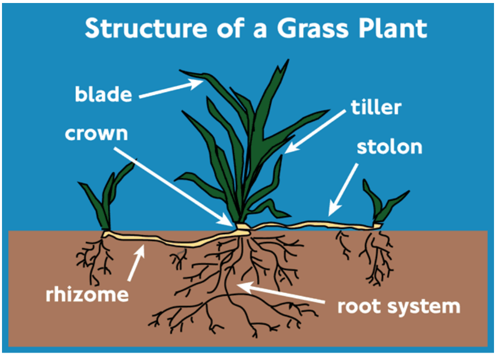


Figure 3.74: Illustration of vegetative growth of stolons and rhizomes of grasses.

Cenchrus ciliaris (Buffel grass): Semi-upright clumps (0.3-1.5 m height), asexual reproduction perennial with yields of 5-6 t DM/ha/year. Tolerates drought and heavy grazing. Suitable for sandy loam, red soils and drier climates. Average nutrient values of green aerial parts (cultivated) (% DM): 30 (DM), 7.1 (CP), 40 (CF); 8.0 (ME, MJ/kg DM); 0.26 (Ca), 0.17 (P).

Chloris gayana (Rhodes grass): Also named Koro-korosan, Banuko (Philippines). A tufted leafy grass (0.5-1.5 m height), highly productive, yielding 10-14 t DM/ha/year, perennial with runners and fertile seed. Thrives in a range of tropical, sub-tropical environments, and used by farmers for grazing livestock or cut-and-carry, but not suitable for making silage. Average nutrition of green aerial parts (% DM); 25 (DM); 9 (CP), 37 (CF), 8.5 (ME, MJ/kg DM), (g/kg) 3.8 (Ca), 2.9 (P), 18.7 (K); and hay, 86.4 (DM), 10 (CP), 35 (CF), 8.1 (ME, MJ/kg DM); (g/kg) 3.1 (Ca), 2.6 (P), 16.9 (K).

Cynodon dactylon (Bermuda grass): Also known as Rumput minyak (Indonesia); cỏ chỉ (Vietnam). Derived from Africa, now widespread across SE Asia including Australia. A nutritious and hardy perennial (10-50 cm height) that spreads vegetatively from stolons and rhizomes, with erect flowering stems reaching ±1 m high. It is used for grazing, cut-and-carry, hay, yielding 10-15 t DM/year (or more with fertiliser application), maintaining quality by frequent grazing or cutting. Difficult to eradicate once established. Average nutrition of green aerial parts (% DM); 31 DM, 9.8 (CP), 31 (CF), 8.1 (ME, MJ/kg DM); 0.45 (Ca), 0 22 (P), 1.53 (K).

Cynodon nlemfuensis (Star grass): Known as Rumput bintang (Indonesia). Widespread in SE Asia, stoloniferous, deep rooted perennial with erect stems and leaves reaching to 70 cm. Similar annual DM yields as *C. dactylon* of 10-15 t/ha when well managed, and more drought tolerant than other Cynodon species. Used by farmers for grazing and cut-and-carry or making hay. Average nutrition of green aerial parts (% DM); 30 (DM), 11-16% (CP).

Digitaria decumbens or *D. eriantha* grass (Pangola grass): A tropical grass (<1 m height) used extensively for high nutritional quality grazing, hay and silage. A creeping stoloniferous perennial, with yields of 10-30 t DM/year. Generally withstands high density 30 day grazing and trampling under ideal conditions (i.e. 700 to 4000 mm rain/year, 16 to 28°C temperature), and persistent through dry periods. Average nutrition of fresh green aerial parts (% DM); 27 (DM), 8 (CP), 36 (CF), 8.3 (ME, MJ/kg DM); 0.31 (Ca), 0.26 (P); and hay: 81 (DM), 7.9 (CP), 36 (CF), 8.2 (ME, MJ/kg DM); 0.48 (Ca), 0.27 (P).

*Megathyrsus (*orig. *Panicum) maximum* (Guinea, Buffalo grass): Also called Rumput banggala (Indonesia); Cỏ ghi nê (Vietnamese]. Optimal conditions for growth are 1 m (or more) annual rainfall and short dry seasons (<4 months). Erect, tufted and vigorous growth, up to 2 m height. Asexually and vegetatively propagated perennial. Established by seed (3-5 kg/ha) as a pasture, sometimes mixed with other grasses (e.g. Rhodes grass) or legumes (e.g. Centro). Yields 10-25 t DM/year, used for grazing, cut-and-carry, silage and hay. It is recommended that Guinea grass pastures should not be grazed below 30 cm to allow vigorous regrowth; alternatively cut-and-carry for grass based rations and supplemented with protein meal to maximise cattle productivity. Average nutrition of green aerial parts (% DM); 23 (DM), 11.2 (CP), 37 (CF); 8 (ME, MJ/kg DM); 0.49 (Ca), 0.24 (P).

Pennisetum clandestinum (Kikuyu grass): Prefers higher elevations (>1900 m), and popular as a dairy pasture in the cooler foothills and coastal areas. A creeping perennial with deep roots, propagating from rhizomes and long runners (stolons), forming leafy tufts (8-15 cm height). Establishment by runners at 1 m spacing (about 1,100 runners/ha) and mixed with a legume, Mainly used for grazing with annual yields of 10-30 t DM depending on soil fertility and rainfall. Grazing height is from 15 to 5 cm to maintain average nutrient values of aerial parts (% DM); 20 (DM), 15 (CP), 30 (CF); 9.7 (ME, MJ/kg DM); 0.31 (Ca), 0.37 (P).

Pennisetum purpureum (Elephant, King[30], Napier grass): Also named Rumput gaja (Indonesia, Malaysia); Buntot pusa (Philippines); Cỏ voi (Vietnam). A tall (3-5 m), perennial, clumping, propagates from noded stem cuttings (35 cm).

[30] King grass is a hybrid of Pearl millet (*Pennisetum glaucum*) x Elephant grass with a mix of traits for better drought tolerance and biomass yield.

Best suited for cut-and-carry or silage, with annual yields of 50-150 t/ha (10-25 t/DM) depending on plant spacing (50-100 cm apart[31]) and fertiliser (urea 100 kg/ha or cattle manure 25 t/ha). After planting, the grass needs at least 3 months of growth (or >1 m high) before the first cut, thereafter can be cut at intervals of 6-8 weeks (i.e. ±7 cuts/year).

Fresh forage should be chopped (3-5 cm) before feeding out, or mixed into the ration. The forage chop can be fed at a rate of 20-30% of the whole ration (DM basis). Stands of Elephant grass are usually replanted every 5-6 years. See Table 3.29 for more detailed nutrient values.

Table 3.29: Average feed values of Elephant grass during growth (DM basis).

Elephant Grass (*Pennisetum purpureum*)	**DM (%)**	**CP (%)**	**CF (%)**	**ME (MJ/kg)**	**Ca (%)**	**P (%)**	**Max Level (% DM)**
Growth:							
42 days	19	10.0	31.6	7.8			25
43-56 days	18	9.1	33.1	7.6	0.5	0.5	25
56 days	19.7	4.7-9.7[1]	33.8	8.2	0.4	0.7	30
57-70 days	21	8.3	33.5	7.5	0.5	0.3	25
Late vegetative	15	11	31.5	9.5	0.6	0.4	
Mature (seeding)	28	4.6	38.2	6.6			

1. Higher value with fertiliser

Figure 3.75: Elephant grass stand for daily cutting (Indonesia).

[31] 50 cm furrow spacing has two adjacent planting furrows (2), separated by an empty furrow (1) in a 2-1-2-1-2 system. 100 cm spacing uses every furrow for planting.

Centrosema molle (orig. *pubescens)* (Centro, Butterfly Pea legume): A deep-rooted climbing perennial legume with trifoliate leaves, pink to crimson flowers, and long seedpods. Grows well in the wet tropics (>1,500 mm/year) and fertile soils, tolerates flooding, shade and short dry seasons; *C. pascuorum* Bundey and Cavalcade cultivars are particularly well adapted to the northern Australian monsoonal climate and longer dry season. Established by seed (2-6 kg/ha), usually mixed with tropical grasses (e.g. Signal, Pangola, Guinea grasses), the legume fixes significant amounts of N, raising soil fertility, pasture yields (contributing ±3 t DM/ha/y in mixed pastures), and boosting forage protein levels for grazing. Also used for hay, and grown as an organic fertiliser in plantations. Average nutrition of fresh aerial parts (% DM): 25.8 (DM), 18 (CP), 31 (CF), 9.3 (ME, MJ/kg DM); 0.95 (Ca), 0.26 (P).

Leucaena leucocephala (Coffee bush, Tamarin tree, legume): Also known as Lamtoro (Indonesia); Ipil-ipil (Philippines); keo giậu (Vietnam). A fast growing evergreen bush or tree found in well drained soils throughout the tropics, with numerous small bipinated leaves and flat seedpods. Usage ranges from firewood (charcoal), food (young seedpods) to forage banks of palatable feed for livestock. Establishment requires seeds to be scarified (manually with sandpaper or mechanically (e.g. small cement mixer lined with abrasive material) before planting (0.5-1.0 m apart within row) directly into cultivated soil, or in polybags for planting as saplings after 3-4 months. For intensive grazing of cattle herds, establish hedgerows (±9 m apart) of leucaena across grass paddocks, or a designate fenced off area of leacaena for intermittent browsing (see Figure 3.76, next page).

The hedgerows and trees are routinely lopped to encourage leaf growth within browsing reach of cattle. Annual yields vary from 5-20 t DM/ha, and optimised by harvesting at 6-8 week intervals or under browsing management. Leucaena leaves contains mimosine which can be toxic at levels greater than 20% of daily rations (DM), mainly affecting imported cattle that do not have the rumen bacterium *Synergistes jonesii* to breakdown the toxin. However, this bacterium will naturally transfer to naive animals when grazing or grouped together with imported cattle that have been in the feedlot for a few months. Average nutrient values of fresh green aerial parts (% DM): 30 (DM), 23 (CP), 20 (CF), 11 (ME, MJ/kg DM); 1.07 (Ca), 0.21 (P) (see Leucaena leaf meal, Table 3.10, page 76).

Figure 3.76: Leucaena-grass hedgerow grazing system (NT) (above); edible green leucaena seed pods (below).

3.8. Cattle under oil-palm

Land resource: The integration of cattle under oil palm is best suited for breeder herds and cow/calf operations where there is sufficient understorey vegetation available. In Malaysia, carrying capacity can range from 20 head of breeder cattle per 200 ha (1:10) to 100 heads per 400 ha (1:4) depending on the age of trees between 5-15 years old, and the topography of the plantation.

Figure 3.77: Australian breeder cattle herd grazing under oil palm (Sabah).

Facilities and equipment: Cattle handling facilities and holding yards are required for processing and holding cattle for integration into palm oil plantations (see Figure 3.78).

Figure 3.78: (Clockwise) Ramp and race, holding yard, portable pen (Sabah); digital scales bars, weighing (Vietnam).

Figure 3.79: (Clockwise) Electric fence posts; polywire (500 m); battery (12 volt) with energiser and digital voltmeter; water troughs; water tanker (Sabah).

Other equipment needed is electric fencing to contain the herd within a grazing cell and portable water troughs and tanker to ensure a continuous supply of water (Figure 3.79). A heavy duty forage chopper is also required to chop palm fronds as a forage based ration for cattle held in holding yards or breedlot (Figure 3.80).

Figure 3.80: Forage chopper.

Stockmen who look after the cattle herd day and night are given access to mobile sleeping quarters or caravan.

Figure 3.81: Stockmen's mobile quarters for herding cattle under oil palm (Sabah).

Feed sources: The main feed source are the edible forages in the understorey and some of the most abundant are listed below, with photos in Figure 3.82:

Asystasia micrantha (Chinese violet): A perennial creeper that is widespread in plantations and is considered an invasive weed, however it is also a nutritious food for animals and humans.

Nephrolepis biserrata (Sword fern, Paku larat): A competitive weed in plantations, and the young shoots are readily eaten by livestock.

Peperomia pellucida (Shiny bush): A leafy perennial creeper with edible forage.

Asplenium longissimum (Spleen wort): An edible fern that thrives in the plantation understorey.

Calopogonium caeruleum (Calopo, Kacang asu) is a twining perennial tropical legume often planted as a cover crop in plantations. The underside of the leaves tend to be hairy and this reduces its palatability, however cattle eat limited amounts (or more) of the forage. Average nutrient values of fresh green aerial parts (% DM): 13 (CP), 35 (Fibre); 8.6 (ME, MJ/kg DM).

Figure 3.82: Dominant understorey forages under palm oil plantations. (Clockwise) Chinese violet, Sword fern, Shiny bush, Spleen wort, Calopo, and understorey grasses, mainly calopo).

Cattle breeds: Australian Brahman and Droughtmaster breeder cattle are particularly suited to this production system.

Feed and water requirements: As with any breeder herd operation based on grazing, the amount of forage available should at least meet the total daily DM intake and nutrient requirements of the herd according to the sum total of AEs. Supplementary feeds are provided to breeder herds grazing understorey forages just prior to calving and early lactation, and mineral blocks/loose mix need to be available all year round (see Table 3.24-3.26, page 129). Clean water should always be available from mobile troughs, filled by water tanker.

Young pregnant breeders due to give birth can be separated from the grazing herd and yarded, and fed rations to maintained body condition during this period of high nutrient demand, using relatively cheap oil palm byproducts (i.e. mainly oil palm fronds and palm kernel cake, Table 3.31, next page). This strategy will increase the chance of a second pregnancy when joined with the bull within three months of parturition (see *Segregation of heifers,* page 123).

Table 3.30: Average feed values of oil palm byproducts (DM basis).

NUTRIENT VALUE OF PALM OIL BYPRODUCTS	DM (%)	CP (%)	CF (%)	ME (MJ/kg)	Ca (%)	P (%)	Max Level (% DM)
PKC (Mech. extract.)[1]	86	15.0	19.7	11.6	0.24	0.62	80
PKC (Solvent extract.)	86	17.9	11.2	13.6	0.28	0.51	80
Oil palm fronds (fresh)	35	5.6	39	5.7	0.53	0.11	55
Oil palm frond silage	30	6.6	34	6.7	-	-	30

1. Mechanical extraction. *Source:* Average of feed values from selected references.

Fresh palm fronds deteriorate nutritionally if left for a few days before feeding; it is therefore recommended to preserve the fronds by making silage. The critical part of silage production is the exclusion of air to ensure optimum anaerobic fermentation (see *Conservation of forage and bulky feedstuffs*, page 66). The fronds are chopped (2-3 cm) and layered in a concrete silo, then pressed down with a tractor. Spray each layer with 5% urea (e.g. dissolve 1 kg urea in 1 L water, mix with 20 kg molasses and spray on a layer of about 100 kg of fronds). Repeat after each layer has been pressed until the silo is full, then cover with plastic sheeting and old tyres. The silo should be ready to open after about a month.

Examples of rations for productive breeders, bulls and yearlings held in breedlots or holding yards associated with oil palm plantations, are given in the Tables and Figure on next page.

Table 3.31: Concentrate ration for hand-fed productive breeder cattle (450 kg) using oil palm byproducts.

RATION INGREDIENTS	DMI (10.2 kg DM)	FM (kg)	% Ration (as fed)
Oil Palm Fronds	2.0	5.7	35%
Palm Kernel Cake	8.0	10.1	63%
Molasses	0.2	0.27	2%
Salt, P (Lick Block)	35 g,15 g = 50 g	50 g	

Table 3.32: Forage based ration using oil palm byproducts for different classes of cattle hand fed in holding yards.

RATION INGREDIENTS	LATE PREG/ EARLY LACT As Fed (kg)	BULL As Fed (kg)	GROWERS As Fed (kg)
Oil Palm Fronds (ad lib)	~15 (73%)	~20 (78%)	10↗ (70%)
Corn (cracked)	2 (10%)	-	1 (7%)
Palm Kernel Cake	3 (15%)	5 (20%)	3 (20%)
Molasses	0.5 (2%)	0.5 (2%)	0.5 (3%)
Salt, P (Lick Block)	35 g,15 g =50 g	50 g	50 g

Note: Bracketed percentages represents percent of ration as fed.

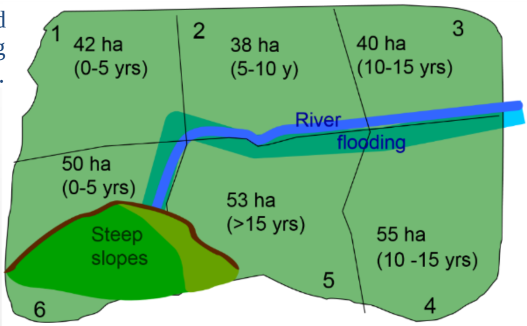
Figure 3.83: (Left to right). Creep feeder for calves; pelleted palm fronds; pelleted palm kernel cake.

Supplement options for calves (using creep feed):
(a) Fishmeal (250 g), rice bran (250 g)
(b) PKC (250 g), milled corn (250 g)

Grazing strategy: Oil palm plantations are normally divided into manageable land blocks usually associated with the original planting cycle. Each block will have a different age range of oil-palm trees, e.g. 0-5 years, 5-10 years, 10-15 years and >15 years. Cattle grazing is limited to areas where trees are between 5 and 15 years old. As the trees grow and the canopy closes, the ground vegetation is reduced due to increased shading (see Figure 3.84).

Cattle and oil palm integrated systems involve running small herds, which are restricted to grazing a small area (cell) of understorey forage for 24 hours before moving to an adjacent cell the next day. This continues over a 90 day cycle after which the herd returns to the original cell and repeats the grazing cycle. Each grazed cell therefore has 90 days to recover forage growth.

Figure 3.84: Suitable land blocks and estimated grazing areas of an oil palm plantation.



Legend:

Block 1. (✕)	0 ha,	trees too young (<5 years).
Block 2. (✓)	35 ha,	(3 ha liable to flooding); trees 5-10 years.
Block 3. (✓)	40 ha,	(no flooding); trees 10-15 years.
Block 4. (✓)	45 ha,	(10 ha liable to flooding); trees 10-15 years.
Block 5. (✕)	0 ha,	trees too old (>15 years), limited forage available.
Block 6. (✕)	0 ha,	trees too young and ½ block has steep slopes.
Total:	120 ha	available for grazing.

It is important to identify potential grazing areas in each block and then estimate the total DM of edible forage available. From the total DM figure, stocking rates (heads or AEs/ha or cell grazing area, per day) and carrying capacity (AEs/total grazing area/season or year) can be estimated, and from which herd size and composition is determined (see Figure 3.85, next page).

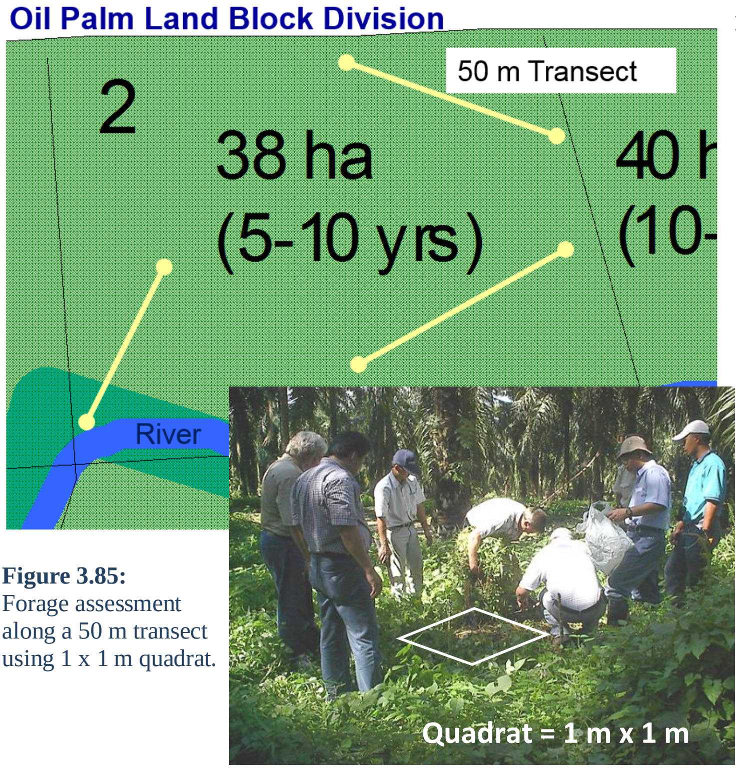


Figure 3.85: Forage assessment along a 50 m transect using 1 x 1 m quadrat.

Transect survey
M=metre, F=forage)

M	F
50	Edible
49	
48	
47	
46	
45	
44	
43	
42	
41	
40	
39	Not Edible
38	
37	
36	
35	
34	
33	
32	
31	
30	Edible
29	
28	
27	
26	
25	
24	
23	
22	
21	
20	
19	Not Edible
18	
17	
16	
15	
14	Edible
13	
12	
11	Not Edible
10	
9	
8	
7	
6	
5	
4	
3	Edible
2	
1	

Forage assessment method:

- Carry out at least three 50 metre (paced) transects from randomly located points across a land block division (see Figure 3.85, above).
- Note the coverage of edible plants for each metre (pace) of transect, and determine (by eye) the percent of edible forage available (see example of transect survey results on right).→
- Place the quadrat on an area of edible forage; cut the forage inside the quadrat and weigh the forage fresh matter (FM) from each quadrat (repeat several times per transect). Dry each forage sample in an oven (80°C for 48 h) until there is no weight change. Determine the percent dry matter (% DM) of the forage as:

Edible Forage DM = (DM g/FM g) x 100%

See Infobox 3.25 (next page) for estimating of herd size.

Infobox 3.25:

Estimation of herd size by forage assessment in integrated cattle and palm oil plantation systems.

Estimated dry matter availability (example):

- *Total Grazing Area (Block 2):* 35 ha
- *Forage Cover (FC):* 28 m out of 50 m (56%) is determined to be edible forage (see example of transect survey, previous page). Note that percent edible forage is estimated from several quadrant measurements collected in each transects block.
- *Edible Forage (EF) fresh matter/m^2 (average of three quadrant samplings):*
  = 450 g (or 0.45 kg) EF (FM)/m^2.
- *Dry matter /ha:* 0.45 kg FM x 25% DM (EF)
  = 0.1125 kg DM/m^2 x 10,000 m^2 (1 ha)
  = 1.125 t DM/ha (EF)
- *Trampling Factor (TF):* Minus 50% EF assumed trampled/spoilt by cattle.
- *Estimated net EF availability:* (1.125 t (EF)/ha x 56% (FC)) x 50% (TF)
  = 0.315 t DM/ha.
- *Total EF availability (Block 2):* 0.315 t/ha x 35 ha
  = 11.03 t DM.

Estimation of carrying capacity (3 Blocks): In this example, the Blocks 2, 3, and 4 all had very similar net yields of edible forage (EF). It was estimated that there was 38 t DM of EF available in 120 ha of total plantation area (see Fig.3.84, page 149). This allows the size and composition of the breeding herd to be calculated using Adult Equivalents (AEs) to estimate carrying capacity over the 3 blocks of the plantation, as follows:

- *Adult Equivalents and feed intake:* 425 kg LW dry cow (AE =1) and DM intake of 2.0% LW:
  = 8.5 kg DM/day (equivalent to 1 AE).
- *Daily feed supply (EF):* 38 t DM/90 days (per cycle).
  = 422 kg DM/day
- *Herd size:* 422 kg DM/8.5 kg DMI (1 AE).
  = 50 AE (equivalent 50 dry cows) see Table 3.33, p. 152, for herd details.
- *Feed supply per hectare:* 38 t DM/120 ha.
  = 317 kg DM/ha
- *Daily grazing area (Cell):* 422 kg EF (DM)/317 kg DM/ha
  = 1.35 ha* (cell size) [i.e. area needed to consume available EF/day]
- *Carrying capacities:*
  = 50 AEs/1.35 ha/day with four 90 d cycles on 120 ha per year.
  = 37 AEs/ha/day for a year
  = 18.5 AEs/ha/year (whole plantation of 241 ha)

* Rounded up from 1.33 ha

Note: Estimations of feed availability and carrying capacity are useful for basic planning of livestock production systems, however due to the variability of biological systems and the environment, in practice these estimates need to be followed up with the situation on the ground. Therefore, close observation of potential issues, and ongoing critical measurements, need to be carried out routinely, especially during the early stages of implementation of the production system, so that timely adjustments and continuous improvements can be made.

Herd size and composition: Oil palm plantations are normally found in tropical areas where there is monthly rainfall and all-year-round vegetative growth. Bulls therefore usually run with the breeding herd all year round and maintain a sustained level of reproduction. Using the above example (Infobox 3.25) of estimated 50 AEs/1.35 ha for the daily SR of the grazing area (cell), the size and composition of the herd can be deduced from the assumptions for rates of reproduction of the breeder herd (see Table 3.33). The herd therefore consists of 20 cows and a bull, plus progeny, with combined AEs of each cattle class totaling 50 AEs. Options such as growing out yearlings in yards would provide more forage availability for grazing and the potential to increase herd size.

Table 3.33: Estimation of herd size and composition from 50 AEs

Class	Head	AE	Total
Cows (Dry)	**4**	**1**	**4**
Cows (P. & L.)	**16**	**1.4**	**22.4**
Bulls	**1**	**1.8**	**1.8**
Yearlings	**11**	**1.1**	**12.1**
Weaners	**12**	**0.8**	**9.6**
Calves	**14**	**Total AEs**	**49.9**

Pregnancy rate (80%), Calving rate (70%), Weaning rate (60%), Mortality (10%). P (pregnant), L (lactating).

Movement schedule: Based on daily forage requirements of the herd and forage availability per area, in the above case each cell grazing area of 1.35 ha should provide sufficient forage for a single day in the 90 day cycle. The herd is then moved to the next cell every day. The number of cells in each plantation Block is shown Figure 3.86 (next page).

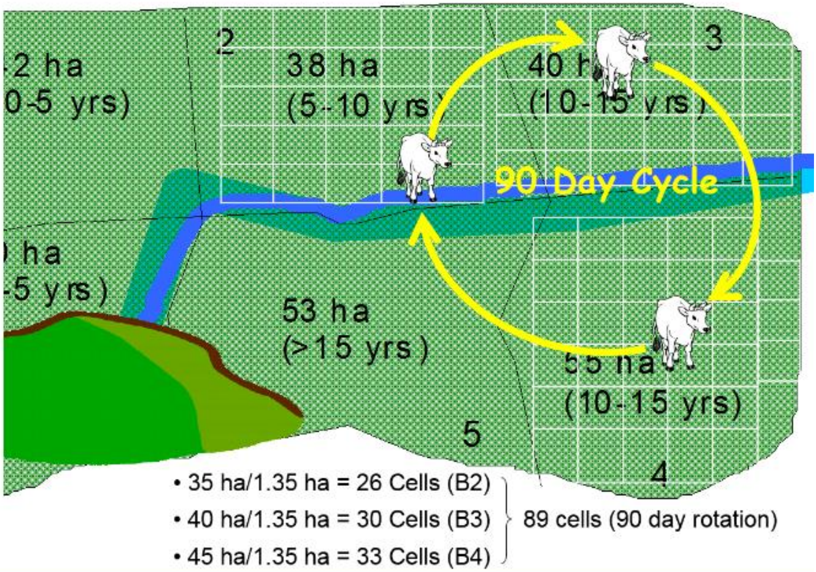


Figure 3.86: Beef cattle integrated with oil palm plantations: Movement of cattle through grazing areas in Blocks, using 26-33 grazing cells in each Block, totalling 89 cells over 90 days.

Breeder management under oil palm: All year round rainfall in oil palm plantations provides abundant forage throughout the year and suitable conditions for continuous mating. As a result, the composition of the herd will have all classes of cattle, from bulls to dry, pregnant and lactating cows, and their progeny (see Table 3.33, previous page). Under short-term cell grazing systems (i.e. moving from one cell to the next every day), there are issues with calving and young calves following the herd. The strategy of separating young pregnant breeders into a breedlot or designated grazing area just prior to calving, and up to 2-3 months after parturition, should also be considered for all breeders in the herd. This will allow better mothering and calf survival as well as targeted supplementation for nursing cows to optimise lactation, and creep feeding to enhance calf growth and development (see Figure 3.83). See also **3.7 *Breeder Herd*** *section*, page 117.


Figure 3.87: Harvesting oil palm bunches Indonesia) and Australian cattle breeder herd grazing under oil palm (Sabah).


3.9. Husbandry and Health

The word 'husbandry' comes from Middle Ages vocabulary of *husbondri, husbanderi, husbandman* etc., meaning farmer. Today's definition of husbandry is 'the careful management of raising livestock or cultivation of crops'. This begins with low-stress handling of animals and looking after their general welfare, which in turn reduces injury and sustains a healthy immune system that ultimately delivers better productivity. SE Asian feedlots and graziers need to have access to qualified veterinary assistance to diagnose diseases and recommend treatments. Large enterprises should employ an animal health officer on site to manage the enterprise's health program and apply basic treatments. For further guidance on bovine diseases, treatments and drugs, the following resources from LiveCorp and MLA are highly recommended: Manual for South-East Asian cattle feedlots [32]; and The Veterinary Handbook for Cattle, Sheep, and Goats [33].

Pre-Shipment: Health protocol requirements of countries importing livestock from Australian generally stipulate that Australia, and the property of origin of the livestock, must be free from major diseases. The protocols also specify a number of treatments required prior to shipment, and an example is given in Table 3.34, next page. Importers should check the protocols to avoid duplicating any pre-shipment treatments when the animals are processed on arrival at the feedlot.

In the past, animal health authorities of importing countries insisted on holding newly arrived Australian livestock for up to 30 days in government quarantine yards at the port of arrival. This was very risky health wise for the Australian cattle because of the likelihood of coming into contact with local livestock carrying infectious diseases. Nowadays, new arrivals are transported from the ship directly to the feedlot where they are quarantined and monitored by animal health officers.

General preventative health: New arrivals to offshore cattle enterprises should be check for injury, illness or other abnormalities like cysts or lumps. Affected animals should be separated into a hospital pen for treatment. Most common transport ailments are:

- Lameness and downers (animals that have fallen in transit), and if not too serious, these usually recover quickly with rest and a feed of fresh forage. If downers are seriously injured (e.g. broken leg), they should be humanely destroyed *in situ* (see ***Humane killing,*** page 171).

- Respiratory infections usually attributable to transport stress (Shipping Fever) which need immediate segregation and treatment with antibiotics.
- Pinkeye and ringworm; also require isolation of animals and, in acute cases, treatment with sulphur (pinkeye) and iodine (ringworm) based ointments will help. For pinkeye, control of flies is the best way to prevent the spread of the disease.

Table 3.34: Example of health protocol requirements for exporting Australian cattle.

COUNTRY OF ORIGIN Must be free of:	**PROPERTY OF ORIGIN** Must be free of:	**PRE-TREATMENTS** Required before shipment
• Foot and Mouth • Brucellosis • Tuberculosis • Contagious Bovine Pleuroneumonia • Rindepest	• Q Fever • Infectious Bovine Rhinotracheitis/Pustular Vulvovaginitis • Paratubercolosis (Johne's Disease) • Bovine Malignant Catarrh • Clostridial Dermatophilosis • Anthrax • Campylobacter foetus infections • Trichomonas foetus infections	• Tick (Acaricides) • Tick Fever (Vaccination) • Worms (Anthelmintics) • Leptospirosis (Vaccination/ Streptomycin) • Campylobacter foetus (Vaccination for bulls only)

Processing (health): After new arrivals have rested for 24-48 hours or more, they are processed into the feedlot or breeder herd system. The health of each animal is assessed and preventative treatments are applied (e.g. vaccinations, parasiticides, anthelmintics etc.), in addition to the pre-shipment health protocol treatments.

Feedlot health: Both feedlot manager and stockmen should always keep an eye on cattle behaviour in the feedlot pens, and look out for abnormalities such large amounts of feed residues, high drinking rates, panting, arched backs, sloppy manure, coughing, nasal discharge, bellowing, and animals lying down on their side. All these signs need to be investigated straightaway and remediated as soon as possible.

Feed residues: Large amounts of feed residues could be a sign of overfeeding or sudden change of a ration ingredient, or it could indicate an illness amongst the pen group. If illness is suspected, replace half the ration with chopped fresh green forage until a diagnosis and treatment has been carried out.

Drinking rates: High drinking rates are normally associated with hot summer days, but when accompanied by panting amongst the pen group of animals, this is a sign of heat stress (see *Heat stress*, page 169). Increases in water consumption could also be caused by high levels of salt in the ration, while low drinking rates maybe the result of high concentration of salts in the drinking water. A sudden decrease in water consumption could also be due to ration changes involving wet ingredients (e.g. spent brewers grains, or fresh forage replacing hay).

Arched back: Animals standing still with an arched back is a classic sign of inanition (not eating or drinking). This could be a *shy feeder* missing out on feed, or is stressed or has a nutritional disorder. These animals should be moved to a separate pen and fed chopped fresh forage. A multivitamin injection and other treatments may be advised by the feedlot veterinarian.

Bellowing: This could just be hungry animals expecting the next feed that has been delayed for some reason. More likely, there are animals fighting and/or there is a badly injured animal. Separate aggressive animals and remove the injured to the hospital pen for treatment.

Coughing: Repeated coughing by cattle could be a sign of pneumonia, particularly new arrivals recovering from transport stress. Check for high body temperatures, which is associated with pneumonia. Separate affected animals before treatment that is normally with antibiotics.

Nasal discharge: Excessive nasal mucus discharge and salivation in cattle and buffalo is symptomatic of the onset of Haemorrhagic septicaemia (see *Shipping fever*, page 163). New arrivals are normally vaccinated against the disease when processed prior to entering the feedlot.

Faecal check: It is likely that cattlemen always knew a good cowpat from a bad one, but it was the dairy industry that formally linked faecal appearance with the nutrition and health of the animal [34, 35, 36]. More recently, the three Cs: Colour (feed), Consistency (moisture) and Content (digestive function) [37], provided a more comprehensive diagnosis, as follows:

Figure 3.88: Typical fresh cowpat from grazing cattle.

- *Colour:* Cattle grazing green pasture typically produce brown, tinged with green, coloured faeces (see Figure 3.88). The colour becomes darker with drier grass and hay. Feedlot rations produce a range of colour depending on the forage to grain ratio, from a light brown-olive colour on grain-based diets, to a darker brown colour on forage-based diets.

  Other shades of colour should be a warning that something is wrong. For example, diarrhoea can produce grey faeces; coccidiosis and haemorrhaging can result in very dark or bloody manure accompanied by a foul smell, and light green or yellowish watery manure can indicate bacterial infections.

- *Consistency:* The moisture content of food and its rate of passage through the animal's digestive system determines the consistency of the faeces, with porridge-like thickness without too much moisture being optimal. Sloppy manure is indicative of high protein intake or heat stress due to increased water consumption. Decreases in water consumption produces drier faeces, as does low protein intake. Sloppy grey manure (diarrhoea) may be indicative of infection, parasites, poisoning, or nutritional disorders.
- *Content:* Optimal digestion should result in well-blended faecal matter, while undigested feed particles in the faeces, such as grain and forage, suggest otherwise. This is likely to be caused by a sudden change of diet or imbalance of nutrients affecting rumen fermentation, resulting in more undigested feed entering the hindgut and being expelled in the faeces. The presence of whole or partly digested grain (e.g. corn) is probably due to feeding whole grain, instead of cracked or coarsely milled grain (up to 10% more digested). Large amounts of mucus in faeces suggests a health issue with gut tissue, and bubbles on the surface of faeces may signify increased hindgut fermentation of undigested feed.

Note: The approach to checking manure for nutritional disorders is different to that of health issues. Signs of a nutritional disorder can be checked from the manure of a group of animals that receive the same ration, while checks for health indicators must be from the faeces of identifiable animals, so that they can be separated for treatment if necessary. A summary of faecal check indicators are listed in Infobox 3.26.

Infobox 3.26: **Summary of Faecal Check Indicators**

Colour:
- Brown tinged with green - grazing fresh grass.
- Darker brown - drier grass, hay.
- Lighter brown-olive colour - grain based rations.
- Brown - forage based rations.
- Grey - diarrhoea.
- Very dark to black plus red blotches (and smell) - coccidiosis with haemorrhaging.
- Light green or yellow - bacterial infection of gut.

Consistency:
- Porridge-like thickness (not too moist) - optimal.
- Sloppy (with frequent drinking) - high or excess dietary protein, stress.
- Sloppy and grey (diarrhoea) - infection, parasites, poisoning, or nutritional disorders (e.g. acidosis).
- Dry - low water intake, e.g. due to high mineral salt content in water.

Content:
- Well blended (brown) - optimal.
- Ration feed particles (e.g. grain, forage) - rumen fermentation issue.
- Whole or partly digested grain (e.g. corn) - consider processing.
- Excess mucus - gut health issue.
- Bubbles/foam - gas production from excess hindgut fermentation, indicating rumen fermentation issue.

Dealing with injured or sick animals: The downside of animal industries is that there will be injuries and sickness to contend with. These circumstances can be significantly reduced by good animal health management and care.

Sickbay: (Also referred to as hospital or sick pens.) Feedlots have dedicated holding pens to separate sick or injured animals for treatment. Injured animals can usually be housed in a group, but animals with infectious diseases need to be isolated. The pens are roofed and sheltered from high winds, storms, and blazing sun. They must be kept clean and have continuous access to water and feed. Floors can be covered with a layer of sawdust or straw to absorb effluent and to make it more comfortable for resting animals.

The sickbay is particularly busy when a new shipment of cattle arrives at the feedlot with a range of injuries (e.g. cuts, bruising, swellings, lameness, downers, broken bones etc.) and stress (i.e. transport, heat). Cattle with serious injuries need treatment and recovery time in the sickbay, while stressed animals should be observed closely post-arrival in case an infectious disease is triggered due to low immunity.

After processing of new arrivals and feeding induction rations, the next wave of possible health problems are nutritional disorders. Particular attention should be given to animals that do not appear to be eating, with diagnoses ranging from stress or temperament to nutritional disorders or disease (see *Poor (shy) feeders,* page 104).

Nutritional disorders: Bovines in their natural habitat are able to select herbage according to their specific needs to exist, whereas lot-fed bovines rely on humans to provide edible feed and an optimal balance of nutrients to meet a set of production targets. The fact that ruminants receive most of their nutrients via a third party (i.e. microbial fermentation) complicates ration formulation, as it needs to be tailored for optimal microbial fermentation to produce the critical nutrients required by the productive animal. The occurrence of nutritional disorders is therefore not surprising, particularly when using alternative feeds such as agricultural waste and concentrates. Common disorders are listed below:

- *Acidosis*: This is caused by cattle (and buffalo [38]) engorging high levels of fermentable carbohydrate (e.g. wheat pollard, cracked corn, etc.) with little or no fibre, triggering excess production of volatile fatty acids (especially lactic acid) in the rumen, thereby lowering pH to toxic levels (i.e. pH <5.6)[32]. This is often referred to as 'grain overload'. Subacute (short-term) symptoms include belly kicking, standing with front legs forward and back legs backwards, bubbly grey diarrhoea, laminitis, inappetance and reduced rumination. In acute cases (i.e. rumen pH <4), animals remain lying down, dehydrated, sometimes bloated, followed by comatose and death within 24 hours. Early treatment of subacute cases is by feeding a fibrous feed such as rice hay for a few days, before gradually introducing a forage-based diet and sodium bicarbonate (25 g/head/day)

[32] Rumen acidity is normally around pH 6.5.

mixed into the ration. [39]

- *Laminitis:* This is an inflammation of tissues (oedema)[33] in the hoof caused by acidosis, and presented as lameness. Treatment of acidosis will also reduce laminitis. The symptom of lameness is similar to that of *Footrot* (see page 164).
- *Rumenitis:* Caused by inflammation of the rumen wall due to prolonged low rumen acidity (or penetration by a foreign object (e.g. nail, wire etc.)), resulting in destruction of tissue by bacterial infection. This can also spread to the liver if the rumen wall becomes perforated. Animals in the later stages of fattening on concentrate rations are particularly susceptible to liver damage by bacterial infections, causing abscesses and high numbers of condemned livers at slaughter, thereby affecting profit margins. Subchronic (short-term or periodic) acidosis is a precursor for rumenitis, therefore treatment is similar; i.e. increase roughage in the diet. [40]
- *Bloat:* This can occur when too much foamy digestive gas is rapidly produced, but cannot escape the rumen, causing the forestomach to swell, and possibly rupture in acute cases. Affected animals look uncomfortable and present with symptoms of belly kicking, head extended forward to enable breathing, protruding eyes, frequent urination and defaecation. The cause is from overeating, particularly certain feeds (e.g. fresh legumes, soybean meal, barley grain); or running while being moved from one place to another. Chronic rumenitis could also be a causal factor. For subacute cases, immediate treatment includes drenching with mineral/vegetable oil, or surfactant (detergent), and replacing bloat-inducing feeds with chopped grass for a few days before introducing rations with less problematic ingredients. Acute cases of bloat require puncturing the rumen with a trocar/cannula implements to release the gas (see Figure 3.89, followed up with drenching to reduce the foam.

Figure 3.89: Entry site for trocar and cannula, the mid-point of left Para Lumbar Fossa flank.

[33] Oedema is swelling of tissue due to a build-up of fluid'

- *Ketosis:* Ketosis is usually associated with lactating cows on energy deficient diets, leading to sustained metabolism of body fat in the liver to compensate for the energy shortfall. This can result in excess fatty acids and ketones accumulating in the liver and bloodstream of the animal causing inappetance. Ketosis is also related to Fatty Liver syndrome [41] in productive cows, due to imbalances in feed energy supply to meet the metabolic demands of the animal. This can lead to health issues around calving, a depressed immune system, and reduced milk production. Long haul transportation stress may also trigger ketosis in fatter cattle due to irregular access to different feeds, poor rumen function and lipolysis. Chronic ketosis may be treated with glucose drenches and appetite stimulants. The best treatment is to avoid the disease with good nutritional management and minimal stress. [42].
- *Urea poisoning:* An overdose of urea, which releases large amounts of ammonia in the rumen, can overwhelm the metabolic processes for dissipating ammonia entering the blood stream, resulting in sudden death. Causes include ingestion of urea granules or poor mixing of granules in rations[34], high-level urea blocks that become wet with dissolved urea and licked by cattle; also feeding unaccustomed animals with rations containing urea without induction. Appropriate handling of urea needs to be taken to avoid these causes of poisoning (see *Urea (46%N),* page 82). [43]
- *Polio encephalomalacia (PEM):* The symptoms of this disease include impaired vision, loss of coordination, muscle tremor and paralysis, all associated with brain cell damage. The main cause is acute deficiency of thiamine (vitamin B_1), normally produced by rumen microorganisms, but then destroyed by high levels of the thiaminase enzymes in rumen fluid produced by certain bacteria found in high grain diets. Animals treated with multiple injections of thiamine at early stages of the disease can make a full recovery [44]. This should be followed by precautionary measures, such as reducing very high grain levels in the ration, and avoid over consumption of sulphur (e.g. in drinking water) which can induce PEM in cattle [45].
- *Grass/Transit tetany:* Progressive symptoms are nervousness, twitching muscles, stiff, staggering, bellowing, and finally, lying down on one side with legs paddling before death. The disease is associated with deficiencies of calcium (Ca) and magnesium (Mg) in blood affecting the nervous system. These two illnesses are triggered by different causes. Grass tetany mainly affects lactating cows grazing lush grasses that are low in Mg, associated

[34] Mixing urea granules into rations is not recommended. Urea should be dissolved in water and mixed with molasses (see *Urea, page 82*).

with high demand for Ca in milk. Transit tetany is mainly caused by stress, related to feed deprivation and crowded conditions during long haul transportation, leading to low levels of blood Ca and Mg. In both cases, treatment is by injections of Ca and Mg, followed by feeding legumes and wilted forages, supplemented with these elements and salt in the ration, or separately in lick blocks.

- *Prussic acid poisoning:* Certain plants used to feed cattle (e.g. sorghum species, Giant Star grass, and cassava) accumulate cyanogenic glycosides, which are a precursor of prussic acid (hydrocyanic acid, HCN). This occurs in grasses when stressed during a dry period or in rapid regrowth after rain. Cassava accumulates cyanogenic glycosides during the growth of the plant, and it must be processed before eaten. Symptoms of poisoning in cattle include salivation, breathing difficulties, staggering, muscle tremors, convulsions, and death within minutes or hours. Prevention is by avoiding grazing or feeding of cyanogenic plants during times of most risk, or by cutting sorghum over 50 cm height or ensiling. Cassava leaf should be wilted and tubers cut, washed and dried before feeding to stock [46].

Infectious diseases:

- *Shipping fever (Bovine respiratory disease - BRD):* This encompasses a range of viral and bacterial infectious diseases (e.g. haemorrhagic septicaemia (HS), pneumonia, and pasteurella) which can develop within 10 days after arrival at the feedlot. The main cause of infection is transportation stress, low immunity, combined with mixing groups of cattle from different places. Initial symptoms are inappetance, inertia, head down, drooling, nasal discharge, fever, and increasing respiratory stress as the disease progresses. Nowadays if there are risks of infection, precautionary vaccines and antibiotics can be administered as part of export health protocols, or at processing prior to entering the feedlot (e.g. HS). Unvaccinated cases at the feedlot should be isolated, treated with anti-biotics and antibacterial drugs to reduce the effect of pneumonia, and then fed good quality grass or rice hay, supplemented with rice bran.
- *Malignant catarrhal fever (MCF):* This is an acute viral disease from the herpesvirus group, which is carried by asymptomatic sheep and transmitted to cattle and buffalo, which have no immunity [21]. However, European cattle appear to be more resistant to the disease. Clinical signs are fever, laboured respiration, nasal discharge of copious mucous, diarrhoea, and death [40]. Australian is free of MCF, and therefore livestock exported to

SE Asia are susceptible to the disease. Animals must be kept away from possible contact with local livestock, especially sheep. Where local sheep are grazed near imported cattle or buffalo feedlots, there should be at least 1 km separating the species.

- *Foot rot:* Bacterial infections of the hoof, particularly between the digits, cause this disease, leaving the animal limping and in pain. The animal tends to stay in one place often lifting the swollen foot off the ground, unwilling to make the effort to eat or drink. Affected animals should be moved to a dry area and given a course of antibiotics. Feedlot cattle with muddy yards are particularly susceptible to infection. [47]
- *Leptospirosis:* A range of *Leptospira* bacteria cause this disease which is symptomatic of loss of appetite and body weight, fever, blood in urine, jaundice, and abortion. Infection and spread are by contact with rodents and other carriers, especially from their urine. People working with cattle are also susceptible to the disease. Health protocols for livestock exports to SE Asia include vaccination against leptospirosis, and affected livestock can be treated with antibiotics. Although infected humans usually recover after receiving antibiotic treatment and hospital care, a vaccination program for stockmen should also be considered. The risk of getting this disease can be reduced by implementing a vermin eradication program around the feedlot or breeder herd facilities. [40, 48]
- *Bovine Ephemeral Fever (3-day sickness):* This is a viral disease carried by mosquitoes and biting midges affecting cattle and buffalo, particularly in the wet season. Clinical signs are fever (drooping eyes), shivering, twitching, stiffness, lying down, runny nose, drooling saliva, watery eyes, and pregnant breeders may abort. Young stock sourced from cooler regions in the dry season are more susceptible if moved to tropical areas. Although the disease is short-lived (3-4 days), affected animals are not eating and body condition deteriorates during this period. No treatment is necessary (except provide water, feed, and shade) while the disease runs its natural course and most animals recover with lifetime natural immunity. Treatment in the form of vaccination is available if the disease is prevalent in the area or there is an outbreak, or to protect valuable stud bulls etc.[49]
- *Clostridia:* The clostridial bacteria are responsible for a number of different diseases in cattle through the release of highly poisonous toxins. The diseases are:
  - Blackleg (fever, muscle stiffness, death) [40],
  - Tetanus (wound infection, tremor, limbs extended, convulsions, death),

- Malignant oedema; (gassy swelling of wound, rapid breathing, weakness, death),
- Pulpy kidney (rapid bacterial growth when fed high grain rations, incoordination, spasms, coma, death),
- Black disease (spores ingested from forage[35] are embedded in the liver, activated by liver fluke (Fasciola) infestation (see *Liver fluke,* next page), causing fatal toxaemia).

A preventative 5-in-1 vaccination covering the five diseases is normally given to weaners before castration, dehorning, and branding, therefore would not be required for livestock imported from Australia. However, progeny of imported Australian breeders will require the vaccination. [50]

- *Botulism:* This is also caused by clostridial bacteria (*Clostridium botulinum*) and is more likely to affect grazing breeder herds lacking in P and protein nutrition. Sources of bacteria are bones (chewed by desperate cattle) and decomposing organic material, including rotting silage. Symptoms are paralysis of the tongue resulting in dehydration, weakness leading to death. A combination of vaccination, supplementation and removal of sources of bacteria, is the best treatment for this disease. [51].
- *Blue Tongue (BTV)*: This insect-borne virus affects sheep, which can suffer acutely (fever, breathing difficulties, ulcers and sores, lameness, inflamed tongue etc.) resulting in high mortality rates. Cattle however only have mild symptoms from BTV, and become carriers of the disease, which can be transmitted to sheep via the vector (*Cullicoides* midge) when feeding on the blood of affected cattle. In Australia, the insect vector is only found in the humid tropical and sub-tropical climates of northern Australia, and more recently, the east coast. Sentinel cattle herds around Australia are used to monitor the blue-tongue free area so that live cattle exports comply with international health protocol restrictions regarding the disease[36] (see also Appendix A2 (illustration), page 230. [52, 53]

<u>Parasites</u>: Breeder herds are routinely treated against internal and external parasites using preventative treatments such as pour-ons (Cydectin®, Ivomec®, Bayticol® etc.) for general control against cattle ticks, roundworms, lungworm, sucking lice, biting lice, mange mites, and buffalo fly. Protocols for live exports include pre-shipment treatments for external

[35] Both bacterial and liver fluke spores are ingested through forage consumption (especially rice hay and straw), thereby exposing feedlot cattle to both diseases.

[36] See Figure 2.8, page 12; BTV-free zone represents about 40% of the national herd.

and internal parasites (see Table 3.34, page 156). Other important parasitic diseases are as follows:

- *Coccidiosis (Black scours):* This is protozoan microorganism that predominately affects calves and weaners through faecal contamination, but it can also infect young cattle (± 250 kg LW) in crowded holding pens. Coccidia live in the cells of the gut lining and damage the cells. Clinical signs are; foul smelling bloodstained diarrhoea, dehydration, and inappetance. Confirmation of the disease is by counting oocysts[37] in faecal samples. Although infected animals usually recover over time, they are unproductive during this period. They can be treated with sulphonamide antibiotics and electrolyte drenches (*Electrolyte supplements,* page 105) to speedup recovery. Preventative measures include adding electrolytes to drinking water and an ionophore (10-20 mg monensin/head/day) to the rations of affected cattle[38]. [54].
- *Liver fluke (Fasciola gigantica):* This disease is widespread at a chronic level (± 25%) in local cattle and buffalo of SE Asian countries. The blood-sucking fluke is found in liver tissue, causing lethargy and anaemia in affected livestock, resulting in reduced production potential of the host animal. Pre-shipment treatment with anthelmintics of exported livestock is usually part of the health protocols. However, imported feeders and breeder cattle could still ingest fresh forage with fasciola cysts that were deposited by snails as part of the lifecycle. Local farmers are encouraged to control snail populations on cultivated grass areas and rice paddies that are sources of feed for cattle and buffalo [40, 55].
- *Ticks and tick fever:* Adult ticks engorge with blood from the host animal before dropping off into pasture to lay thousands of eggs. When the eggs hatch, the tiny larvae climb up the grass and are picked up by the hair of the grazing cattle, and grow into adults to complete the life cycle. Heavy tick infestations can cause large quantities of blood loss resulting in deterioration of body condition that can lead to death. Ticks are also carriers of the *Babesiosis* microscopic parasite and *Anaplasmosis* bacterium that destroy red blood cells (haemoglobin), causing a severe or fatal tick fever. Vaccines are available but require 2 months to be effective, and long-acting acaricide can be used as well. *B. indicus* cattle, crossbreds, and buffalo are quite resistant to ticks, yet preventative treatments are generally administered prior to the export of Australian cattle. [56, 57].

[37] Contains fertilized egg or zygote.

[38] Monensin is poisonous to buffalo and must not be added to buffalo rations.

- *Buffalo fly (Haematobia irritans exigua):* Also named *Siphona exigua,* swarms of these flies can overwhelm cattle and buffalo, especially in the wet season, causing irritation, sores (linked to parasitic worms) and distraction from feeding, leading to lower productivity and poor condition. The flies are more attracted to animals with darker coats, however tropical cattle (*B. indicus*) and buffalo are more tolerant than *B. taurus.* Chemical fly control treatments are the most commonly used, but there is a risk of resistance to chemical treatments over time if not managed properly. Some proprietary pour-ons and sprays are designed to treat a range of parasites including buffalo fly. Insecticide impregnated eartags and backrubbers (see Infobox 3.27 and Figure 3.90) can also be used to control the buffalo fly. [58].

Infobox 3.27:

BACKRUBBERS

This is a convenient method allowing cattle and buffalo to treat themselves with insecticide against buffalo flies. A backrubber consists of a 4 m chain suspended between trees or posts so that it sags 1 m above the ground at the lowest point. A plastic tube (one end blocked) with holes every 10 cm is tied along the length of the chain and hessian bags are wrapped around the chain and tubing that is connected to a container. Insecticide (e.g. *Supona*®, *Exiguard*®, etc.) can be mixed with sump oil and poured into the container. The mixture drip feeds down the plastic tube and soaks into the wrapped hessian.

Figure 3.90: Buffalo fly backrubber

- *Old world screwworm fly (Chrysomyia bezziana):* The fly is a parasite of cattle and buffalo in the tropics, and a notable disease threat to tropical cattle operations. The fly lays eggs near open wounds (e.g. from injuries (palm frond cuts, etc.), scratches (barbed wire, etc.), fly bites, and procedures like castration). The maggots hatch and feed on the wound fluids and flesh causing extensive tissue damage. Infested animals scratch, rub and bite the injured tissue. Treatment is by removing the maggots and cleaning the wound. Preventative measures include applying insecticide during the fly season (warm to hot months); checking facilities for potential hazards that could cause an open wound; conduct husbandry procedures before the fly season (cooler months); and initiate a systematic eradication program by introducing large numbers of sterilised male flies. [59].

Routine health checks: Daily health checks of all holding pens for sick or injured animals is essential. Sick animals should be removed to a hospital pen for treatment, and in the case of mortalities, standard procedures for disposal of carcasses apply (according to local regulations) (see *Carcass disposal*, page 171). Fallen animals (downers) need attention as soon as possible, and during the summer, especially in heatwave conditions, signs of heat stress requires an immediate response (see *Heat stress*, next page). Other signs to look for are bullying and shy feeders, both of which will require appropriate action.

Downers: This happens predominantly during transportation due to sudden braking or acceleration of the truck causing animals to lose their footing. Whilst most fallen animals can get up again, sometimes animals fall awkwardly and break a leg, or are trampled on when unloading. This is why it is important to check for downers when unloading and try to prevent other animals from trampling on the fallen animal as they exit the truck.

Figure 3.91: Downer with splayed back legs after slipping on the muddy concrete floor. In this case, the animal recovered with help from stockmen.

Older culled cows and skinny animals are prone to falling in the feedlot, especially new arrivals that are weaken by transport stress and lose their footing on a slippery concrete floor. This can be avoided by covering the floor of the holding yard with a layer of sawdust or straw for a week or so until the cattle are settled.

Downers are usually recoverable with help from skilled stockmen to get them standing. However, for downers that are severely injured (i.e. broken leg) or obviously in a lot of pain, they should be humanely killed *in situ* as soon as possible. This should be done out of sight of other animals (see ***Humane killing***, page 171).

Heat Stress: Tropical cattle tend to be more tolerant than buffalo to direct sun, and hot dry or humid conditions, due to physiological differences in body temperature control (thermoregulation) (see Table 3.17, page 115). On particularly hot summer's days, managers should look and listen for signs of heat stress. The main symptom in cattle is panting, from a normal breathing rate of 24-40 breaths per minute (BPM) with mouth closed, to 150 BPM, with tongue hanging out and salivating, which is indicative of severe heat stress.

Figure 3.92: Heat stressed cattle imported from southern Australia (Sabah)

Animals with heat stress are not productive as they become distracted by their own discomfort. The basic feedlot design for shelter and shade (see *Feedlot holding pens* and Figure 3.6, page 29) and ample cool water (see *Drinking water*, page 60 and Table 3.8, page 62) is not sufficient for extreme heatwaves. Feedlots that regularly experience heatwaves should consider installing sprinklers in the pens as evaporative cooling is the most effective way of cooling down heat-loaded animals (see *Feedlot design*, page 111 and Figure 3.62 (sprinklers), page 112). Furthermore, managers of feedlots in the tropics should have a risk management plan to anticipate a heat stress event in order to mitigate the heat load of the cattle and maintain productivity.

A practical way to predict a heat stress event is from radio broadcasts of local weather (i.e. expected temperature and humidity), and on-farm weather instruments for measuring temperature and humidity, to estimate heat stress values from a hazard chart. The combined temperature and humidity value is known as the Temperature Humidity Index (THI). When THI reaches 72 (see Table 3.35, next page), this alerts the manager to the heat stress threshold, and he initiates preventative measures, such as turning on the sprinklers for 15 minutes per hour, and modifying the ration to reduce heat of digestion by reducing forage and replacing it with a high protein concentrate according to requirements. The heat stress thresholds for cattle and buffalo in terms of THI values are given in Table 3.36 (next page).

Table 3.35: Weather hazard chart of Temperature Humidity Index (THI) values for cattle and buffalo heat stress thresholds [60].

Temp	Humidity (%)																			
ºC	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
24.0	66	67	67	68	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75
24.5	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76
25.0	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76	77
25.5	68	68	69	69	70	70	71	71	72	73	73	74	74	75	75	76	76	77	77	78
26.0	68	69	69	70	70	71	71	72	73	73	74	74	75	76	76	77	77	78	78	79
26.5	69	69	70	70	71	72	72	73	74	74	75	75	76	76	77	78	78	79	79	80
27.0	69	70	70	71	72	72	73	73	74	75	75	76	77	77	78	78	79	80	80	81
27.5	69	70	71	71	72	73	73	74	75	75	76	77	77	78	79	79	80	81	81	82
28.5	70	71	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	82	83
29.0	70	71	72	72	73	74	75	75	76	77	78	78	79	80	80	81	82	83	83	84
29.5	71	72	72	73	74	75	75	76	77	78	78	79	80	81	81	82	83	84	84	85
30.0	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	85	85	86
30.5	72	73	73	74	75	76	77	77	78	79	80	81	81	82	83	84	85	85	86	87
31.0	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	86	86	87	88
31.5	73	74	75	75	76	77	78	79	80	80	81	82	83	84	85	86	86	87	88	89
32.0	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88	89	90
33.0	74	75	76	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89	90	91
33.5	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90	91	92
34.0	75	76	77	78	79	80	80	81	82	83	85	85	85	87	88	89	90	91	92	93
34.5	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
35.0	76	77	78	79	80	81	82	83	84	85	85	87	88	89	90	91	92	93	94	95
35.5	76	77	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94	95	96
36.0	77	78	79	80	81	82	83	84	85	86	97	88	89	91	92	93	94	95	96	97
36.5	77	78	80	80	82	83	83	85	86	87	88	89	90	91	92	93	94	95	96	98
37.0	78	79	80	81	82	83	84	85	87	88	89	90	91	92	93	94	95	96	98	
38.0	78	79	81	82	83	84	85	85	87	88	90	91	92	93	94	95	96	98		
38.5	79	80	81	82	83	84	85	87	88	89	90	92	93	94	95	96	98			
39.0	79	80	82	83	84	85	86	87	89	90	91	92	94	95	96	97	98			
39.5	79	81	82	83	84	86	87	88	89	91	92	93	94	96	97	98				
40.0	80	81	83	84	85	86	88	89	90	91	93	94	95	96	98					
40.5	80	82	83	84	86	87	88	89	91	92	93	95	96	97	99					

Death

Unstressed | Mild stress | Moderate/Serious | Severe stress

Table 3.36: Temperature Humidity Index (THI) heat stress thresholds and symptoms in buffalo and tropical cattle [61].

THI	Buffalo	Cattle (*B. indicus*)
<72	No heat stress	No heat stress
72-79	Mild heat stress	Mild heat stress
80-89	Moderate to Serious heat stress	Moderate heat stress (THI 78-82) Serious heat stress (THI 83-89).
>90	Severe stress towards death	Severe heat stress towards death

Humane killing: A .22 rifle or stunner (see ***Percussive stunning,*** page 176) can be used for this purpose. The target for a rifle shot or stunner is similar for cattle and buffalo. Figure 3.93 (photos 1 and 3) shows the intersection of two diagonal lines, from the eye sockets to the base of the horns (or horn buds), which represents the target entry point for the captive bolt of a stunner or firearm bullet. Photo 2 indicates the angle for holding the stunner or rifle. A penetrating bolt stunner is likely to be more effective when used from the back of the head (pole position) as seen in Photo 2. A higher calibre rifle will be required for large bulls (cattle) and adult buffalo in order to penetrate the cranium.

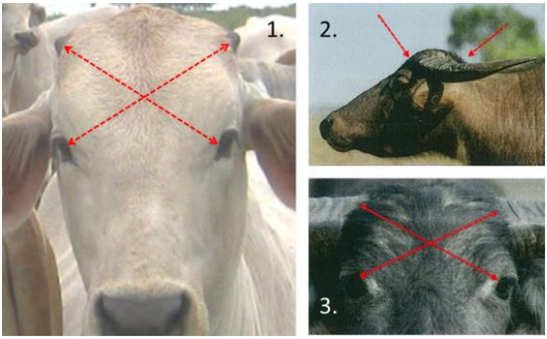


Figure 3.93: Targets and trajectories for humane killing of cattle and buffalo using stunner or firearm.

Humane killing of badly injured animals should be done quickly at the place where they were found. If a non-penetrating stunner is used then the animal must be checked for insensibility (i.e. no rhythmic breathing or corneal reflex) before cutting the throat within 20 seconds of stunning. If a penetrating bolt stunner or rifle is used, ensure the animal is dead before removing the body to a slaughter area for bleeding and salvage (animals humanely killed due to infection should be disposed of by burial or fire (see *Carcass disposal*, next section).

Carcass disposal: Cattle enterprises should have a contingency plan for disposing of carcasses. The plan should include a dedicated area of elevated land that is not likely to flood or contaminate watercourses, and should not be upwind or in view of public areas. The plan should also be aligned with local regulations.

A dead animal must be removed from the feedlot or other location as soon as possible by using a front-end loader to take the body to the burial area (i.e. without dragging the carcass). (If local authorities allow the burning of carcasses, and the area is remote, then this type of disposal could also be considered, especially for diseased carcass).

A trench is dug that is at least 1.5 m long x 1.0-1.5 m wide (per carcass), or 3 m long for 2-3 carcasses. The burial pit should be 5 m deep so that more than 2 m of soil covers the carcass space when the trench is filled. Line the bottom and lower side of the trench with a bentonite/soil mixture to reduce leakage. Before lowering the carcass into the trench, ensure to puncture the rumen to let gases escape. Once in the trench, diseased carcasses may be sprinkled with dehydrated lime to kill pathogens. At this point, the trench is backfilled and packed down, leaving a slight mound over the top to prevent the puddling of rainwater (see Figure 3.94). [62]

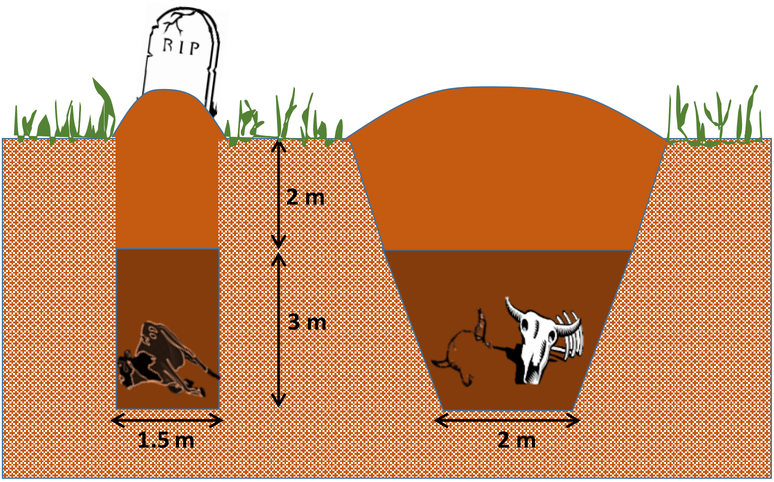


Figure 3.94: Trench (left) and Battered (right) burial pits. The latter is used to prevent fragile walls from collapsing.

3.10. Abattoir operations

Lairage: These are cattle pens near the abattoir for holding stock prior to slaughter. Cattle normally arrive the day before slaughter and the holding pens should have sufficient floor space (i.e., 2.5 m^2/head) for groups of animals preferably from the same truck, plus shade and water troughs. A maximum water curfew (no water) of 12 hours (including travel time to the abattoir) can be applied in order to vacate faeces. Arrivals that have been travelling for more than 12 hours without water or feed should be rested for a day or two with access to clean water and feed. For same day travel and processing, cattle are rested in the holding pen for at least 2 hours prior to slaughter. While a shorter timeline for trucking and slaughter is the least stressful for cattle, it does not necessarily improve beef quality [63].

***Halal slaughter*:** Islamic law safeguards Muslims in their choice, preparation and consumption of halal (pure) food, and protects the principals of good health and wellbeing, while beholden to the sanctity of life and religious credence. Domestic herbivore animals are mostly acceptable as a source of food, but not swine as they are omnivores (plant and flesh eating) and capable of infecting humans with lethal pathogens. Other dietary restrictions include:

- Carrion and dead animals are considered unfit for human consumption due to harmful toxins formed during the decomposition process. This includes the slaughter process of stunning[39] in modern abattoirs, which may be irreversible and kill some animals before exsanguination (cutting the throat and draining the blood). This is an important issue for Imams responsible for certifying halal slaughter.
- Blood is deemed harmful as it contains products of metabolism, and is a medium for toxins and bacteria when exposed to the air therefore is not permitted for consumption.
- Any food, product or enterprise associated with pork are prohibited under Islamic law, including byproducts like lard for cooking and as an ingredient in beauty products etc., and there should be no cross-contamination with other halal products. Abattoirs therefore must keep pig slaughter lines separate from halal slaughter lines, or at least slaughter on different days than other species with vigorous cleaning of the lines in between days.

[39] Stunning means a blow to the head to cause temporary unconsciousness, followed by recovery; this is called ‘reversible stunning’ and is approved for halal slaughter. If the animal is killed by the stunning procedure (i.e. ‘irreversible stunning’), this is not considered a halal slaughter.

According to the Koran, halal slaughter and correct purification of meat should be done with compassion, respect and without cruelty to the animal, as follows [64]:

- The slaughter person must be a sober adult Muslim, although Jew or Christian familiar with the process can perform the slaughter if necessary.
- The slaughter process should avoid unnecessary pain and suffering, and be hidden from the sight of other animals.
- Ensure the knife is sharp, but do not sharpened in front of the animal.
- Provide water for the animal to drink and leave it untied (or loosely tied); do not proceed until the animal is calm.
- Sheep and goats are laid down on the left flank, while cattle can be loosely tethered, however all animals must face towards Mecca.
- Just prior, or during the act of slaughter, the name of Allah must be declared with the words ‘Bismillah, Allahu akbar’ (in the name of God, God is the greatest).
- Slaughtering is done by cutting the animal’s throat (trachea, oesophagus, blood vessels) in one smooth motion, so that the blood flows out rapidly, thereby cutting off oxygen to the brain, and resulting in a quick death.

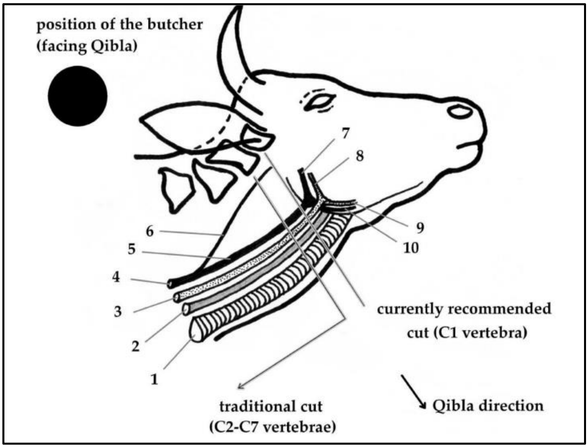


Figure 3.95: Location of incision for halal slaughter of cattle [65].
Legend:

1. Trachea
2. Oesophagus
3. Right coronary vein
4. Common carotid artery
5. External carotid artery
6. Internal carotid artery
7. Maxillary artery
8. Maxillary vein
9. Linguofacial vein
10. Linguofacial trunk

With livestock exports to countries practicing ritual slaughter (halal and kosher), and the expansion of multiculturalism in western society, there are concerns that non-stunning slaughter methods cause unnecessary pain and distress contrary to animal welfare guidelines [66]. Early experiments using electrocardiogram (EEG) on sheep and calves found loss of consciousness occurred within 10 seconds following the throat cut, and an increase in heart rate and flow of blood, whereas stunning was unreliable in its effectiveness [67]. Later research using more developed techniques found that ritual slaughter (i.e. ventral-neck incision) rendered the animal unconscious (therefore insensible to pain) within 3-5 seconds for small ruminants, and up to 60 seconds for cattle. On the other hand, stunning was instantaneous in causing unconsciousness and unawareness of pain.

Although the World Organisation for Animal Health (OIE) code allows halal and kosher ritual slaughter in line with key requisites, many countries (including Australia[40]) have regulated pre-concussive (non-penetrating) stunning prior to ventral-neck incision as part of their animal welfare policies. This is widely accepted by Islamic law because non-penetrating stunning (i.e. does not penetrate the skull) renders the animal temporarily unconscious, allowing ritual slaughter to take place before it recovers. Electric stunning is also accepted as halal by most Muslims (see below). In both these cases, the heart is still beating which is essential for maximum exsanguination.

***Electric stunning*:** Cattle are stunned by passing an electrical current through the brain of the animal, knocking it out for a few minutes, so that the throat can be cut while the animal is unconscious. This method (called *head-only*) is commonly used in Vietnamese abattoirs; it is also generally accepted as halal ritual slaughter by Islamic law. A cardiac arrest can be induced by a second electric shock from the head to the thorax (New Zealand method).

The animal should be calmly restrained in the knocking box and water drizzled onto the head prior to stunning. The stunner device (wand), which can deliver 350-400 volts and 1.5-2.5 amps (= 450-1000 watts), is placed on the forehead of the animal and a continuous electric shocked is applied for 2-3 seconds. The animal should collapse instantly and the restraint immediately released. The side of the box is opened allowing the unconscious animal to slide onto the slaughter floor. The slaughterman checks for insensibility (e.g.

[40] A few small abattoirs are allowed to practise ritual halal and kosher slaughter of small ruminants without pre-conditions.

Figure 3.96: Electric stunning power box and wand (Vietnam).

no rhythmic breathing or corneal reflex) before 'sticking' (cutting the throat) on the slaughter floor for ritual slaughter. For non-ritual slaughter, the hoist chain is attached to the animal's hind leg and hoisted above the floor, prior to sticking. From stunning to sticking must be completed within 20 seconds to ensure insensibility. The hoisted animal is bled into buckets for at least 2 minutes before further processing.

An issue sometimes with electric stunning is uncontrolled flaying or paddling of legs caused by the electric shock, which can be a safety hazard for slaughtermen.

***Percussive stunning (penetrating)*:** The operational device is called a captive bolt. When the bolt is fired, it shoots up the barrel like a bullet, but it is stopped from completely leaving the barrel. The kinetic energy and speed, and length of protrusion of the bolt from the end of the barrel, is sufficient to hit the animal's skull and penetrate the brain, thereby instantly killing the animal (i.e. irreversible stunning).

***Percussive stunning (non-penetrating)*:** A similar stunning device using a bolt with a mushroom head is designed to hit the animal's skull and cause concussion without damaging the skull and brain (i.e. reversible stunning). Pre-concussive stunning is used for religious slaughter (see Halal slaughter, page 173).

Figure 3.97: Pneumatic stunner (above) and captive bolt stunner (below); both optional as penetrating or non-penetrating.

Abattoir facilities and equipment: In the past, many SE Asian slaughterhouses were the grotesquely cruel and filthy killing fields of livestock. With importations of cattle from Australia, and food safety and welfare education over many decades, so have the slaughter houses changed into accredited abattoirs [41] that are humane and clean. Many feedlots now operate their own on-farm abattoirs or use upgraded public or private abattoirs located nearer the city market (see Figures 3.98 and 3.99). A number of small abattoir designs are provided at Appendix A8.

Figure 3.98: (From the top) Philippines slaughterhouse in 1990s; Vietnamese feedlot abattoir in 2015.

Figure 3.99: Modern mobile abbatoir (Sabah).

<u>*Knocking boxes*</u>*:* There are a wide range of boxes and restraints to choose from depending on stunning method and type of slaughter (e.g. ritual). For percussive and electric stunning, the most common is a knocking box with winch-able side panel, and a ramp from the box floor to the slaughter floor, for ease of moving the concussed or dead animal. Some boxes have a space at the front of the box for the animal's head, so that the neck can be cut for ritual slaughter. There is also a box with a hydraulic side panel and a clamp, which holds the animal as the side panel folds down to the slaughter floor where the throat is cut (see Figure 3.100 and 3.101, next page).

[41] The word slaughterhouse originally referred to the shed where butchers would slaughter their livestock, whereas abattoir (from the French word *abattre*) means an industrial building for large scale mechanised, regulated slaughter of livestock.

Figure 3.100: (Left to right) Winch-able side panels of knocking boxes (Vietnam, and Indonesia). *Note:* Stunner hanging above (O); hydraulic side panel with concussed buffalo (Sabah).

Restraints: The aim of the restraint in the knocking box is to keep the animal's head still for an affective electric or percussive stunning. Figure 3.101 shows a range of restraints, from a neck clamp used in Vietnam for electric stunning, to a chin-lift extension for cutting the throat. See also Appendix A8 for more details.

Figure 3.101: (Left to right) Head clamp open; head of electically stunned animal being released from clamp. *Note:* Stunning wand (X) Vietnam); hydraulically clamped animal about to be stunned; restraint with chin-lift extention for throat cutting.

Promotional issues: Can beef products, derived from imported Australian Commercial Cattle fattened in SE Asian feedlots, be promoted as Australian beef or not? Apparently not, because the fattening process did not occur in Australia under Australian conditions. Although the cattle are born and bred in Australia, there could be a misconception that product quality of beef from SE Asian feedlot operations are the same as from an Australian feedlot, even though conditions are very different. Generally speaking, the use of '*Australian beef*' cannot be written on packaging, however '*Locally produced beef from imported Australian cattle*' is more acceptable (see Figure 3.102). However, there is a grey line between shipments of slaughter stock that are held in a feedlot for the short-term (up to one month) and feeder cattle that are fattened in feedlots for three months or more before slaughter.

Figure 3.102: Supermarket promotion of 'whole beef imported from Australia' derived from a local feedlot of imported Australian cattle.

HACCP: Hazard Analysis Critical Control Point is a standardised risk management procedure designed to protect food safety, in this case beef. While the Exporter Supply Chain Assurance System (ESCAS) regulations only cover the welfare of imported Australian cattle up to the point of slaughter, it is in the best interest of importers to use HACCP accredited abattoirs (including their own facilities) for processing imported feedlot cattle. This will ensure food safety (and avoid litigation) and protect the meat quality attributes of the imported cattle according to customer requirements (see **5. ENTERPRISE MANAGEMENT PROCESS**; page 219).

HACCP involves carrying out a hazard analysis and risk assessment to determine critical control points for each standard operational procedure in the slaughterhouse, from arrival of cattle to slaughter, carcass chiller, boning room, cold chain storage and delivery, and affiliated butcher shops. A system of monitoring and managing these critical control points for each operation is then developed, together with the corrective actions to be taken and documented. For example, slaughter and boning out floor preparation involves:

- Cleaning and sanitation of floors and equipment (e.g. viscera trolley, cutting table etc.).
- Sterilization of equipment (e.g. carcass saw, handsaw, knives, scabbards, mesh gloves etc.) requires soaking in hot water (55-60°C) containing detergent or sanitiser (or 82°C if water only) for 20 minutes, after which the items are scrubbed and rinsed in warm water.
- A pre-operational hygiene inspection is carried out before commencing slaughter or boning out operations.
- Regular checks of work surfaces, including equipment, walls, aprons, knives etc., are done with swabs to test for microbial contamination.

Cold storage of meat products is another important hazard area, particularly fresh meat, where temperature, humidity and storage time are critical factors. Although pathogenic microorganisms are unable to grow at below (<) 5°C, they will become active again above this temperature. Recommended temperatures for fresh and frozen meat storage are given below:

- *Side chillers:* Carcass sides should be hanging in the chiller within 2 hours of slaughter. For each batch of sides, the air temperature of the chiller is set at 0°C with a fanned air speed of about 2.5 metres/sec., until the surface temperature of carcass side reaches 7°C in 24-48 hours. At this point, the sides are ready for boning out in an air-conditioned room of 10°C.
- *Chillers (0°C):* Fresh meat for the cold chain must be stored below 5°C, and it is suggested the storage temperature should be maintained closer to 0°C where there is frequent opening and closing of the chiller door.
- *Freezers (-18°C):* At this temperature, frozen beef can be stored up to one year; however, the formation of ice crystals in muscle cells reduces meat quality, whereas blast freezing retains much of the meat quality.

3.11. Records

The purpose of having records is to be able to monitor individual performance of cattle, whether fattening in the feedlot or breeding on pastures. Record keeping is the key to profitable cattle and buffalo production, because without records, it is easy to miss problems that can lead to economic losses. These problems include rising mortalities, weight loss, disease, low calving rates, and incorrect herd structure. It is especially important that breeder herd records be used to monitor breeding performance in order to remove unproductive stock from the herd [68]. Feedlots also need to keep records of feed consumption and growth rate as a key economic performance indicator.

Figure 3.103: Eartag ID

Basic records: These are required to characterise all new arrivals and existing stock (see Table: 3.37, next page):

- *ID eartags:* All cattle should be identified with an eartag.
- *Breed:* Comparison of different breeds enables selection of the best performing breed for the location of the enterprise (e.g. Brahman cross, Brahman (high grade, HG), Droughtmaster etc.). Hair colour may also be recorded.
- *Sex/Age:* Male (M), female (F), and date of birth (DOB). Alternatives include sex/weaner, sex/yearling, yearling heifer or bull, heifer, cow, spayed heifer or cow etc.
- *Body condition score (BCS):* This is an important observation for feedlot and breeder management in terms of feeding and breeding decisions, and as a visual assessment of performance and market readiness (see Appendix A1).
- *Pregnant:* Apart from new arrivals, yearling heifers and cows in breeder herds are regularly checked for pregnancy status.
- *Lactating:* Adult breeders are checked for lactation status. Lactating means the cow is nursing a calf. Cows that are pregnant and still nursing a calf are a good performance sign, and cows which are neither pregnant nor lactating (i.e. dry cow) should be monitored closely and considered for culling.
- *Weight:* All new arrivals should be weighed. Lot-fed cattle are weighed at turn-off and during the feeding period to monitor growth rates. All cattle classes in breeder herds are usually weighed when they are at the yards for weaning, pregnancy testing or for other reasons.
- *Comments:* Veterinary treatments, notes on injuries, mortality, culling, calving details etc., are examples of comments to be recorded and dated.

Table 3.37: Basic cattle recording sheet for processing imported cattle and buffalo.

CATTLE RECORDING SHEET

DATE: 30/04/2020

LOCATION: Bukit Indah Feedlot, West Java

ID	TYPE (Breed/ Sex)	AGE	BCS	LW (kg)	PREG	LACT.	COMMENT
300	Bra/M	03/19	3.5	373	-	-	Pen 3, all treatments
296	Bra/M	04/19	3.5	335	-	-	Pen 4, all treat (AT)
282	Bra/F	01/19	3.0	295	-	-	Pen 1, spayed, AT
290	BraX/M	02/19	2.5	287	Shy feeder, monitor, Hosp. Pen, AT		

Remember to write the date of the recording

Name of recorder: Bagus

Herd records: Breeder herds should be yarded and characterised at least twice a year in order to monitor the physiological state of the cows, bulls and progeny. Calves are weighed, sexed and ID tagged at birth, making sure that the mother's ID and the date of birth (as near as possible) is also recorded. In addition to basic records, breeder herds should have record cards for each cow and calf. The example in Figure 3.104 (next page) covers the cow's details on one side of the card and calving data on the other side.

<u>Cow and calving records:</u> The important records for cows are as follow:

- Cow's ID, DOB, parents details (Sire and Dam).
- Cow's live weight at birth, 3 months (optional), weaning, yearling (prior to 1st mating (joining)).
- Cow's joining date, and bull's details (verified data under calf's Sire).
- Pregnancy testing details (date, status), calving date.
- Calf's ID, DOB, sex, sire.
- Calf's birth weight (and date of weighing if not DOB).
- Calf's weaning weight and date.

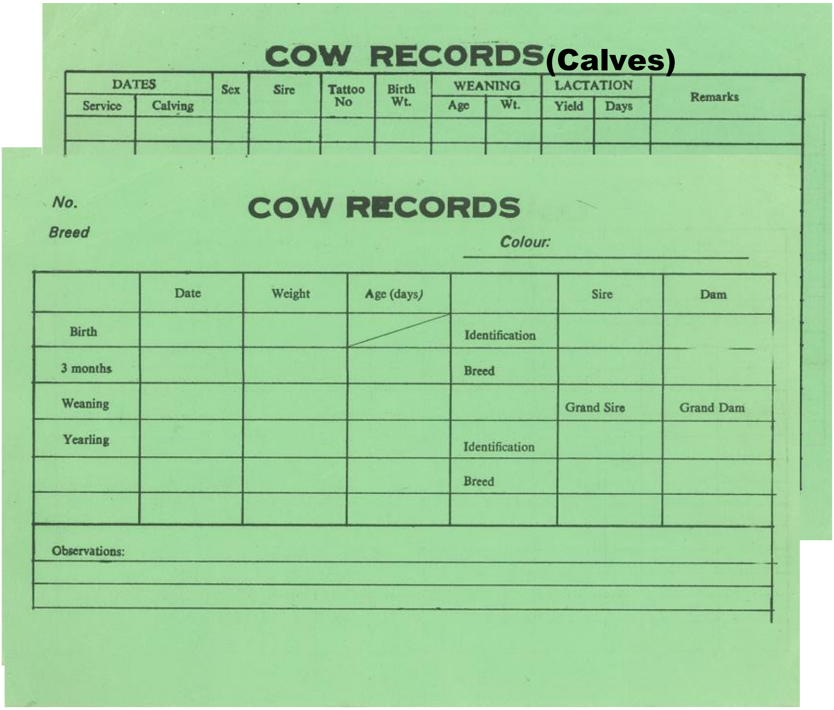


Figure 3.104: Example of cards for cow/calf records.

Feedlot records: Replacement feeder cattle are inspected and characterised on arrival at the feedlot, using a basic recording sheet (see Table 3.37, page 182) as part of the processing procedure to allocate the animals into pen groups. The main criteria for keeping records of feedlot animals is to monitor feed efficiency (measured by the Feed Conversion Ratio (FCR)), in terms of feed consumption per kg live weight gain. This data provides a snapshot of the economic performance of a group or consignment of cattle (see *Feed conversion ratio (kg DMI/kg LW)*, page 194).

Feed records: See *Feed adjustments* and Infobox 3.20, page 102.

Measuring dry matter: There are three drying methods for measuring the dry matter of fresh feedstuffs and rations, as follows:

- *Oven:* Take about 100 g of plant material sample (or 150 g of well-mixed ration sample) and cut into 3-5 cm pieces. Record the tare weight of an empty aluminium foil tray (approx.19 x 11 x 4.5 cm) or equivalent. Empty the fresh sample into the tray and record the combined weight of tray with sample, before placing in the oven at 85-90ºC for 24 hours. Then, remove from the oven and record the weight of the tray with sample. Carefully mix the sample around in the tray, before replacing it in the oven for a further 6 hours. Weigh the tray with sample again and if there is a change in weight from the 24 h weight, replace in the oven for another 3 hours. Continue this routine until there is no change in weight. At this point, subtract the tray tare weight from the first and final weights to get the net FM and DM weights of the sample material. The DM% of the sample is the net DM weight divided by the net FM weight (e.g. 26 g DM/113 g FM x 100% =) 23%.
- *Microwave oven:* Record the tare weight of a microwave-safe plastic container before adding about 100-150 g sample of plant or ration material cut into 3-5 cm pieces. Then record the combined weight of the container plus fresh sample. Set the microwave to medium power (400-500W) and place the container with sample, together with a glass of water, on the rotating tray. Microwave for 3 minutes, then record weight of the tray with sample. Carefully mix the sample in the tray before microwaving again for a further 1 minute. Reweigh the tray and sample, and repeat if necessary, until the weight is unchanged or constant. See example below to calculate DM%:

DM% = [31 g (DM+tray)-5 g (tare)=26 g] / [118 g (FM+tray)-5g (tare)=113 g] x 100% = 23%

- *Sun drying method:* Larger samples can be collected and spread out in a bigger tray. Protect from wind gusts that could blow away the sample especially as it becomes drier, and ensure that the possibility of rain is minimal. Record the tare weight of the empty tray and with the fresh sample of plant material before sun drying. Record the weight of the tray with sample at sundown and keep in a dry room overnight.

Table 3.38: Calculation of % ration DM.

Ration Ingredients	DM (%)	DMI (kg)	FMI (kg)
Elephant grass	30	2.44	10.0
Corn (cracked)	91	0.28	0.31
Rice bran	91	1.99	2.19
Wheat pollard	88	0.71	0.81
Palm kernel cake	89	1.14	1.28
Copra	90	1.14	1.26
Molasses	75	0.17	0.23
Salt	100	0.03	0.03
Limestone	100	0.15	0.15
	Total DM	8.05	16.26
Ration DM% (8.05/16.26 =) 49.5%			

The next day, continue to sun dry until midday and record the weight, repeat every 3 hours (including the following day) until the weight is constant. Remember to subtract the tare weights when calculating the DM% (see equation previous page).

Note: An alternative way of measuring DM% of rations is by calculating total DM and FM of ingredients in the ration (see Table 3.38).

Liveweight records: Cattle nowadays are mostly weighed using digital cattle scales, i.e. Tru-Test or Gallagher scales. These scales are positioned in the race, either under the crush or just before the crush. Weights are automatically recorded and saved for downloading later into a computer file, or directly into a farm record program. Avoid weighing cattle in the heat of the day if over 30°C, by operating early in the morning or later in the afternoon. For feedlot cattle, weigh animals first thing in the morning before feeding. If recording live weights to monitor growth rates, withdraw food and water for about 12 hours to minimise weight errors[42] due to excess rumen contents. Subsequent weighing of the same cattle should be done at the same time of day as previously.

[42] New arrivals at the feedlot are likely to have much less rumen contents (<8% LW) when weighed at processing, than after a month of consuming feedlot rations and water (±10% LW rumen contents).

Pasture records: Cattle operations that rely mostly on grazing pastures as a source of nutrition for their breeding herds, require records to manage the pastures. This includes general observations, pasture condition, fencing, paddock yields, stocking rates, grazing systems, calendar schedules for grazing, weeding, fertilising, checking water troughs, growing hay and crops. Details of plans for pasture development, soil sampling, planting improved grasses and legumes, and reticulation of drinking water, are also included in the pasture records. Many commercially available livestock management computer programs can assist with pasture management (see below).

Once operations have started and recordings are made, these observations become extremely valuable for forward planning and improving grazing strategies. As these are developed, their performance can be followed using historical and current record trends.

Digital records: There are a number of livestock management computer programs that assist farm managers to keep cattle records, and use the records to monitor the performance of the beef cattle herds or feedlot operations. Software for breeder herds will feature detailed livestock and grazing records to help with management of pastures, including supplementary feeding and costs; breeding programs and tracking due dates such as calving, weaning etc.; records of veterinary treatments and deaths. Most of these computer programs will also have a budget section that can monitor the profitability of the operation. Listed below are some examples of these programs for Breeder Herd operations:

- *Stockbook:* This program has a range of data collection options to help manage genetic potential, fertility, weight gain, and other performance measures, thereby identifying unproductive animals for culling. It also includes software allowing direct collection of individual weight recordings from the yard.
- *Agriweb:* This software uses daily farm records to report on production costs, current herd status, and stocking rates, and is designed to help managers make better decisions.
- *Herdmaster:* The program is designed for easy data entry and livestock herd management. It is also linked to Breedplan which measures EBV of bulls and helps farmers to develop tailored breeding programs
- *Koolcollect:* This program collects individual animal data as cattle are weighed in the yard, which can be uploaded into farm management programs.

Examples of software for feedlot operations:

- *Cattle Fattening Records (Possum Gully Software):* This software uses a range of individual cattle records to monitor their performance, and pen-feeding records are used to calculate feed conversion and costs. A feed commodity inventory system also keeps track of feed stocks.
- *Elynx (StockaID-lite):* This program has a number of modules to capture animal data at feedlot entry including, ID, weights, manual inputs, and feed management (Feedbunk 3000), and financial data (Feedlot 3000).

Alternatively, a computer savvy feedlot manager or associate can develop an uncomplicated feedlot management computer program using Microsoft Excel spread sheets, that focuses on particular needs for records, measurements, and feed formulation (see Appendix A10, page 263).

Pen records: Every pen containing animals should have a notice or black/white board with the Pen No. and hand-written information about the feeding regime, and other relevant notes. As this record may change on a day-to-day basis, the onsite information ensures that staff can follow the changes without error (see Figure 3.105).

Figure 3.105: (Left to right) Pen notice (pen no., total head, average LW, concentrate (kg), forage (kg); real time calf records (Sabah).

3.12 Budget Projections

Assumptions and targets: Budget estimates are critical to enterprise planning. At first, guestimates of performance targets and costs will need to be made in the absence of real data, in order to get a ballpark idea of the financials. As the assumptions are replaced with more realistic targets and actual costs, the more confident we can be with the outcome. It is also important to develop an accurate model that captures all the operational costs involved. The financial model will help to identify areas needing attention to reduce costs and improve efficiencies, and to find opportunities to add value to the operation. The financial analysis is focussed on the operational costs of the feedlot; it does not usually include capital costs of infrastructure, equipment and long-term loans.

Feedlot budget projection: The main financial data requirements for a feedlot operation in SE Asia are listed below (see examples in Table 3.39, page 192):

- *Landed price:* Cattle are priced as USD/kg LW (CIF), according to classes of cattle (e.g. medium feeders, ±350 kg LW; slaughter stock, ±425 kg LW; bulls, ±500 kg LW, etc.) as listed on the consignment documents. The price includes Costs, Insurance, and Freight (CIF).
- *Rate of exchange:* Current exchange rate of USD against the destination currency is required to complete the financial analysis in the local currency.
- *Customs:* Import duties, Value-Added Tax (VAT), quarantine charges.
- *Transport:* Costs of trucking the cattle consignment from the port to feedlot.
- *Processing:* Eartags and drugs are the main costs during processing.
- *Performance targets:* Use the performance targets in Table 2.4, page 17, for developing the financial model.
- *Consumption index (CI):* Targets for feedlot entry and turnoff of feeders is 325-425 kg LW. The average DM feed intake therefore is based on 350 kg LW feeder at the mid-way point of the feeding period, using 2.5% LW (CI) or refer to Table 3.4, page 49, for different classes of cattle. Older cattle tend to eat less towards the end of the feedlot period thereby averaging about 2.3% LW at the mid-way point. Once the financial module is set up then a range of liveweights and CIs can be tested.
- *Feed costs:* This is the cost of feed (as fed), and should include leftovers or a correction factor for wasted feed. Stockfeed represents a significant part of the overall feedlot costs. Using the above performance targets and stockfeed prices, the Feed Conversion Ratio (FCR) can be estimated (see Infobox 3.28, page 195) and provide a useful guide to the potential profitability of the operation.

- *Labour:* Labour costs are factored into the analysis on a per head of cattle basis (e.g. [$2,000 (total wages/month) x (3 months operation) = $6,000]/500 feeders = $12/feeder). This includes stockmen, feed shed staff, supervisors, admin staff, farm manager etc., whoever is involved with the operation. Also, the cost of a veterinarian (on site or local) and drugs used to treat animals during the feeding period. *Note:* Cleaning of cattle pens is often outsourced and paid for in manure; this is a win-win for both parties as the feedlot saves on fuel and wages for mechanical cleaning, and the cleaners can on-sell the manure for better returns than a cash payment.
- *Utilities:* Electricity and water costs can be high in a feedlot operation, and may be supplied by generator and bore. There are opportunities to reduce these costs by investing in renewable energy sources (solar, methane etc.).
- *Fuel:* Fuel is used by the tractor to pull the feed trailer 2-3 times per day, and other machines and vehicles are used around the feedlot. Transport costs to bring cattle from the port and to the abattoir are also included in the financial analysis.
- *Repairs and maintenance:* There is always a need to fix a gate here or replace a broken grate there. The factor of 1.5% of asset value of the feedlot facility may be used to estimate this cost.
- *Letter of credit (LOC):* Importers normally have a short-term (120-180 days) bank loan arrangement to cover the payment for each consignment of cattle. Start-up or new importer's LOC may include operational costs such as feed costs. The financial module takes into account the total cost of a short-term loan completed within the budget time-line, but the interest payment for long-term capital investments loans is not usually included.
- *Feedlot mortality:* This is allowed for by a default of 0.5% mortality.
- *Value of slaughter stock:* Feedlot slaughter stock are often sold at the market rate to abattoirs, via middlemen. Many feedlots also have their own abattoir, or contract a local slaughterhouse, to slaughter and process their animals for value adding of slaughter stock as a whole carcass, and carcass products. In this case, the total feedlot costs to produce the slaughter stock are fixed at breakeven value, and added to the slaughter and processing costs to determine the Benefit/Cost outcomes of post-slaughter sales (see Table 3.39, page 192: In this example, the profitability of value adding was less than the sale of slaughter stock).
- *Value adding costs:* The costs of processing slaughter stock range from that of an on-site abattoir vertically integrated with the feedlot, or a contract with a local slaughterhouse. Some large feedlot companies are totally integrated, from the feedlot and abattoir, to butcher shops and restaurants.

- *Sales:* Current prices are used for sales of feedlot products (e.g. pre-slaughter price, manure price (if sold). The sales of value added products include whole carcass, or carcass product (beef cuts), plus blood, bones, head, hocks, and hide (see Table 2.3 for carcass yield of beef cuts, page 13). Other sale opportunities include cattle manure or processed compost as organic fertiliser for plant nurseries and garden.

Profit Variables: The main profit variables are the landed price of feeders, which is influenced by good seasons (average price) and drought (a low or high price depending on demand) in northern Australia, and local SE Asian domestic prices for meat (higher around festival time). Local stockfeed prices and feedlot performance of cattle affects profitability. Some examples of variables that could positively influence returns are given below:

- An increase in feedlot performance (e.g. from 1 to 1.1 kg ADG) reduces time in the feedlot and saves feed cost, and can increase returns by 2-3%.
- On-farm production or contract growing of fresh forage by local farmers is better quality and costs less than purchasing a substitute (i.e. hay) stockfeed.
- For post-slaughter operations, optimal carcass dressed weights of 54% or more will substantially increase the amount of saleable meat, and return 3% or more (at least $3 extra per dollar spent).
- Value adding of subprimals by manufacturing meat products such as meatballs (see Figure 3.106) could also improve profit margins.

A combination of the above positive variables could double returns from 8% to 16%, which is more than the feedlot example with returns of 13% (Table 3.39, page 192).

Figure 3.106: Meatballs factory adjacent to abattoir (Thailand) .

Profit (P), Cost/Benefit (C/B) Analysis and Returns: Budget projections measure three important factors. Firstly, Profits (net of costs) are simply the total sales subtracted by total costs (P = (B-C)), e.g. (see Feedlot Budget Projections, Table 3.39, page 192):

P = ($1,252.75 (B)-$1,111.16 (C)) = $142.16/head.

In the above case, if the consignment is uniform in terms of class of cattle, live weight and age, then it is expected that a consignment of 1000 head will bring a net profit of $142,160. If the consignment is not uniform, then different groups of cattle will need to be subjected to budget projections separately.

The second measure is the Rate of Return (R) by the formula [((B-C)/C) x100], e.g. (see Table 3.39, Feedlot[1] and Adding Value[2] Budget Projections):

R = ($1,199.28(B²))-[$1,111.16(C¹) + $37.53(C²)] = $50.58/$1148.69= 4.5%

The third measure is the gross Benefit/Cost (B/C) ratio of the benefit value ($) for each dollar spent, e.g. (see Table 3.39, Feedlot Budget Projection):

B/C = ($1,253.75 (B)/$1,111.16 (C)) = 1.13 or 1:13 ($1 spent → $13 returned).

The projections for the feedlot and value adding examples in Table 3.39 show that the returns on value adding of feedlot slaughter stock was less than half (4.5%) compared of pre-slaughter sales (13%). In this situation, it would be better to focus on ways of improving the feedlot operation to achieve the target of 15% returns or more. A solid Rate of Return is needed to pay back loans and costs of capital investments in infrastructure and equipment.

Risks: The main risk is an upward variation in the landed price of Australian feeder cattle. An increase in price of 10c/kg LW would reduce returns on pre-slaughter prices by 4%. This is an external factor caused by volatility in supply and demand, exchange rates and oil prices, which cannot be controlled by the importer. Also beyond control is the cost of finance, which is related to the performance of the local economy. However, negotiating a lower interest rate would help to mitigate the other increases.

Some cushioning of these factors can be made by importing lighter feeders (250-275 kg LW) for backgrounding on forage-based rations for 45-60 days prior to maximising productivity on feedlot rations. An increase in local feed costs of 10% is likely to decrease returns by 1%, and early planning to stabilise feed supply and costs is critical, as it forms a large proportion of the budget. Consideration should be given to on-farm cropping, negotiation of long-term fixed price contracts for stock feed, or securing a supply of cheap waste feeds such as brewer's grains, soybean waste, etc.

Table 3.39: Examples of budget projections for a feedlot operation comparing sales of slaughter stock (Feedlot), and post-slaughter sales of carcass products (Value Adding). (See text for more details and Appendix A11 for more examples).

Feedlot Budget Projections (Per Head Basis)							
PRODUCTION TARGETS		DATA INPUT		PRICE/UNIT		PRICE/HD (VND)	PRICE/HD (USD)
Feedlot Entry LW		325	kg				
Slaughter LW		425	kg	VND 67,850	per kg	VND 28,836,250.00	$1,253.75
Feed Period		100	days	$2.95	per kg		
ADG (kg)		1	kg/day				
COSTS						Out	lays
Feeders CIF Port		337.5	kg LW@ USD	$2.50	per kg LW	VND 19,406,250.00	$843.75
Customs/VAT (5%)				VND 57,500.00	per kg LW	VND 970,312.50	$42.19
Quarantine						VND 5,000.00	$0.22
Transport (port-feedlot)						VND 75,000.00	$3.26
Veterinary Drugs						VND 60,000.00	$2.61
Feed cost:				VND 1,850	/kg ration (as fed)		
As Fed		18.9	kg x days	100	Total Feed Cos	VND 3,503,191.49	$152.31
Ration DM		47%					
DM Intake	(at 50 days)	8.90	kg dry matter				
Labour:					Salary, etc.		
Stockmen	(1 pers/200 feeders)			VND 1,725,000	per month	VND 28,462.50	$1.25
Supervisors	(1 pers/1000 feeders)			VND 4,550,000	per month	VND 15,015.00	$0.66
Office Staff	(3 persons)			VND 4,000,000	per month	VND 13,200.00	$1.74
Manager	(1 person/3000 feeders)			VND 6,750,000	per month	VND 7,425.00	$0.33
Utilities/Fuel				VND 2,520,000.00	per month	VND 10,080.00	$0.44
Finance (Cattle	15%	180	days			VND 1,435,531	$62.41
					TOTAL COST	VND 25,529,467.31	$1,111.16
US$=	VND 23,000	Vietnamese Dong			NET PROFIT (B-C) or LOSS	VND 3,306,782.69	$142.59
					RETURNS ON $ SPENT	13%	13%
					BENEFIT/COST RATIO (BCR)	1.13	1.13

Value Adding Budget Projections (Per Head Basis)							
PRODUCTION TARGETS & YIELD DATA				PRICE/UNIT		PRICE/HD (VND)	PRICE/HD (USD)
Slaughter LW		425	kg	VND 60,069	per kg	VND 25,529,467.31	$1,109.98
Feed Period		100	days	$2.61	per kg	Breakeven (price=feedlot cost)	
ADG (kg)		1	kg/day				
Dressing		53.00%		SALES VALUE		Body Value	Body Value
Carcass Yield	100%	225.25	kg	VND 122,457	per kg	$27,583,371.00	$1,199.28
Boneless Meat	70%	157.7	kg	VND 174,938	pr kg		
Prime Cuts*	20.00%	31.5	kg @	VND 310,500.00	per kg	VND 9,791,617.50	$425.72
2nd Cuts*	25.00%	39.4	kg @	VND 207,000.00	per kg	VND 8,159,681.25	$354.77
3rd Cuts*	23.00%	36.3	kg @	VND 100,000.00	per kg	VND 3,626,525.00	$157.68
Meat Trim*	16.00%	25.2	kg @	VND 80,500	per kg	VND 2,030,854.00	$88.30
Fat Trim*	12.00%	18.9	kg @	VND 34,500	per kg	VND 652,774.50	$28.38
Offal/Tail		15	kg @	VND 51,750	per kg	VND 776,250.00	$33.75
Bone (% carcass)	18%	40.5	kg @	VND 28,750	per kg	VND 1,165,668.75	$50.68
Hide		25	kg @	VND 27,600	per kg	VND 690,000.00	$30.00
Head				VND 690,000	per animal	VND 690,000	$30.00
* As % of Boneless Meat (BM)					TOTAL	VND 27,583,371.00	$1,199.28
COSTS					ADDED-VALUE	VND 2,053,903.69	$89.30
Abattoir contract:	($37.50/hd)					Out	Lays
Slaughter Cost	(5 pers/day/12hd)			VND 4,250,000	per head	VND 59,028	$2.57
Deboning	(5 pers/day/12hd)			VND 4,250,000	per kg BM	VND 59,028	$2.57
Chiller/Freezer hi	(60c/t/h for 10 days)			VND 894,240	per t/day	VND 745,200	$32.40
					TOTAL COST	VND 863,255.56	$37.53
US$=	VND 23,000				NET PROFIT (B-C) or LOSS	VND 1,190,648.13	$50.58
					RETURNS ON $ SPENT	4.5%	4.4%
					BENEFIT/COST RATIO (BCR)	1.045	1.044

Table 3.40: Example of a budget projection for a small herd of 50 cows plus bulls and progeny, and with both grazing under oil palm and breedlot facilities (Sabah).

Brahman Breeder Herd (50 cow base) - Breedlot/Pasture										
			UNITS			UNIT SALES	/COST		TOTAL SALES/	COST
SALES (A)						MYR	USD		MYR	USD
Culled Bulls		2	head	525	kg LW	MYR 9.38	$2.25	kg/LW	MYR 9,851.63	$2,362.50
Culled Cows		7	head	450	kg LW	MYR 7.51	$1.80	kg/LW	MYR 23,643.90	$5,670.00
Yearling Heifers		6	head	300	kg LW	MYR 10.43	$2.50	kg/LW	MYR 18,765.00	$4,500.00
Bulls (Tested)		16	head	475	kg LW	MYR 12.51	$3.00	kg/LW	MYR 95,076.00	$22,800.00
								TOTAL SALES	MYR 147,336.53	$35,332.50
PURCHASES (B)										
Herd Bulls		2	head	450	kg LW	MYR 12.51	$3.00	kg/LW	MYR 11,259.00	$2,700.00
Slasher		1	unit			MYR 12k			MYR 12,000.00	$2,877.70
								SUBTOTAL	MYR 23,259.00	$5,577.70
OPERATIONAL (C)										
Vet Drugs		50	unit			MYR 2.09	$0.50	/head	MYR 104.25	$25.00
Fertilser		60	bags			MYR 10.43	$2.50	/bag	MYR 625.50	$150.00
Herbicide		150	litres			MYR 6.26	$1.50	/Litre	MYR 938.25	$225.00
Concentrate Feed		15	MT			MYR 3,544.50	$850.00	/MT	MYR 53,167.50	$12,750.00
Mineral Block		50	blocks			MYR 75.06	$18.00	/block	MYR 3,753.00	$900.00
Wages		3	staff	12	month	MYR 874.99	$209.83	/pers/m	MYR 31,499.68	$7,553.88
Utilities (fuel/elect.)		30/120	Ltr/kWh/m	12	month	MYR 4.17 / 10.43	$1/$2.5	/unit	MYR 16,513.20	$3,960.00
Finance (interest)		1	year	8%	annual	MYR 23,259.00	$5,577.70	/purchases	MYR 1,860.72	$446.22
			m=Month					SUBTOTAL	MYR 108,462.10	$26,010.10
								TOTAL COST	MYR 131,721.10	$31,587.79
		USD $ =	MYR 4.17	Malaysian Ringgit				NET PROFIT (B-C) or LOSS	MYR 15,615.43	$3,744.71
								RETURNS ON $ SPENT	12%	12%
								BENEFIT/COST RATIO	1.12	1.12

Figure 3.107: (Right to left) Imported and local Brahman breeder herds on pasture (Indonesia), and under oil palm (Sabah, Malaysia).

Breeder budget projections: The costs of breeder herd operations are similar to that of feedlotting in terms of cost items, with the addition of pasture management expenses including fertiliser and herbicides. Breeder herd operations also sell a range of cattle classes, from culled cows, to young bulls and heifers (see Table 3.40, previous page). In this case, there are a number of small oil palm plantations in the area, running breeding herds of 50-100 breeders and plenty of demand for tested bulls, breeder cow replacements and feeders for a local feedlot. See Appendix A11 for more examples.

Feed conversion ratio (kg DMI/kg LW): Feed costs are a major part (15-25%) of the total feedlot budget, therefore feed efficiency to produce beef is a critical measurement of performance and economic status of the operation. A feed conversion ratio (FCR) of 7 (i.e. 7 kg DM feed needed for 1 kg LW gain) is a good target measure of efficiency for feedlot cattle performance[43]. The FCR value is used to compare the feed costs relative to beef production (see Infobox 3.28, next page).

Method:

(i) 60 days after arrival of consignment and before feeding in the morning, randomly choose three or more pens of cattle (e.g. 25 head/pen) on the same ration and weighed each pen separately.
(ii) Return cattle to their pens and provide their morning feed.
(iii) Take well mixed, 200 g samples of the ration (as fed) from each pen while the cattle are feeding. Dry the samples in an oven (see *Measuring dry matter*; page 184) until there is no weight change with further drying.
(iv) Calculate DM% of the ration sample (e.g. (DM g/FM g) = 70%) for each pen separately (if there is an outlying result, repeat sampling and drying for that pen).
(v) Total up the recorded amounts of ration fed daily to each pen of cattle during 60-day feeding period (see Infosheet 3.20, page 102). Likewise, add the feed leftover data separately and subtract from feed supplied if more than 3%[44]. For each pen, calculate average total feed intake (as fed) per head over 60 days (i.e. 18.5 t/25 head = 740 kg/head) and convert to DM (e.g. 740 t x 70% DM = 518 kg), using the ration DM measured above.
(vi) Determine the average cost of the ration (kg as fed) for each pen over the 60-day period and convert to cost per kg DM.

[43] In 2000, the average FCR ratio for 12 feedlots surveyed in Indonesia was 8.8 (pers.).

[44] 3% leftovers is normal; if records are available, higher than normal amounts of leftovers can be subtracted from feed provided to get a more accurate result of DMI.

(vii) Calculate the average LW gain/head over 60 days for each pen, by subtracting feedlot entry LW (recorded at processing) from the 60-day weights (e.g. 63 kg LW).

(viii) The measures calculated so far are:
> Average LW gain/head/60 days for each sample pen.
> Average total feed consumption (as fed/head/60 days) for each pen.
> Average total feed consumption (DMI/head/60 days) for each pen.
> Average cost of ration (per kg as fed and DM basis) over 60 days.

(ix) A quick estimate of the Feed Conversion Rate (FCR) is, i.e.:

$$\text{FCR (Pen 1)} = \frac{518 \text{ kg (Average total (DMI/head/60 days)}}{63 \text{ kg (Average LW gain/head/60 days)}} = 8.2$$

(x) The FCR ratio is normally refined to DMI/head/day and ADG/head (e.g. divide by 60 days), i.e.:

$$\text{FCR (Pen 1)} = \frac{8.63 \text{ kg (DMI kg/head/day)}}{1.05 \text{ kg (ADG/head)}} = 8.2 \text{ (1: 8.2) or}$$

e.g. 1 kg gain for 8.2 kg feed DM

(xi) The FCR ratio provides an economic snapshot of feedlot performance in terms of the feed cost of production, e.g. feed cost of ADG 1kg:

$$\text{FCR (Pen 1)} = \frac{12.3 \text{ kg (FMI kg/head/ day)}}{1.05 \text{ kg (ADG/head)}} = \underbrace{11.8 \text{ kg} \times \$0.25/\text{kg FM}}$$

= 1 kg gain feed cost = $2.95 as fed

Infobox 3.28: SUMMARY

CALCULATION OF FEED CONVERSION RATIO (FCR) & COSTS

(a) Feeding period (day): 60
(b) Cattle numbers (head): 25
(c) Total feed consumed (tonne, as fed): 18.5
(d) Total feed consumed (t DM @70% DM): (c x 0.7 =) 12.95 tonne
(e) Feed consumed (kg DM/hd/60d): ((d x 1000)/b =) 518 kg
(f) Total gain (kg LW/hd/60d): 63 kg

(g) **FCR:** (kg DMI/kg LW gain): (e/f) (518/63=) **8.2**
(h) Ration cost (kg FM): = 25c (25/0.7=) 36c DM
(i) Feed cost (as fed) for 1 kg LW gain: = ((c/b)/ f) x 25c/kg
= $2.95 kg as fed

3.13 Live Cattle Export Regulations

Australia has strict rules for looking after livestock. From birth to death, farm animals wear an electronic eartag from the National Livestock Identification System (NLIS). The ID tag is linked to a central database, which stores the Property Identification Code (PIC) where the animal was born, and its lifetime movements along the supply chain up to its death. The NLIS serves as an important traceability tool for disease control and food safety for both domestic and export markets. The NLIS is also important for monitoring the in-country supply chain of Australian livestock exported to SE Asia.

Australian livestock exporters are licenced by the Australian Government Department of Agriculture, Water and Environment (DAWE)[45]. They must have an Approved Export Program (AEP) and an approved Exporter Supply Chain Assurance System (ESCAS) for exporting livestock (mainly cattle, buffalo, sheep and goats) to feedlots in SE Asia (and other overseas destinations). Exporters also need to have an Import Permit and pre-shipment health protocol from the importing country before submitting a Notice of Intent (NOI) to DAWE prior to the export date.

ESCAS is designed to make sure that the health and welfare of each animal in a consignment can be monitored throughout the offshore supply chain up to the point of slaughter. It assures OIE animal welfare standards, control of stock and traceability within a closed offshore supply chain, backed up by independent audits of accredited facilities (e.g. feedlot and abattoir), transport, and Standard Operating Procedures.

The responsibility for monitoring ESCAS is the exporter and his technical team. They are required to scan the NLIS tags of all animals in each consignment, when they arrive at the feedlot, and after slaughter at the abattoir (and any deaths in between). The NLIS data is sent to the database, with a full report sent to DAWE when the last animal in the consignment has been slaughtered. The exporter is also responsible for arranging ESCAS related agreements with local livestock transport companies, and audits of the importer's facilities and operation. He must also report

Figure 3.108: NLIS tag

[45] For more information about livestock export regulations, go to: https://www.agriculture.gov.au/export/controlled-goods/live-animals/livestock/information-exporters-industry

any breaches of ESCAS regulations to DAWE. Where there are serious breaches by the importer (or exporter) then further export permits may be withheld by the authorities until the matter is investigated, and future compliance can be assured by the exporter.

Not all importers agree with ESCAS, in fact some are outraged that Australia has ongoing control of the management of the cattle that they have purchased, and there is no use trying to explain or reason with them. Other players are willing to import Australian cattle but once the cattle are in the feedlot, and thinking that nothing will happen, they knowingly breach the regulations to their advantage. The larger cattle companies generally accept the ESCAS regulations and understand the principles of good cattle management. At first, these companies may breach one or two regulations, however it is usually a genuine mistake or misunderstanding.

Note that ESCAS does not apply to the export of breeder stock, or their progeny born overseas and lot-fed. Therefore importers can import pregnancy tested first calf heifers and lot-feed their progeny without being subject to Australian regulation. This also applies to calves born to heifers or cows in SE Asian feedlots that were tested negative for pregnancy before shipment.

Some standard export criteria for cattle and buffalo: (see ASEL)[46].,

- Individual cattle and buffalo liveweights must be between 200 – 500 kg (exemptions must be approved).
- *B. taurus* cattle sourced from south of latitude 26^{o} in Australia must be exported between 1 May and 31 October, if crossing the equator to SE Asia.
- Breeder cattle must be no more than 6 month pregnant (<190 days) on arrival at importing country, and submit to pregnancy testing.
- Female cattle exported as a feeder must be spayed or pregnancy tested 30 days prior to shipment.
- Cattle horns must be less than 12 cm, or have the solid non-vascular tip of the horn removed to within this distance.
- Buffalo must be conditioned for handling, hand feeding and drinking from troughs for at least 3 weeks before export.

[46] Australian Standards for the Export of Livestock (ASEL). Access online for more information: https://www.agriculture.gov.au/export/controlled-goods/live-animals/livestock/australian-standards-livestock

- All livestock to be exported are assessed on body condition score of approximately 2-4 (out of 1-5 BCS). Emaciated and over fat animals will be rejected, along with any signs of sickness, severe injury or deformity.
- Export yards must be designed and operated according to ASEL.
- Animals of different species must not be mixed in a single pen.
- Different classes of cattle and buffalo should not be mixed in a single pen.
- Cattle and buffalo of different sexes, pregnancy or health status, age, size and/or weight should be grouped appropriately and penned separately.
- Cattle and buffalo must be fed daily at least 2.5% LW of feed of sufficient quality to meet maintenance requirements.

Note: There must be no Monensin (Rumensin®) in buffalo feed.

- Buffalo must remain at the export yards, fed and watered for 5 days before, shipment, while cattle must spend at least 2 and 3 days in the yards, fed and watered, before a short or longer voyage respectively.
- Cattle and buffalo pen densities for a short-term stay (<30 days) in the export yards ranges from 2.4-4.0 m^2/head for 300-500 kg LW (calculated as kg LW x (0.04/5)); for longer term stays (>30 days) pen density is 9 m^2/head for 500 kg LW (kg LW x (0.09/9).
- Ship pen densities for cattle exported to SE Asia range from 1.294-1.813 m^2/head for 300 to 500 kg LW respectively, while buffalo are given 10% more space, i.e. 1.424-1.995 m^2/head for 300 and 500 kg LW.
- Cattle and buffalo feeders and slaughter stock must be provided with 2.0% LW of feed daily consisting of pellets and at least 1% chaff or hay. Animals under 250 kg LW and breeders with up to 6 incisor teeth (i.e. 3-4 year old Brahman) should be fed at the rate of 2.5% LW, including 1% chaff or hay.
- Ship drinking water allocation per head (cattle and buffalo) is 12% of body weight.

China's subtropical southeast coast: This area is very suitable for *B. indicus*-type cattle and a great opportunity for the development of livestock exports from the Northern Australia (see Figures 3.108 and 3.109, next page). Currently local beef cattle production is small-scale in this area with the occasional larger feedlots, using Chinese Yellow cattle or hybrid cattle, which are more adapted to sub-tropical regions (see Appendix A2 for more information).

Figure 3.109: Indicative comfort zone for Brahman cattle in China.

Figure 3.110: Gui West breed (Limousin x Simmental crossbred) from the Guangxi Huishen Farms, Guangxi Province (China).

4. STANDARD OPERATING PROCEDURES (SOPs)

SOPs are made to be exceeded, especially animal welfare, handling and health. The outcomes save time and money, adds value to the end product, and brings an acute sense of duty of care for the living asset.

SOPs are approved management practices to ensure that animal welfare is part of the worker's psyche when working with cattle and buffalo on a daily basis. Each enterprise should develop a set of SOPs that reflect their own operations. Further information can be sourced from the following resources MLA [69], PISC [70]. OIE [71].

SOP for handling cattle and buffalo: Feedlot operators have a duty of care for the welfare of imported Australia livestock and for the safety of their workers, particularly through the principles of low-stress handling, as this has both operational and commercial benefits (see section **3.2 Cattle and Buffalo Handling**, page 32). Key points of the SOP are:

- All personnel should have a duty of care for the welfare of animals and safety of workers.
- The aim is to handle animals carefully according to their instinct in a way that minimises stress and injury to the animal, as well as workers. Animals that are treated well are more likely to be healthier and produce good quality beef products.
- Stockmen must be trained in low-stress handling of cattle and/or buffalo and have a good understanding of animal behaviour, using the Flight Zone methodology to control the movement of animals (see ***Flight zone***, page 33). *Note:* Working with buffalo can take a bit longer than with cattle.
- Facilities should be compatible with handling and holding cattle and buffalo in a stress-free environment, enabled by non-slip floors, gates positioned to facilitate movement, lane ways and races designed for easy flow of animals. Holding yard densities need to provide enough floor space (i.e., ≥2.5 m^2, cattle; ≥4.0 m^2, buffalo) for animals to lie down and rest comfortably, with anytime access to feed and water, and floors that a regularly cleaned.
- Cattle and buffalo should always be handled calmly and gently, using a few experienced stockmen. Work with minimal noise (e.g. no shouting, banging etc.) and do not use electric prodders, sticks or twisting of tails, and keep unauthorised people away from stockyard operations. Avoid handling animals during heat of a summer's day.
- Stockmen should be acutely aware of factors that may distract moving livestock (i.e., loud noises, dogs, fertiliser bags, drain covers etc; (see ***Other***

stress factors, page 35). Prior to moving stock, always check the pathway from A to B for unlatched gates and possible distractions.

- Use 'cattle talkers' or 'clappers' to persuade a baulking animal to move along a race or through a gateway (see Figure 3.12, page 35).
- Stockman should take advantage of the natural herding instinct of cattle and buffalo to follow the leader, and allow the group to make their way to the end of a laneway, down a ramp, or into a holding yard, without intervention.
- Buffalo are better managed in small groups, and respond best to quiet and gentle handling by a few familiar stockmen (see ***Handling buffalo***, page 113).
- Cattle and buffalo can become aggressive if treated roughly, or are stressed. Stockmen should be mindful of the animal's size and strength and back off, leaving the animal to calm down.
- *Escape strategy:* If an animal escapes from handling facilities, remain calm and allow the animal to quieten down. Chasing the animal will only increase its stress levels. It may be easier to return the escaped animal with some 'friends', by allowing a few animals to join the escapee and herding them together back to the yard.

Figure 4.1: Standard procedures for handling cattle affixed to a wall at a feedlot in Vientnam.

***SOP for unloading from the ship*:** This operation must be well planned in advanced by the importer, as he will need to inform port authorities and customs, organise sufficient cattle trucks and prepare the feedlot for new arrivals. The exporter's representative is usually present to oversee the unloading of the cattle and their arrival at the feedlot. He will be in contact with the captain to confirm the time of arrival of the ship. The key points of SOPs for discharging livestock are:

- If permitted by the captain, unload ship's cargo of pre-ordered feed first, and transport it to feedlot for feeding into troughs prior to the cattle arriving.
- Contact the ship's head stockman about the unloading sequence of different classes of cattle or buffalo, and the health status of animals. This information should be passed on to the feedlot for their preparations.
- Allow the ship's crew to set up the unloading ramp and transfer box on the quay, and make sure that there is plenty of space for the trucks to manoeuvre. Fix canvass screens on the outside of the transfer box gates and fences to block the animal's view beyond the side of the race, and check the unloading equipment and gates are secure.
- Clear the dockside of unauthorised personnel and spectators.
- Prior to unloading, position the first truck at the transfer box. Ensure the back of the truck is aligned with the platform so there is no gap, the truck's tailgates are open, and the ramp gates are secured to the sides of the truck.
- Inform the ship's crew to start the discharge, and as the cattle descend the ship's ramp, call out the number of cattle required for each the truck (see ***Transportation of livestock***, next page). *Note*: Feedlot stockmen normally handle the animals at the transfer box and loading end of the operation. For buffalo consignments, offer experienced stockmen from the feedlot to help with the whole discharge operation, from the ship's holding pens to loading onto trucks, as crew may not be trained to handle buffalo.

Figure 4.2: (Left to right) cattle boat docked; ramp and transfer box (blue) in place; cattle unloading into truck (Indonesia).

Figure 4.3: (Left to right) SEALS double loading transfer box; loading discharged cattle from ship onto trucks with SEALS transfer box (Vietnam).

- Using low-stress animal handling practices, move small groups of animals down the ramp and into trucks in a quiet and gentle manner, only using 'push' pressure when necessary. Let the group leaders make their own way down the ramps and into trucks, and allow the remaining group to follow the leader.
- Record numbers of animals (and class) loaded, together with the truck's plate number. This information should be phoned through to the feedlot manager to assist with arrival preparations.
- Once the truck is full with the pre-determined number of animals, ensure the drop door and tailgate are closed securely.
- When the loaded truck has completely left the box, the next truck can back up to the ramp. Double loading transfer boxes speed up the loading process.

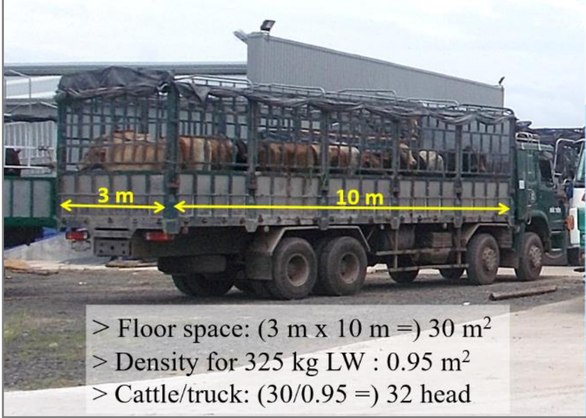
SOP for trucking livestock (Land Transportation): Trucking itself is stressful for livestock, aggravated by handling (loading, unloading), no food and water, and hot weather. The aim is to transport cattle and buffalo safely from A to B by truck with minimum stress. The best time to load and truck cattle is early morning or late afternoon. Key points of the SOP are:

Figure 4.4: Rusty truck floor, unsafe for transportation of livestock.

- Inspect a sample of trucks engaged for transportation to ensure their suitability, e.g.:
  > Condition of truck crate for potential injury hazards (e.g. rusty floors, protruding objects, etc.).
  > Check crate floor for anti-slip cleats or mesh, otherwise add a layer of sand and/or sawdust for better footing.

> Ensure side panels are at least 1.8 m high; it may be necessary to put rope netting over the top of an open crate for extra security.
> Measure the floor space of the truck's crate in square metres (m^2) and determine the number of cattle that can be loaded for each type of truck, according to class of cattle (see Infobox 4.1, below).

Infobox 4.1: Calculation of truck load capacity for livestock.



Recommended [72] loading densities for cattle and buffalo

LW (kg)	Density (m^2/hd)
250	0.8
300	0.9
350	1.0
400	1.1
450	1.2
600	>1.5

- Discuss with drivers (many of whom are experienced with livestock) about the need to drive in a steady manner and pay attention to the following:
  > Acceleration should be smooth and gradual (avoid jerky starts).
  > Braking should be anticipated and gradual (avoid sudden stops)
  > Slow down when going around corners, especially roundabouts.
- Trucking new arrivals from port to feedlot requires careful planning. Large numbers of animals need to be transported, sometimes for long distances, and a continuous flow of trucks is the most efficient in terms of minimising transportation time. The following data is necessary to determine the least number of trucks required (see Appendix A14):
  > Note cattle loading density of each trucks (i.e. heads/truck). Be aware that trucks with different floor spaces are likely to be used.
  > Allocate an average time for loading each truck at the port (i.e. 15 minutes), plus travel time by truck to the feedlot (e.g., 3 hours), plus the turnaround time at the feedlot, including unloading and quick snack (i.e. 30 minutes), and travel time to return to the port (usually a bit quicker without a heavy load (i.e. 2½ hours). Add up each allocated time for the round trip, including loading and unloading times (i.e. 6 h 15 minutes).

> Divide the estimated round trip time by the loading time (at the port), to get an estimate of total number of truck required (i.e. 6 h 15 min./15 min.=25 trucks). If each truck carried 32 head, then 800 head could be delivered in 6 hours by 25 trucks in one cycle. For a shipment of 2000 head, this would require (2000/800) 2.5 cycles, meaning that each truck would need to do a second delivery of cattle, and half the trucks would need to do a third delivery to complete the discharge. This type of operation is normal for feedlots that are within 3-4 hours from the port, while longer distances would require more trucks. The transport plan can be visualised at Appendix A14.

- Drivers should inspect the crate of cattle within 30-60 min. after beginning the journey to ensure that the cattle are settled and there are no serious issues. For distances that take less than 3 hours, drivers should not stop for a meal, but wait until arrival at the feedlot and cattle are unloaded. For long distance transportation, repeated inspections of the animals are required every 2-3 hours, coinciding with a short break.

SOP for loading and unloading procedures: Animals are moved safely from yards to a cattle truck or from a truck to receival yards. For unloading operations, all animals must pass through a race to scan the NLIS tag numbers of each animal before entering the holding yard. Key points of the SOP are:

- Ensure that there is sufficient yard space for outgoing cattle waiting to be loaded, or for cattle arrivals to be unloaded, and that separate yards are allocated for different classes of cattle (e.g. feeders, older bulls, etc.).
- Make sure clean water is available in the yards for incoming cattle. Provide roughage and water if the outgoing cattle are expected to be in transit for more than 6 hours, or if new arrivals are to be held in receival yards for an extended period.
- Check the laneway from the ramp to the holding yard (or vice versa) is clear, and side gates are secured, prior to each unloading or loading operation.
- Direct the driver to manoeuvre the truck so that the crate floor and doors are aligned with the ramp (see Figure 4.5, next page). Ensure that the ramp gates are secured to the sides of the truck to prevent cattle from escaping.
- When ready to unload, open the rear doors/gates of the truck carefully then quickly get out of the way. Allow animals to make their own way down the ramp and into the race for scanning the NLIS tag, with minimal handling and noise.
- Count and record numbers of animals passing through the race, and observe their condition.

Figure 4.5: Yellow markings to help driver align truck with the ramp (Vietnam).

- Separate injured or sick animals into a hospital pen for treatment. Check for fallen animals in the truck and deal with them accordingly (see ***Dealing with injured/sick animals***, page 159, and ***Humane killing***, page 171.
- Before loading, prepare a group of cattle according to loading density of truck crate (see ***SOP for Trucking livestock*** and Infobox 4.1, pages 203-204).
- Injured or sick animals should not be transported. Allow animals to make their own way up the ramp and into the truck with minimal handling. Scattering some straw on the crate floor will help to entice the group leader animal into the truck.
- After unloading or loading, verify bill of loading and note any variations, before completing the paper work for the driver. Retain copies of the documentation.

SOP for management of new arrivals: The aim is to prepare a new shipment of cattle or buffalo for entry into the feedlot operation. After the voyage and road trip to the feedlot, the animals arrive with elevated stress levels, which can lead to unpredictable behaviour and injury during unloading and handling. The main aim is to settle the new arrivals into their new environment as quickly as possible. Key points of the SOP are:

<u>Transport stress:</u> This can be minimised as follows:
- Avoid transportation and loading/unloading during the day if it is very hot and humid.
- Commence unloading as soon as possible after arrival.
- Give cattle and buffalo the opportunity to walk off the transport vehicle themselves and into the race for scanning NLIS tag numbers, separate sick and injured animals, and allow healthy animals to make their way to the holding yard with minimal human intervention.
- Let the new arrivals rest in the receival yards for up to 24 hours with access to coarsely chopped hay or fresh forage, and clean drinking water, before further processing.

- Provide electrolytes in the drinking water during the initial rest period (see *Electrolyte Supplements* and Table 3.15, page 105).

Processing: New arrivals are individually recorded, treatments applied, and then drafted into similar groups before entering an allocated feedlot pen. Key points are:
- Ensure feedlot holding pens have been prepared to receive processed cattle (i.e. troughs and floors cleaned, fresh bedding provided, check water valves and gates latches, etc.).
- Choose the cooler part of the day (or night with lights) for processing. Move a group of cattle into the forcing yard and through the processing race, with minimal stress to animals.
- Record eartag numbers, characteristics (breed, sex, etc.) and live weights, and write the information on the basic recording sheets together with the date (see section **3.12 Records** and Table 3.37, page 181-182).
- Apply the feedlot health program (e.g. vaccinations, anthelminthic pour-ons, drenches, vitamin injection, etc.) as required, and note the treatments on the recording sheet under Comments.
- Draft the animals into similar groups before sending to allocated feedlot pens; record the pen number of each animal on the recording sheet.

Induction rations: The aim is to stabilise feed intake of newly arrived cattle by the gradual introduction of feedlot rations over several days (see *Feeding new arrivals,* page 103). Key points are:
- Provide coarsely chopped fresh forage or hay during the first few days of feeding.
- Concentrate feeds are incrementally introduced into the ration over a period of 7-10 days (see Infobox 3.21, page 104).
- Observe closely the feeding habits of new arrivals during the induction period and remove poor feeders (3-5% of shipment) into lower density pens (see *Poor feeders*, page 104, and *Overcrowding,* page 105).

SOP for holding pen management: Maintain feedlot cattle in a healthy productive state and safe environment, by establishing a daily routine to identify animal health and pen hygiene issues, and the need for repairs to the facilities, as follow:

Health: Check all holding pens for sick and injured animals and those in poor condition. Sick and injured animals should be removed (to a hospital pen) for treatment. Consider moving individuals in poor condition into a low density pen for observation. In the case of a mortality, standard procedures for disposal of carcasses apply. Fallen animals or downers need to be attended to as soon as possible (see ***Dealing with injured or sick animals***, page 159).

Hygiene: Ensure that the waste disposal program is maintaining a proper level of hygiene in the holding pens (see ***Waste management,*** page 106), with dry floors for animals to lie on. Adjust the cleaning schedule if necessary.

Repairs: Observe the state of repair of each holding pen, including water leaks, loose wires, bent rails, and protruding objects, and remove any rubbish that is lying around (i.e. plastic bags, syringes, string, paper etc.).

SOP for feed management: Maintain cattle and buffalo in a healthy and productive state, by providing clean water and palatable feed containing a balance of nutrients in sufficient quantities to meet requirements. Key factors are:

Ration formulation: The aim is to provide enough nutritious food to meet the physiological needs of cattle and buffalo, as follows:

- All feedstuff should be fresh and new. Rank or mouldy forage or rancid concentrate must not be included in a ration and should be thrown out.
- Store enough ration ingredients to cover a period of at least 2 weeks.
- Formulation of a basic feedlot ration can be used initially to start a fattening operation, however it is advisable to get assistance from a rumen nutritionist to fine tune the ration formulation.
- The standard feedlot ration is based on 65% fresh forage and 35% concentrate (or 30% forage and 70% concentrate DM basis). The concentrate (100%) consists of 55% energy concentrate feeds, 40% protein meals, and 5% additives (see *Standardised ration* and Table 3.9, page 75).
- Formulate the concentrate component of the ration based on the specified proportion of ingredient according to feed category (Table 3.10, page 76). *Note:* Concentrate ingredients are mostly dry (90-100% DM), but there are some feeds (e.g. brewers spent grains, tapioca waste, soybean waste, etc.) that contain moisture and should be converted to DM before adding as an ingredient in the concentrate component of the ration.
- Combine the forage and concentrate ration components as a 30:70 ratio (respectively), based on the DM of the green forage; or a 65:35 ratio based on fresh forage (FM). Likewise for dry roughage and concentrate ratios (see Table 3.9, page 75). In both cases, the concentrate mixes are dry feeds.

- Breeder cattle on overgrazed, drought affected, or poor quality pastures must be fed with supplementary feed to meet maintenance requirements of the herds, and additional feed for pregnant and lactating breeders (see *Supplementary feeding* and Table 3.24, page 128).

Feed supply: Standard procedures for providing a continuous supply of formulated rations for cattle and buffalo are as follows:

- Daily feed requirements (DM basis) for a group of animals are calculated from the total live weight of the group, and a Consumption Index of 2.5% LW (see *Feed consumption*, page 72 (*A*) and page 99 (*B*).
- To calculate feed supply for a new group of animals, see *Daily feed supply*, and Infobox 3.19, pages 199-101.
- Feed consumption should be monitored daily and adjusted weekly according to amount of leftovers. If there are consecutive days of significant leftovers then total feed offered should be reduced accordingly, and if there are consecutive days without leftovers then feed should be increased (see *Feed adjustments* and Infobox 3.20, page 102).
- Record the amount of ration fed to each pen daily, together with amount of leftovers daily. This is important data for monitoring feed efficiency (see ***Feed conversion ratio (DMI kg/kg LW)***, and Infobox 3.28, page 194-195).

Preparation: Maintaining ration consistency as follows:

- Fresh forage and dry roughage needs to be chopped into ± 3 cm lengths with a forage chopper, and mixed with the concentrate by feed mixer or by hand.
- Ration ingredients should be changed as little as possible or gradually over time, as slight changes in proportions or types of ingredients can upset rumen digestion.
- The use of multiple energy and protein ingredients in rations facilitates feed management, especially when adjustments to ration formulae have to be made due to unavailability or high price of an ingredients.

Feeding Out: Feed troughs should never be empty for more than a few hours. A lack of feed will destabilise the digestive function of the rumen and affect productivity. Standard procedures for feeding yarded cattle are as follows:

- A proportion of the daily premixed ration should be fed at least 3 times a day, at the same time of day.
- Before feeding in the morning, remove and record leftovers in the feed trough, and clean the trough.
- For manual feeding in smaller feedlots, roughage and concentrate feeds can

be fed separately, with ⅓ of forage and ½ of concentrate components of the ration provided in the morning and again in the afternoon, and the remaining ⅓ of forage is fed out in the evening. Feed fresh forage first to all pens before adding concentrate and mixing it into the remaining forage by hand or with a fork.

- Salt and mineral additives are premixed into the concentrate before feeding or provided in lick blocks placed in the feed trough. Molasses (diluted with water) can be manually sprayed (using a watering can) or dribbled on top of the forage as it is fed into the trough.

Water: Ensure that cool clean water is available at all times:

- Rule of thumb for daily requirements of water by Brahman type cattle at temperatures of 30°C is 15% of LW.
- For lactating cows, increase allowance by 30% (e.g. [(15% LW) + ((15% LW) x 30%)].
- For temperate breeds of cattle (*B. taurus*), increase allowance by 25% (as above).
- Monitor water requirements as temperature rises.
- Adding minerals and salt to rations tends to increase drinking rate, and high levels of minerals/salt in drinking water can depress feed intake.
- General drinking water allowances for tropical cattle and buffalo are given in Table 4.1 below (also see section on ***Drinking water***, page 60).

Table 4.1: Indicative water allowances for productive tropical cattle breeds at different live weight and temperatures.

Cattle Liveweight	Water Intake (L/day)		
	25°C	30°C*	35°C
250 kg	20	27	36
300 kg	24	32	43
350 kg	28	38	50
400 kg	32	43	58
450 kg	36	51	65
500 kg	56	78	100
Dry Cow	34	45	61
Pregnant	49	65	86
Lactation	61	77	98

SOP for heat stress and other climatic factors: Climate change is already triggering rising temperatures and extreme weather events (e.g. drought, floods, destructive winds etc.), all of which are likely to increase in severity towards the future. The aim is to mitigate as far as possible the impact of these climatic events on livestock by having an emergency plan for each type of weather event. Key points of action are as follows:

- *Heat stress:* The critical time in SE Asia is the summer rainy season and its effects on cattle and buffalo shipments, land transport and feedlots.
  > Buffalo are more susceptible to heat stress than cattle when directly exposed to the sun.
  > Check for signs of heat stress by observing respiration rates (breaths per minute, BPM). For moderate stress (direct sun, 30ºC) in buffalo is 75-85 BPM, and for Brahman is 80-100 BPM. It is recommended that respiration rates of 60-70 BPM in both species signals action to reduce the heat loads.
  > Options for reducing heat stress include erecting structures with shade cloth covers, regular hosing down of animals with water spray, turning on sprinklers or mist fogger fans for 15 minutes per hour (see *Feedlot design (buffalo)*, page 111; Figure 3.62, page 112; *Heat stress (buffalo)*, page 115).
  > For breeder herds, check water troughs regularly in paddocks to ensure there are no issues with valves and water flow during a heatwave.
  > Erect shade structures in grazing paddocks that have no shady trees.
  > Develop a risk management plan for reducing heat stress of livestock during the hot season. This includes;
    - preparation for mass presentations of new arrivals with heat stress,
    - pre-empting the arrival of heatwaves from weather forecasts,
    - utilising a weather hazard chart to monitor the heat stress risk and taking action before a heatwave event.

- *Flooding:* Check the feedlot site or the breeder herd paddocks for areas of possible flooding. Consider constructing suitable drainage to minimise the risks of inundation. Develop a risk management plan that pre-empts a flooding event and deadlines to evacuate animals from a feedlot or pastures to a higher area that is surrounded by a fence.
- *Destructive winds:* These come with typhoons and storms that are common in SE Asia.
  > In a typhoon prone area, authorities usually have a building code for local climatic events such typhoons. If not, ensure that the feedlot and other buildings can withstand at least a category 1 typhoon.

> Ensure that large trees are removed from nearby buildings and animal pens, and flimsy materials such as corrugated iron, empty drums etc., are kept in a shed.
> Feedlot sites that are prone to strong prevailing winds should consider building a windbreak to protect the cattle yards. This could be a double line of evergreen trees along the windward side of the feedlot boundary and far enough away from falling onto buildings.

SOP for breeder management: Herd size depends on carrying capacity of the farm and seasonal availability of pasture. The reproductive cycle revolves around seasonal rainfall and high pasture growth (or need for supplementary feed) for mating, pregnancy, calving, weaning, and marketing of progeny. This requires careful planning to manage the operational activities of a breeding program. Key points are as follows:

Estimation of herd size from carrying capacity: The aim is to determine the right balance between breeder herd size and pasture availability over the year.

- Estimate carrying capacity of farm to determine a herd size (AEs). See *Stocking rates (SR) vs. Carrying Capacity (CC)* and Infobox 3.23, page 130; section **3.7 Breeder Herds** and Infobox 3.22, page 117-118.
- Assess pasture annual production and quality using a quadrant and transects across paddocks to get a measure of carrying capacity (see ***Forage assessment method,*** page 150). Estimate seasonal pasture growth (e.g. wet season, dryer season, quarterly) and height of grass. Refine by estimating amount of forage (t DM/ha) available for grazing down to 15-20 cm above ground level for short grazing cycles (< 4 weeks) (see Info box 3.24, p.136), and down to 5 cm above ground for longer periods of rotational grazing, during each season.
- Work out SR/paddock rotation schedule (see Infobox 3.23, page 130) from pasture assessments.
- Estimate supplementary forage requirements when there is a shortfall of pasture DM availability. Plan for hay production or other arrangement (e.g., weaners and yearlings can be hand fed to reduce SR on pastures). See **Herd projections**, page 118.
- Plan schedules for mineral and concentrate supplementation (see *Supplementary feeding* and *Important minerals for reproduction*, page 128)
- Identify breeding strategy (mating, pregnancy testing, culling, weaning, and calving); see ***Breeding strategy***, page 121, *Operational planning calendar* and Table 3.23, page 127, and Appendix A7.

<u>*Muster and Processing*</u>*:* The breeder herd is mustered into the yards 2-3 months after removal of bulls (Controlled Mating), or every three months (Continuous Mating). The herd is processed for the following information (see ***Herd records*** and Table 3.37, page 182-183):

- Herd characterisation records updated (identification, sex, age, body condition score, reproductive status (pregnant, lactating, dry), liveweight and date of recording.
- Health treatments applied.
- Pregnancy testing.
- Cows culled (mostly determined by pregnancy testing).
- New calves identified and weighed.
- Calves (>120 kg LW) weaned.
- Heifers (>320 kg LW), ready to be joined with bull.
- Herd bulls checked/moved/culled.


CATTLE RECORDING SHEET FOR

BREEDER HERD CHARACTERISATION

DATE:
LOCATION:

ID	TYPE (Breed/Sex)	AGE	BCS (1-5)	PREGNANT	LACTATING	WEIGHT (kg)	COMMENTS

Figure 4.6: Cattle recording sheet (breeders). See Table 3.37, page 182.

Weaning: Weaned calves are yarded for 1-2 weeks with ample water and feed (forage and calf pellets). They should be worked through the yards several times as part of training. See *Weaning*, page 123.

Culling: Use predetermined culling criteria to remove unproductive females and bulls (reproductive performance, temperament, age etc.). See *Selection and culling criteria*, page 121.

<u>*Heifer Management*</u>*:* (see *Segregation of heifers*, page 123)

- It is recommended that first-calf heifers be segregated at parturition for the first few months of lactation and fed supplementary feed, in order to maintain their body condition prior to returning into the main herd for their second mating.

SOP for animal health:

- Feedlot and breeder operations must have access to, or employ, a trained veterinarian or animal medic.
- Biosecurity includes isolation of transport carrying new arrivals from port to feedlot (i.e. drivers should not stop trucks near local livestock). Erect a strong surrounding fence around the feedlot (or grazing enterprise) to keep local livestock outside. Consider disinfecting incoming vehicles and people entering the premises.
- Feedlot health plans are essential to manage sick and injured animals, and outbreaks of disease. Key points are:

  > Plan a designated 'hospital or sickbay' holding pens for treating sick and injured animals.

  > Prepare for injured, sick and stressed animals discharged from a new shipment.

  > Allow new arrivals to rest for a few days before processing.

  > At processing, conduct health checks and apply local preventative treatments (i.e. vaccination against Hemorrhagic septicemia (Indonesia) etc.).

  > Negotiate with local quarantine officials to take random blood samples from new arrivals when they are processed. (i.e. 2 or 3 days after arrival and recuperation).

  > Keep a stock of emergency treatments (e.g., trocar and cannula for bloat, see Figure 3.89, page 161) and drugs for common injuries and nutritional disorders.

Figure 4.7: Feedot sickbay with patient.

- Buffalo diseases are similar to cattle, however special attention is required to protect buffalo imports from Malignant Catarrhal Fever, consumption of Monensin (Rumensin®) in feed, and clinical signs of Urolithiasis (bladder stones). See *Buffalo health*, page 115.
- Breeders are particularly susceptible to disease and physical events around calving and lactation. These include calving difficulties such as breached calves and retained placenta, and diseases (e.g. milk fever, mastitis, metritis, etc.). Staff should carefully observe cows and calves, from parturition onwards in case of signs of birthing difficulties and other issues (see ***Dealing with injured and sick animals***, page 159).
- *Faecal check:* Stockmen should be able to relate the colour, consistency and content with the health status of animals (see *Faecal check*, page 157).

SOPs for humane killing and disposal: Badly injured animals that cannot stand up and are obviously in pain need to be humanely killed *in situ* as soon as possible (see ***Humane killing***, page 171), whereas downers that have slipped can usually get back on their feet with a bit of help from stockmen. Animals that are found dead in the yard, or die from disease, need to be disposed of in a designated site according to local regulation (see ***Carcass disposal***, page 171). Key points are:

- Do not drag an injured animal along the ground or lift it with a frontend loader, and do not wait until later to kill the animal.
- If other animals are close by, remove them from the area or block their view.
- Kill the animal at the place where it was found, using a rifle, stunner, or as a last resort, a sharp knife. If the stunner is non-penetrating, then check the animal's sensibility (re-stun the animal if not unconscious), before cutting its throat within 20 sec of stunning, and wait for the blood to stop flowing.
- Remove the body of the animal for disposal and clean up the area where the animal was killed. Add some detergent to the water to neutralise any smell of blood.
- In a designated area for disposal of dead animals, burn the carcass (if allowed by authorities) or dig a trench (~1.5 m^2 x (5 m depth)). Puncture the rumen to release gases, then lower the carcass into the trench, sprinkle lime over the body. Backfill the trench (see page 172 for more details).

SOP for slaughter: Feedlot and abattoir managers have a duty of care to ensure that cattle and buffalo are killed humanely according to standard operating procedures. Options for slaughter are; the halal throat cut, electric or percussive stunning and a rifle shot. After slaughter, the electronic NLIS tags are removed from the animal's ear and kept by importer until the whole shipment has been processed through the abattoir. Key points are as follows:

Arrival at lairage: SOPs apply for animal handling, loading at the feedlot, transportation and unloading at the abattoir's pre-slaughter holding yards (or lairage).

- The lairage should have shade, cool clean drinking water and feed troughs, and a water hose for cleaning muddy animals. For buffaloes, the addition of sprinklers is recommended to avoid heat stress on hot summer days.
- Where possible, keep animal groups from the same truck together in the holding pens, and separate aggressive animals, particularly bulls from different groups, to avoid bruising.

- Provide sufficient floor space for animals to lie down and rest (>2.5 m^2/head).
- *Curfews:* It is usual practice for slaughter stock to be processed the day after arrival. The withdrawal of feed is limited to 12 h, including transit time from feedlot to abattoir, and time in lairage. Curfew guides are as follows:
  > For more than 12 h without feed, provide feed and water on arrival and rest up to 12 hours, with a feed curfew if necessary before slaughter.
  > Less than 12 h without feed, provide feed (optional) and water on arrival and rest for at least 2 h before slaughter.
  > Note that continuous access to water and roughage feed (e.g. no curfew) is also recommended up to slaughter, in order to keep animals calm and to maintain meat quality.

Slaughter process: Abattoirs in SE Asia usually operate at night when the temperature is cooler. Keeping animals calm up to the point of slaughter is critical to preserving meat quality. The aim is to kill the animal instantly or stun the animal senseless with a single blow before cutting the throat:

- Ensure abattoir staff (stunner operator, slaughter man and butchers) are ready with their equipment to receive animals for slaughter, and that the knocking box and restrainer are functioning properly.
- The knocking box entry door remains closed until an animal has been stunned, sticked (throat-cut), exsanguinated (bled out), removed from bleeding area, and the floor washed. At this point the stunner operator should signal for the next animal.
- With the entry door of the knocking box closed, calmly herd a few animals into the forcing yard.
- Select the next animal to go through the sliding gate into the slaughter race, allowing it to walk up race to the entry door of the knocking box. At this point, close the sliding gate behind the animal to prevent it from reversing backwards (allow an agitated animal to calm down before further action).
- Keep noise to the minimum and ensure personnel are not be visible to the animal except for the stockman near the race.
- When ready, the stunner operator opens the entry door of the knocking box, allowing the animal to walk forward into the box. The entry door should be closed as soon as the rear end of the animal is in the box.
- Restrain the head of the animal once it is in position in the restrainer (ideally, the animal's head is already in the restrainer device; if not, let the animal step back and try again, using a 'cattle talker' if necessary).
- Apply the stunning procedure as soon as the animal is restrained (see **3.10 Abattoir Operations**, page 173, about stunning equipment).

- Ensure the animal drops to the floor of the knocking box and is still, before opening the side door and transferring the animal to the slaughter floor.
- Take remedial action immediately if the animal does not drop to the floor or is still conscious after stunning. This could happen if not stunned properly or the stunning device is faulty. There should be a spare device or a firearm kept nearby the slaughter box to re-stun or kill the conscious animal.
- The slaughter man checks the status of the animal before cutting the throat. > For *reversible stunning* (i.e. electric and concussive non-penetrating stunning), the animal should have no rhythmic breathing and no corneal reflex (e.g. just a fixed stare), therefore insensitive to pain.
  > For *irreversible stunning*, (i.e. captive bolt or rifle shot), there should be no bodily signs of movement (e.g. the animal is dead). Usually, a chain is attached above the hock to hoist the animal above the floor before cutting the throat.
- After reversible stunning and checks for insensibility, the animal's throat can be cut on the slaughter floor (ritual slaughter), or its body is hoisted (see above) before cutting the throat. *Note*:

The throat must be cut within 20 seconds of reversible stunning.

- Allow the animal to bleed for at least 2 minutes before further processing.
- Retrieve the electronic NLIS tags for safe keeping at the feedlot office.

Carcass preparation: ESCAS regulations do not cover Australian cattle and buffalo beyond their slaughter. However there are post-slaughter best practices for dressing and chilling the carcass to maximise the meat quality of imported Australian livestock. The key points are:

- (Optional) Apply an electrical stimulator from nose to rectum after bleeding out. This hastens the buildup of lactic acid from muscle glucose which brings on *rigor mortis* more quickly, preventing cold shortening in the chiller thereby improving meat quality.
- Lower the body and neck of the hoisted animal onto a cradle, and remove the hoist chain.
- Wash hide thoroughly.
- Remove four legs (at the hock and knee).
- Open up hide starting from the centre of the back legs (hocks) to below the rectum and from rectum to the brisket, and from the centre of the front legs (knees) to the brisket, using a sharp skinning knife.

- Skin back the hide to the edge of the cradle without cutting any muscle.
- Insert a hook in the tendon behind each hind leg (hock) and attach hooks to a spreader bar, and fix the spreader bar to the hoist hook.
- Open the abdomen by scoring with knife from the centre of the brisket and along the centre of the abdomen (after removing the penis of a male animal).
- Saw through the centre of the brisket and ensure that the oesophagus is blocked from leakage.
- Use the winch to raise the hind legs about 30 cm off the cradle.
- Block the rectum with a plastic bag to restrict manure from expelling.
- Remove skin (hide), tail, and head from the raised part of the carcass.
- Remove kidneys and hoist the carcass to the vertical position; to remove the rest of the hide.
- Free the guts from the carcass and allow them to drop into the offal trolley. Separate other offal as needed. Lift the carcass onto the rail and lower the spreader bar away from the carcass.
- Split the carcass with the saw and thoroughly wash each carcass side.
- Slide the carcass sides into the chiller allowing plenty of space between carcasses for air circulation. Carcasses should be hanging in the chiller within 2 hours of slaughter.

Monitor chiller temperature to ensure it is maintained at 0-2°C during chilling, until the surface temperature of carcass sides reach 7°C in 24-48 hours. At this point, the sides are ready for boning out in an air conditioned room of 10°C (see *HACCP*, page 179).

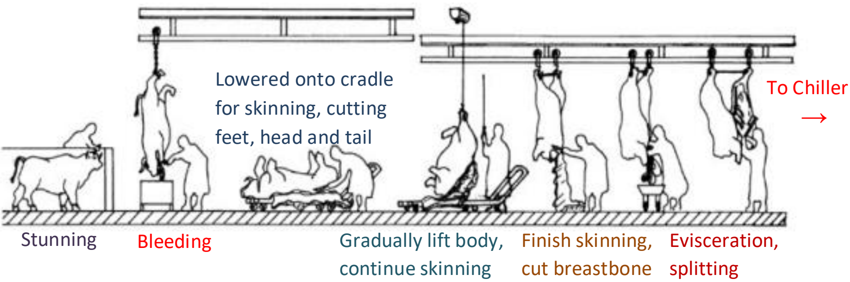


Figure 4.8: Illustration of a slaughter line and cattle carcass preparation [73].

5. ENTERPRISE MANAGEMENT PROCESS

Good management results in quality products that satisfy customer needs.

Total Quality Management: Total Quality Management (TQM) is a management process that uses objective based assessment of enterprise performance in meeting customer and regulatory requirements. It can be certified under ISO 9001[47] to reassure customers that the cattle operation meets international standards and consistently provides quality products. HACCP can also be included in the TQM certification. Both these certifications are required by most international supermarkets in SE Asia (see ***HACCP***, page 179). The key areas of TQM are as follows:

Customer focussed: Determine the product specifications (and services) required by the market, in terms of live weight and degree of finish or fatness, and get feedback on product quality from the market (buyers, traders, butchers, supermarkets, etc.). Good or high quality is a subjective measure that exceeds a standard. The quality of services to the market is evaluated as performance to requirements (e.g. targets are met, orders arrive on time, etc.), and quality of goods are assessed as suitable for purpose (e.g. reasonable prices for a range of beef cuts used for stews or tender steak).

Ultimately, it is consumer satisfaction with a product or service that determines the quality and value of that product.

Marketing: Advertise the products and services of the enterprise:

- Potential traders and markets should be approached for their interest in buying products from the enterprise. These conversations will help decide which products are in demand, enabling some operational adjustments to meet that demand.
- Public advertising is also an important part of marketing. However, a new enterprise should wait until it is fully operational and can deal with an increase in demand without loss of product quality before considering an advertising campaign.

[47] International Standards Organisation (ISO), series 9001 (manual). In-country representatives provide audits, training and certification services.

Process management:

- Plan the resources and a production system that will produce the specified product to market requirements.

Figure 5.1: Continuous review and improvement.

- Establish Standard Operating Procedures for every stage of the enterprise's production system and develop an Operations Manual as a standard reference book that is unique to the enterprise.
- Continuously monitor, measure and evaluate operational performance against output targets.
- Regularly review all aspects of the operation and implement recommendations for improvements to operational procedures.

Labour: Ensure workers know exactly what they have to do:

- Provide training so that workers have the knowledge and skills to undertake workplace tasks (Fig. 5.3, p. 221).
- Reduce risk of staff shortages (e.g. due to sickness, attending funerals etc.), by multi-skilling workers in one or two tasks outside their workplace task.
- Write clear duty statements for each worker, including work instructions for each operational task.
- Develop a simple reporting system that monitors the performance of workers in each operational task group (see Figure 5.2).

WORKPLACE WEEKLY REPORT	
Stockmen	Shed 4 (Pen 1-6)
Week	14 (2003)
Staff: Benjamin David Molly	✓ ✓ Absent Wed (NS off)
Workplace Tasks: Day shift: 6 am - 5 pm Night shift: 5 pm - 6 pm Sunday roster:	 Ben, David, Molly (Wed, off) Ben, Mon-Wed. David, Thu-Sat Molly (Wed, off)
6.00 am: Inspect pens	P3, Downer #306, OK, Fri
6.30 am: Clean feed troughs, bag left overs, check water troughs	P1, big leftovers Wed, less Thu
7.00 am: Assist with feeding, identify poor feeders.	One shy feeder #112 to sickbay
7.30 am: Break	
8.00 am: Clean pens weekly, move cattle to laneway	Pen 3&4, Mon Pen 5, Thu
10.00 am: Clean up around shed, lane-ways. General assistance.	David & Ben moved pen 5 to race and handling, Fri
12.00 pm: Break (1 person stay at shed).	Molly - Mon, Tue, Fri David - Wed, Thu Ben - Sat, Sun
1.00 pm: Check pens/animals	Repair water valve, Pen 1, Sun
1.30 pm: Assist with feeding	✓
2.00 pm: Monitor cattle. General assist (1 person stays)	David & Ben assisted Shed 6, Tue, Sat. Molly stayed
4.30 pm: Assist with feeding	✓
5.00 pm: Day shift completed	

Figure 5.2: Example of a workplace report.

Figure 5.3: (Clockwise) Training programs and technical brochures for Feetlot and Breeder Managers, Government Livestock Officers and Farmers in SE Asia. *Note:* The above brochures for the Philippines and for South East Asia are available on line or from DITT.

- Prepare an Operations Manual with SOPs as a standard reference book and place copies in the canteen and other accessible places.
- Ensure that employment includes reasonable working conditions, i.e. limited daily working hours, rest breaks and one day off per week, holiday leave, sick leave and medical expenses covered, etc. Well-treated staff feel valued and aspire to do the best job.

Measuring Performance: The performance parameters provide an objective basis for measuring internal operational productivity.

- Operational performance of feedlots is assessed by measuring cattle productivity (growth rates) and feed efficiency (feed costs per LW gain) during the production process. Culls and mortality rates are also taken into account in assessing operational performance.
- Operational performance of breeder herds is assessed by measuring

reproductive performance (i.e. weaning rates) and productivity (i.e. total weaners (kg LW) per breeders mated, or per ha). Culls and mortalities are also assessed, with the aim of minimising their effects on overall performance outcomes. This depends on number of heifers available as herd replacements and are retained in the herd, and the attrition rates of older cows. If replacement heifers that are produced exceed the numbers of culled unproductive heifers and old cows, then the surplus heifers could replace more cows, or sold at a higher price than the culled breeders.

- Enterprise Performance is based on the analysis of financial parameters (Feed Costs, Total Operating Costs) to estimate Production Costs and the Profitability of the enterprise. Profitability can also be expressed as the ratio of gross returns to total costs or the Benefit/Cost Ratio (see *Profit, Cost/Benefit Analysis and Returns,* page 190).

Enterprise Evaluation and Reporting: The purpose of regular evaluation of an enterprise is to see whether it has achieved its expected targets in terms of productivity and profitability.

- Monthly and annual reports should focus on comparisons of performance outcomes against planned targets and industry benchmarks.
- Where targets have not been achieved, this should be carefully examined to identify causes and possible solutions.
- Make recommendations for improvements in operational procedures together with an implementation plan.
- The results will be apparent at the next evaluation cycle.

Infobox 5.1:

EVALUATION REPORT

Introduction
- Background
- Objectives and Targets

Performance
- Measurements and Results

Discussion
- Results vs targets
- Problem identification
- Recommendations
- Plan of action

Mission Statement: Develop a mission statement (usually subtitled Vision, Mission, and Values) that articulates succinctly the core purpose and values of the enterprise, particularly with regard to the treatment of personnel, animals and the environment (see Infobox 5.2, below).

Infobox 5.2

MISSION STATEMENT (Example)

Vision

A future leader in fattening cattle for market requirements, using world best management and animal welfare practices to make our cattle as comfortable as possible.

Mission

We are cattle whisperers and we can think like cattle. Our mission is to demonstrate that bonding with cattle produces the best quality beef.

Values

While our cattle wellbeing is paramount, our focus is also on our customers' needs. To achieve their needs, and our production targets, requires teamwork, so our workers are highly valued and treated like family. Honesty, safety, training, listening, decision-making, respect for one another, are also very important, as is the natural environment. These ingredients makes for ideal working conditions.

Performance monitoring: Using records to monitor productivity and profitability of the enterprise operation.

Body Condition Score (BCS): Use BCS to sort new feeders replacements into similar groups and to grade cattle ready for turnoff (see Appendix A1):

- The BCS of new arrivals for backgrounding or finishing is a good indicator of previous nutritional management and subsequent performance. For example, a backward store (BCS=2) feeder has more value adding potential than a forward store (BCS=4). It is likely to gain weight faster in the feedlot and produce a leaner carcass, compared with a forward store feeder under the same conditions. Measurements of BCS should be recorded when processing new arrivals and used to allocate cattle of similar body condition into pen groups for targeted feeding.
- The BCS can be used to determine when cattle have reached market specifications by assessing the level of fatness prior to turnoff. Each score represents a range of fatness over the rump (P8) site (see ***Fatness***, page 7 and Appendix 1).

Performance parameters: Use records and parameters to calculate feedlot and breeder herd performances against targets (see Table: 2.4, page17).

- *Feedlot:* Standard measures are Growth Rates or Average Daily Gain, and Feed Conversion Ratio (FCR):
  > *Average Daily Gains (ADG) or Growth Rate (kg LW/d)* = Live weight gain (LWG)/day:

  $$ADG\ (kg) = \frac{(\text{Final LW - Initial LW})}{\text{Days}}$$ [Benchmark = 1.1 kg.]

  > *Feed Conversion Ratio (FCR),* (see also page 195)
  = Average daily DMI kg/ADG kg [Benchmark = 7]

  > *Convert Average Dry Matter Intake (kg DMI) → Fresh Matter Intake (kg FMI or as fed)* = DMI/ration DM %
  > *As fed Feed Costs ($/LWG kg)* = Average Daily Feed Cost (as fed)/ADG.
  > *Production Costs ($/LWG kg)* = Total Operating Costs/ADG.

- *Breeder herd:* Standard measures are Calving Interval, Weaning Rate, Average Daily Gains (ADG) or Growth Rates and Mortalities. Additional performance parameters include Pregnancy and Calving Rates, Weaners Produced per Breeders Mated. [74]

  > *Reproductive Rates:*
  = Pregnant/Cows Mated (%) [Benchmark = 80%]
  = Calves Born/Cows Mated (%) [Benchmark = 75%]
  = Weaners/Cows Mated (%) [Benchmark = 65%]

  > *Calving Interval:*

  $$= \frac{\text{Months between Calving}}{\text{12 months}}$$ [Benchmark=1.33(16 months)]

  Note: This helps to identify individual cows for culling, and herd average (i.e. Culls/Total Herd Cows (%)).

  > *Breeding herd efficiency:*
  = Total Weaners (kg LW)/100 kg Breeder mated.
  [Benchmark=25kg/100kg Breeder]

  (See example next page)

Example: 20 mated breeders (total LW 8,500 kg; 28 AEs) produced 15 weaners (total LW 2,250 kg) = [(2,250/8,500) x 100 kg] = 26.5 kg weaner/100 kg breeder, or (2,250/28) = 80 kg weaner/1 AE.

> *Weaners produced per Hectare:*
= Total Weaners (kg LW)/ha/year

> *ADG of weaners and yearlings on pasture:* = LWG kg/no. of days
[Benchmark = 0.7-1.0 kg/d]

> *Culls (%) and Mortalities (%):* These are the proportion of unproductive cattle in the production system that were sold or died before reaching turnoff targets. Breeder mortality:
[Benchmark = 2%]

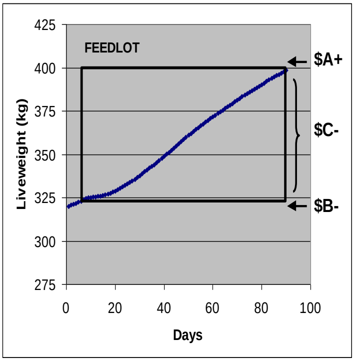


Figure 5.4: Profitability = $A-($B+$C)

• Standard measures of enterprise performance are Profit, Cost Benefit Analysis and Returns (See page 193):

> *Net Profit ($/unit):*
= ((Sales ($A)) – [(Purchase Price ($B)) + (Operational Cost ($C))]/unit[48]

See Figure 5.4; Figure 2.15, page 21, and **3.12. BUDGET PROJECTIONS,** page 188.

> *Returns (%):*
= [(Gross income ($) – Total Costs ($))/Total Costs ($)] x 100%
(e.g. [(($30,000-$25,000)/$25,000) x 100%] = 20%

> *Cost Benefit Analysis (i.e. Ratio of $ returned vs. $ spent):*
= Gross Income ($)/Total Costs ($)
(i.e. $30,000/$25,000 =) 1.2, or $1 spent returns $1.2 benefits.

[48] Unit: i.e., Operational days, consignment, year, head, etc.

6.→APPENDICES

Appendix A1: Body Condition Scores (visual) and Fat Scores (manual).

Visual assessment of Body Condition Scores (BCS):

BCS=1 (POOR): Emaciated condition (very thin, no fat (P8=0-2 mm), wasted muscle); bone structure clearly visible (hollow abdomen, rib cage with deep indentations, protruding hips, pin bones sharp to touch, prominent tail head), dry coat; uncertain ability to travel reasonable distance.

Note: Cattle in this condition are at *critical survival weight* and should be penned and fed separately to improve their condition.

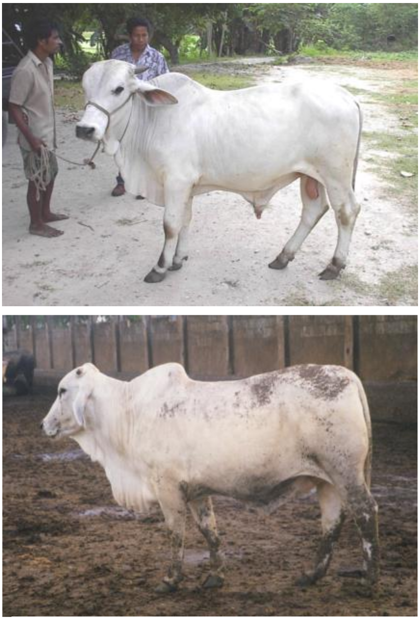
BCS=2 (BACKWARD STORE): Poor body condition (thin, lean (P8=3-6 mm fat), concaved muscle), visible bone structure (visible rib cage, hips/pins/ tailhead prominent), dry coat; sufficient strength to travel reasonable distance.

BCS=3 (STORE): Medium body condition (light fat cover (P8=7-12 mm), flat muscle), bone structure just visible (ribs just visible, hips/pins/tailhead less prominent), clean coat.

BCS=4 (FORWARD STORE): Good body condition (smooth and well covered with light to medium fat deposits (P8=13-22 mm), medium muscle development (i.e. some filling out of muscle), bone structure not visible but can be felt with firm pressure, clean/shiny coat.

BCS=5 (PRIME STORE): Body condition is fat with bone structures (ribs, hips, pins) buried in fat (P8=23-32 mm). Heavy to very heavy muscle development and mounds of fat visible beside the tail-head. Over exertion of animals in this condition could lead to heart attack.

Note: BCS system for buffalo, next page.



Figures A1.1: 1-5 visual assessment of BCS (see also [75]).

Hand assessment of fat scores:

Fat Score	P8 Site (mm)	12/13th Rib (mm)	Hand Assessment*
1	0-2	0-1	No fat around TH.
2	>2-6	2-3	SR sharp to touch; SR/HB feel hard.
3	>6-12	4-7	SR/HB slightly rounded; light fat on TH.
4	>12-22	8-12	SR hard to feel; more fat cover on HB & TH.
5	>22-32	13-18	SR not felt; HB well covered; TH fat mounded.
6	>32	>18	Bone structure invisible; TH buried in fat tissue

* Short ribs (SR), Hip bone (HB), Tailhead (TH) *Source: MLA* [76]

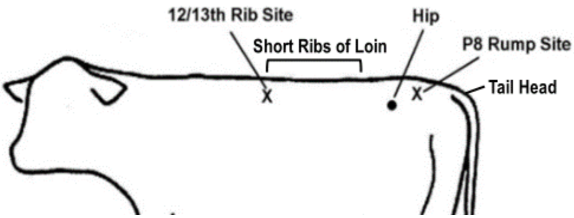


Figure A1.2: Reference points for manual assessment of fatness.

Table 1 : The Body Condition Scale for Buffaloes

Score	Posterior View	Lateral View	Visual and Palpable Features
1	 Plate 3a	 Plate 3b	An emaciated animal. Cavities on side of tail-head are very pronounced, the borders of pin bones very sharp, individual bones of spine and the borders are visible, ends of ribs are very pronounced and can be palpated easily palpated, no fat under the skin.
2	 Plate 4a	 Plate 4b	A thin animal. Cavities are less pronounced, borders of pin bones very sharp, individual bones of spine are less visible, ends of short ribs less sharp but can be palpated are very pronounced and can be palpated, thin layer of fat under the skin.
3	 Plate 5a	 Plate 5b	A lean and healthy animal. Cavities are not present, borders of pin bones are rounded, individual bones of spine are not visible and muscles are detectable over the bones, ends of short ribs can still be palpated with firm pressure, a medium layer of fat under the skin.
4	 Plate 6a	 Plate 6b	A fat animal. Cavities are filled out, borders of pin bones are rounded, individual bones of spine are not visible there is muscularity over the bones, ends of short ribs can only be palpated with strong pressure as they are covered with a thick layer of fat under the skin.
5	 Plate 7a	 Plate7b	An obese animal. Buffaloes or cattle of this condition are usually not found in village farms. Cavities are not present, borders of pin bones are very rounded, individual bones of spine are not visible and there is abundant muscle and fat over the bones; ends of short ribs are not palpable as they are covered with a thick layer of fat.

Figure A1.3: 1-5 Body Condition Score system for Murrah buffalo (original text has been re-typed for clarity). *Source:* MLA [77]

Appendix A2: Infosheet on the advantages of importing NT beef cattle into Southern China [78].

What are the Advantages of Importing Northern Territory Beef Cattle into Southern China?

Introduction

The Northern Territory (NT) has a long history of cattle breeding and production, as well as extensive experience in exporting live cattle to Southeast Asian cattle breeding and fattening farms, adding value to beef before selling for slaughter. The NT's specialty cattle breeds are well suited for industrial-scale beef production because of their adaptability in the tropics and high yields. Every month, a large number of live cattle are exported from Darwin to Southeast Asian countries to supply cattle fattening enterprises and cattle breeding enterprises.

NT cattle breed

The NT's commercial cattle breeds are mainly Brahman and Droughtmaster, and also Australian Swamp and Riverine buffalo. During the 20th century, NT Brahman cattle were the product of decades of crossbreeding, using imported American Brahman bulls (subspecies: *Bos indicus*) to breed with Hereford and Shorthorn breeder cows, now NT cattle have a high Brahman genetic content. To this day, in the harsh climatic conditions of the NT, the Brahman cattle are grazing on vast natural pastures and continue to breed and produce high yields. They have good disease resistance and heat-resistant *B. indicus* traits, and have inherited superior growth rates and carcass meat yields to produce healthy and nutritious beef, similar in quality to *Bos taurus* cattle. Droughtmaster has higher genetic content of *B. taurus*, which is more suitable for subtropical climate; Swamp buffalo are also exported for meat consumption, and River buffalo are used for meat and dairy (cheese) production.

NorthernTerritory Commercial Cattle

Beef cattle feedlot productivity

The NT Brahman Herd is the main source of live cattle exports from the NT to Southeast Asia. At about 18 months old and weighing around 325 kg, these cattle are ready for shipment. During the voyage, the livestock are fed specially formulated feed pellets to maintain their weight until they arrive at the importer's farm. Using the best cattle rations, the cattle are fattened for 90-120 days, with a genetic potential for daily growth rate of 1.2 kg, therefore the slaughter weight can reach 435-470 kg or more, according to market demand.

Chinese beef market

Until the middle of the 20th century, China did not have any special cattle for meat consumption because they were recognized as too valuable as working animals and milk sources, and should not be slaughtered as a source of food. For centuries, people did not want to eat beef because they respected these beasts of burden. After the 1950s, all this changed with the industrialization of agriculture and livestock production. As the beef industry developed into the new millennium, both beef cattle numbers and beef production have increased substantially in order to keep up with the demand for this high-quality food from the growing middle-class consumer urban population. More and more beef, including beef from Australian, is being imported into China, and an increasing number of live cattle have been sourced from neighbouring countries in Southeast Asia to make up for the shortage of beef supply. By 2020, the per capita beef consumption is expected to reach 4.3 kg, and the gap between supply and demand will widen substantially, requiring more beef.

Opportunities for NT live cattle exports to China

In 2015, the China-Australia Free Trade Agreement was signed to allow the importation of live cattle for fattening or slaughter, and by 2019 there will be a 10% tax exemption. Australian slaughter cattle have already been exported to Ningbo Port, Zhejiang Province on the east coast of China. NT commercial cattle are highly recommended for importing into the tropical regions of southern China, namely in the agricultural areas of Yunnan, Guangxi, Guangdong, and Fujian. In this area, local beef cattle production is small-scale, managed by family farmers and small businesses, using Chinese Yellow cattle or hybrid cattle, which are more adaptable in tropical climates than the preferred Angus and Limousin cattle. The hot climate and abundant agricultural industrial by-products are the best environment and the best opportunity for NT cattle to have the most efficient production capacity on an industrial scale, providing quality and healthy food for China's growing middle class urbanites. At present, China's quarantine regulations can only allow live cattle imported into southern China to be slaughtered within 2 weeks, but as the demand for beef increases, the quarantine restrictions may be lifted to allow live cattle to be imported into the feedlots of the tropical coastal areas, as long as there is no health risk to other livestock. The main ports of live cattle shipping in the south are Beihai (Nanning) and Huizhou (Guangdong), the latter being proposed as Darwin's 21st Century Maritime Silk Road. These ports are at least one day closer to Darwin than the eastern coastal ports of China, making freight costs cheaper.

Beef quality factors

People say that quality is just the feeling of consumer satisfaction. Beef has many different qualities, such as taste and tenderness, many nutritional attributes as well as a sense of well-being. When these factors come together, this is really the best quality beef. The taste and tenderness comes from the freshness and cooking method. Nutritional attributes are protein (for healthy muscle), iron (for blood oxygen), zinc (for strengthening the immune system), Vitamin B12 (hydroxocobalamine, for protecting the nervous system), and omega-3 fatty acids (for healthy heart and brain function). The sense of well-being comes from the cultural links between Chinese folklore and cattle, such as China's zodiac ox, and the legendary Cowherd and Weaver Girl love story, which now symbolizes Chinese Valentine's Day on the seventh day of the seventh month of the lunar calendar. On Chinese Spring Festival and Valentine's Day, these two festivals often advertise the eating of beef; by celebrating New Year while eating traditional beef hot pot, or enjoying a romantic dinner while eating special Western beef dishes. Furthermore, it is easy to cook homemade foods using beef from NT cattle, such as stir-fries, beef stew, soup and hot pot, as well as delicious Western barbecue steaks.

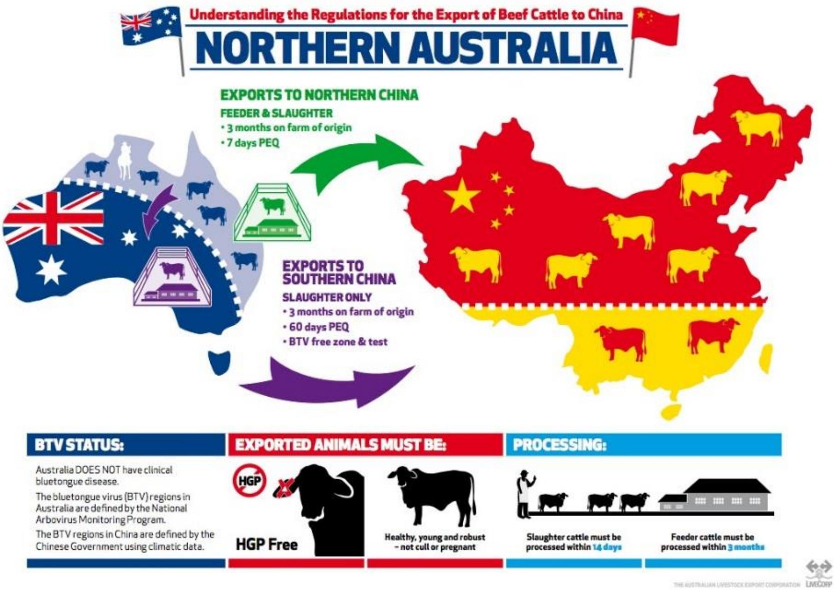
Live cattle export process

The Australian Government's Department of Agriculture and Water Resources (DAWR) controls the live cattle export process and manages animal health risks and animal welfare compliance along the export supply chain. The main concern for livestock in Australia is animal welfare management from birth to slaughter, so livestock exports are monitored by the livestock Exporter Supply Chain Assurance System (ESCAS) from the arrival port to the farm, and at the slaughterhouse. These movements are all within a closed supply chain with periodic assessments of animal welfare issues. ESCAS is also a food safety and quality traceability certificate. This system requires close cooperation between exporters and importers. Generally speaking, it should not be a problem for Chinese importers, because their respect for cattle in Chinese history and culture is just another form of animal welfare. Anyway, good cattle-raising people know that badly treated cattle will produce poor quality beef.

In addition to the usual cattle disease, China's health protocol also focuses on the possibility that Australian cattle may carry Bluetongue virus and infect the local sheep industry. There is a blue tongue disease area in the northern part of the Northern Territory, so only slaughter cattle from there can be exported to China 60 days after their quarantine outside the risk zone. At present, only imported cows outside the blue tongue risk zone are allowed to be imported into areas above 30 degrees latitude in China. Prior to obtaining an export license, Australian exporters must provide DAWR officials with necessary documents, including import licenses, completed health agreements and ESCAS forms. Officials will also check the documents before cattle go to the ship and do not allow unhealthy animals to board.

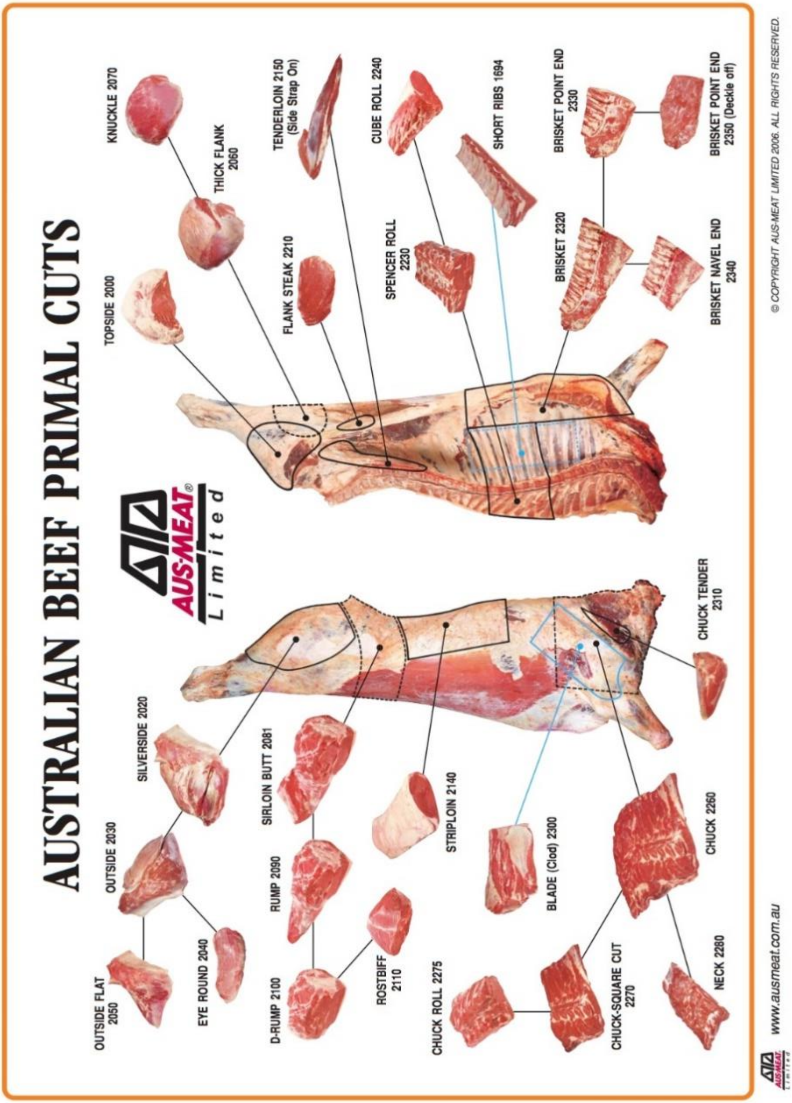
Further information on the NT livestock export process and commercial contacts can be found at:

- The NT Livestock Exporters Association (NTLEA) at: www.ntlea.com.au.
- NT Government Department Primary Industry at: https://nt.gov.au/industry/agriculture/livestock/cattle/contact-livestock-industries-development-division
- Australian Government Department of Agriculture and Water Resources (DAWR) at: www.agriculture.gov.au/export



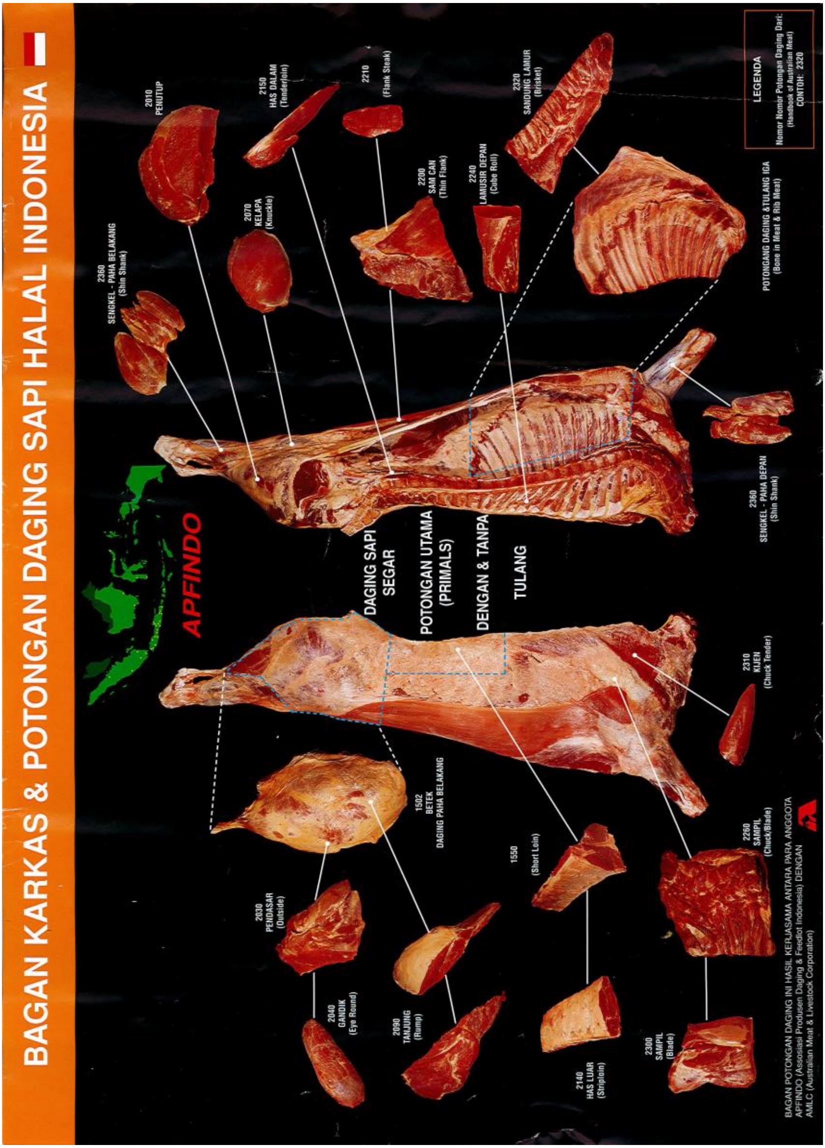
Appendix A3: Australian beef charts**.**

Figure A3.1: Australian beef primal cuts (AMLC, 2006).



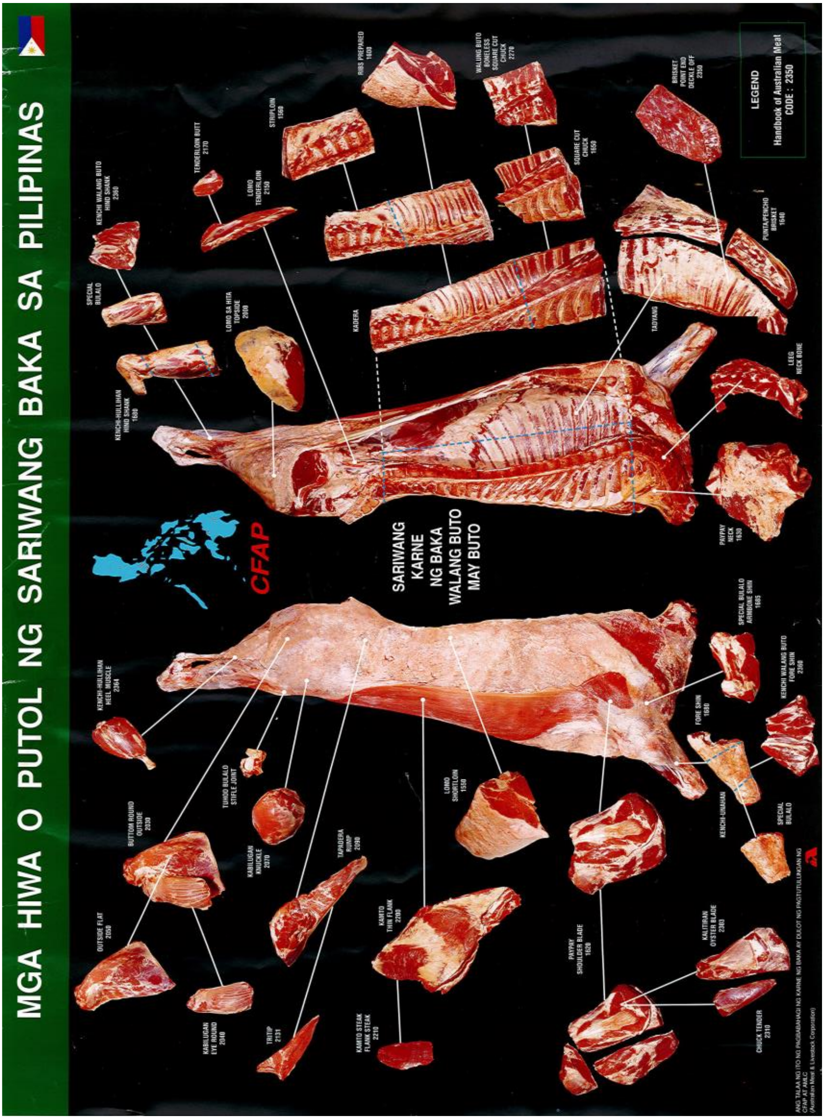
(Appendix A3 cont.)

Figure A3.2: Australian beef cut chart: Indonesian (Apfindo & AMLC).



(Appendix A3 cont.)

Figure A3.3: Australian beef cut chart: Philippines (CFAP & AMLC).

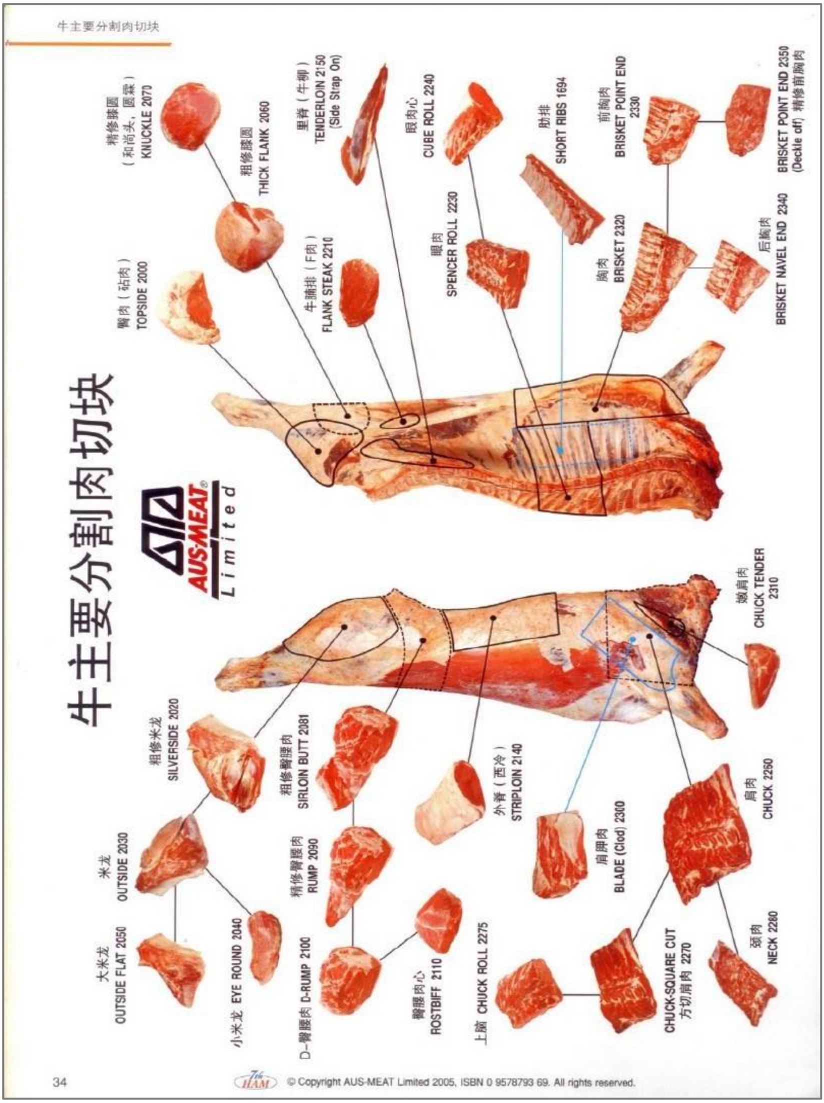


(Appendix A3 cont.)

Figure A3.4: Australian beef/veal primal cuts: Vietnamese (Novico/Ausmeat) (2005).

(Appendix A3 cont.)

Figure A3.5: Australian primary beef cuts, China (Ausmeat 2005).



Appendix A4: Facilities and equipment details.

Ramps:

Features of single lane ramp:

- 700-750 mm wide race.
- <20° slope and slatted floors for good foot grip.
- Ramp height according to deck height of local cattle trucks.
- 2-3 old tyres fixed to side of unloading dock as buffers
- Side gate to secure gap between truck and unloading dock.

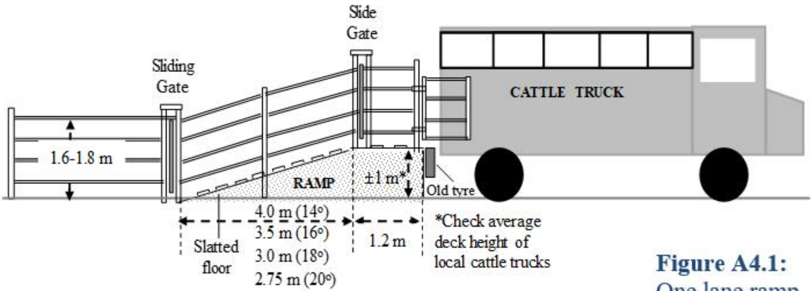


Figure A4.1: One lane ramp.

Features of a two lane ramp:

- Forcing gate into single lane for loading
- Wider lane for unloading large numbers of cattle.

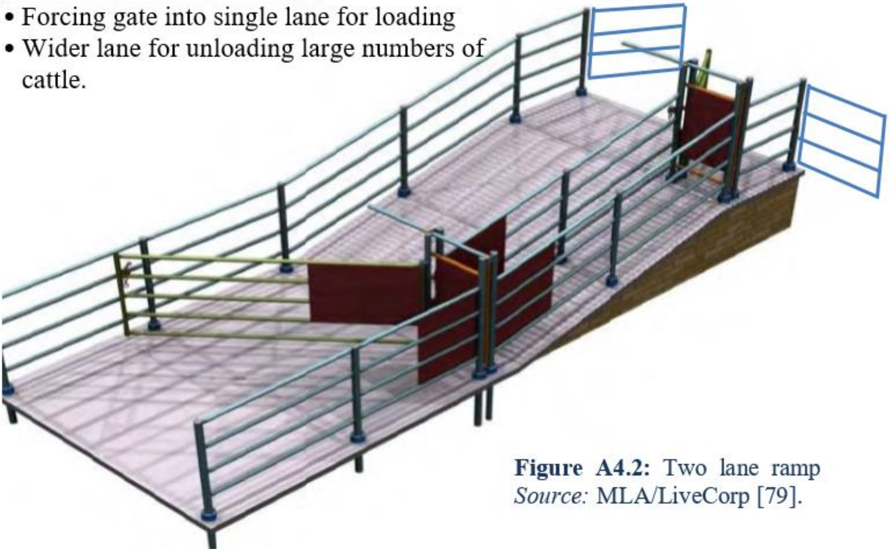


Figure A4.2: Two lane ramp *Source:* MLA/LiveCorp [79].

(Appendix A4: cont.) ***Race and handling yards:***

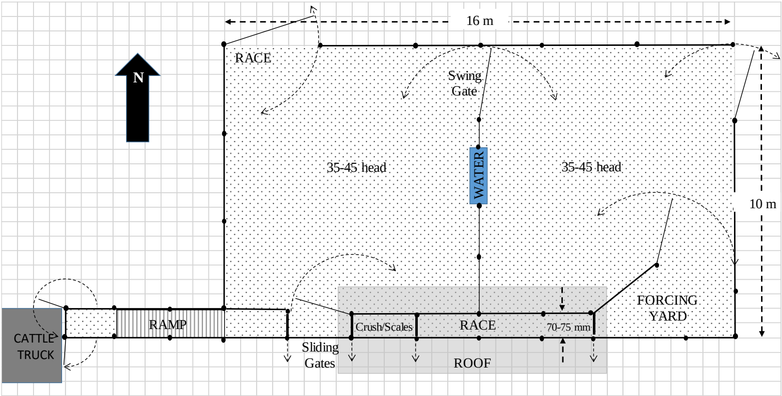


Figure A4.3: Generic plan of handling yard suitable for small scale grazing herd or feedlot operations.

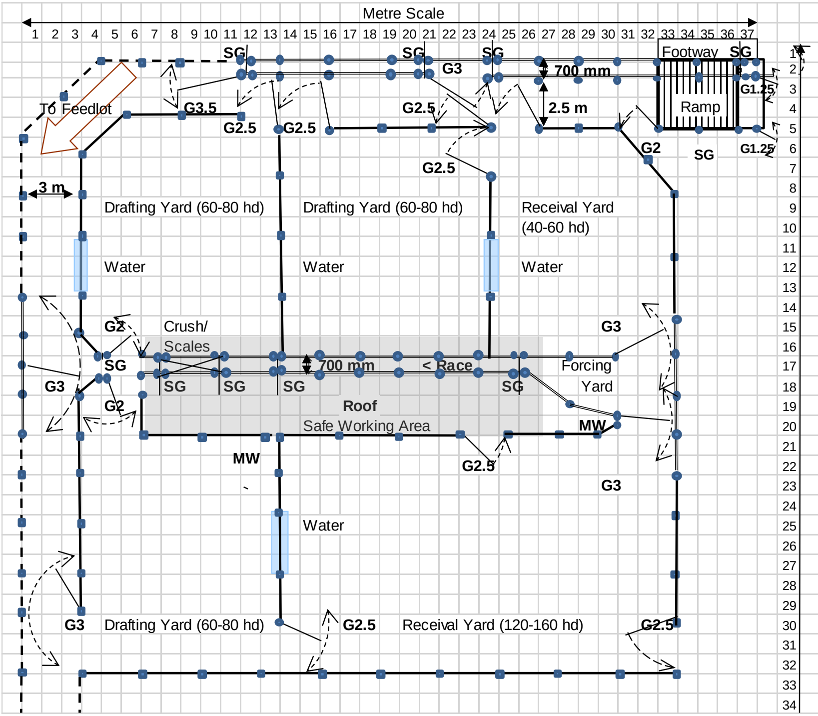


Figure A4.4: Plan of handling yards for a large feedlot.

(Appendix A4: cont.) ***Race and handling yards:*** (cont.)

Figure A4.5: (Left to right) Cattle in handling yards waiting to be processed, and muddy race (photos are related to the centre of plan in Figure A4.4) (Vietnam).

Feed and water troughs:

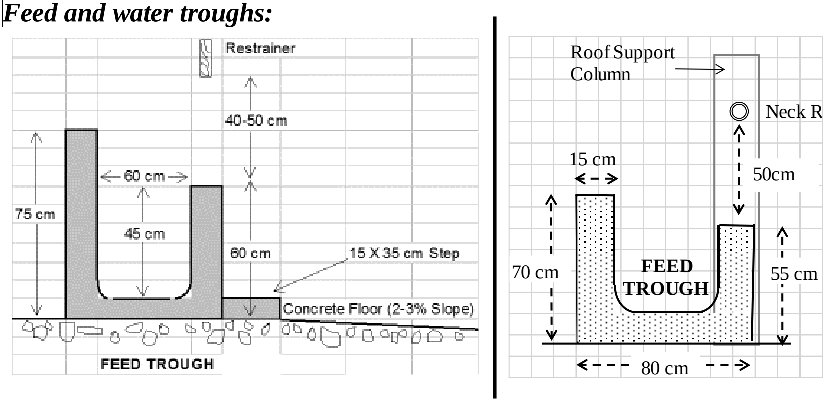


Figure A4.6: Generic dimensions for cattle feed troughs.

Figure A4.7: (Left to right) Feed troughs: Cable restraint (Indonesia); pipe restraint (Vietnam); and conveyer belt used as a trough (Indonesia). *Note:* Lick block supplement in trough.

(Appendix A4: cont.) ***Feed and water troughs:*** **(**cont.**)**

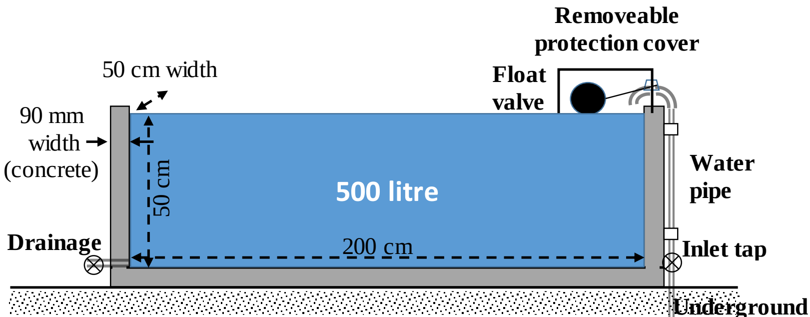


Figure A4.8: Generic drinking water trough (concrete or galvanised steel) for cattle feedlot or paddock grazing.

Figure A4.9: A variety of cattle water troughs used in paddocks grazing and feedlots in SE Asia (i.e. Philippines, Vietnam, and Indonesia) and NT (centre left).

(Appendix A4 cont.)

Holding pens:

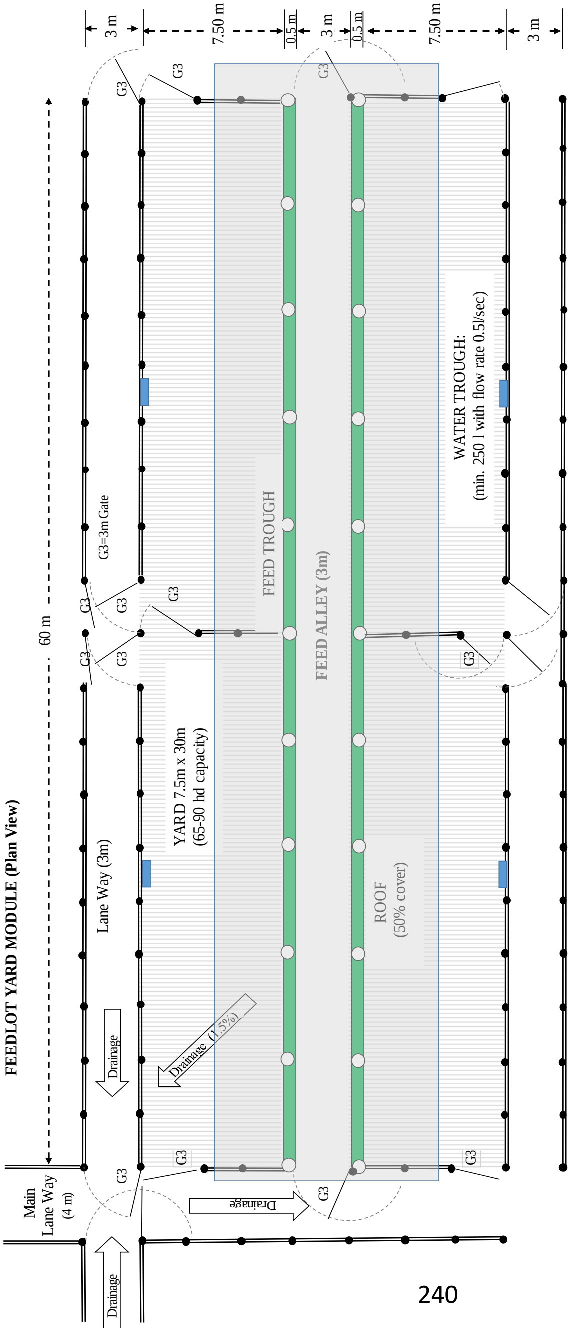
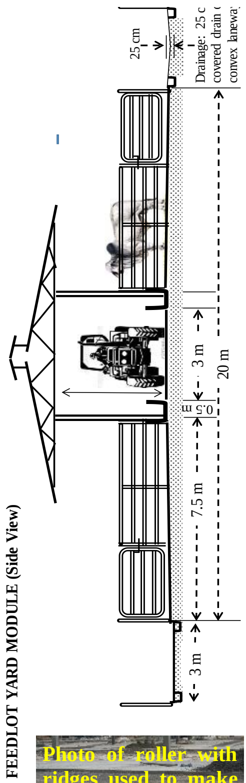
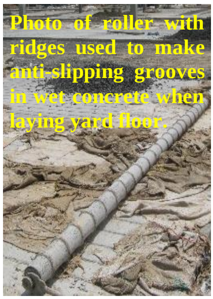


Figure A4.10: Plan and side view of generic feedlot holding pen module; see also device for making anti-slipping yard floors (below).





(Appendix A4: cont.) ***Holding pens:*** (cont.)

Figure A4.11: (Clockwise) Feedlot holding pens in Indonesia, Philippines, Brunei, and Vietnam.

(Appendix A4 cont.) ***Fences and gates:***

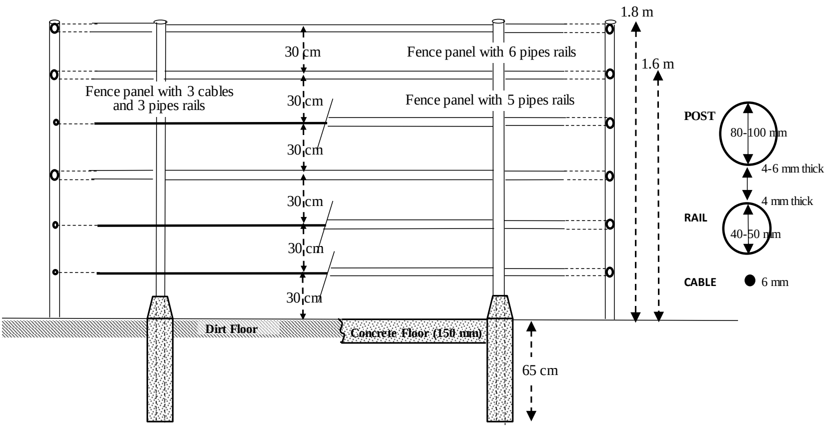


Figure A4.12: Illustration of steel pipe and cable fencing for feedlot and handling

Fences and gates: (cont.)

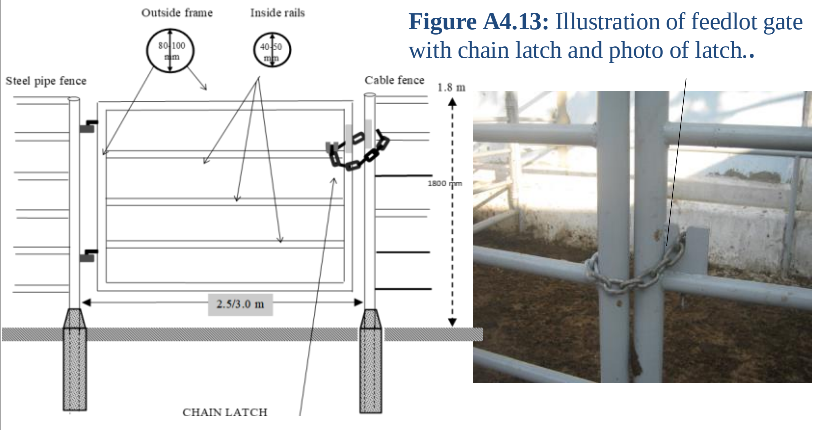


Figure A4.13: Illustration of feedlot gate with chain latch and photo of latch..

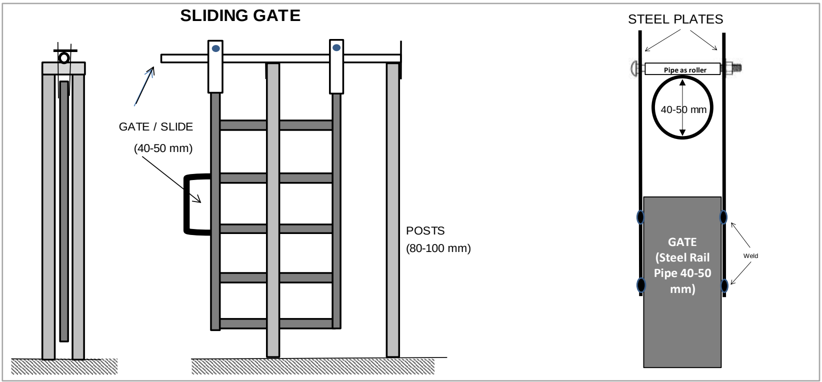
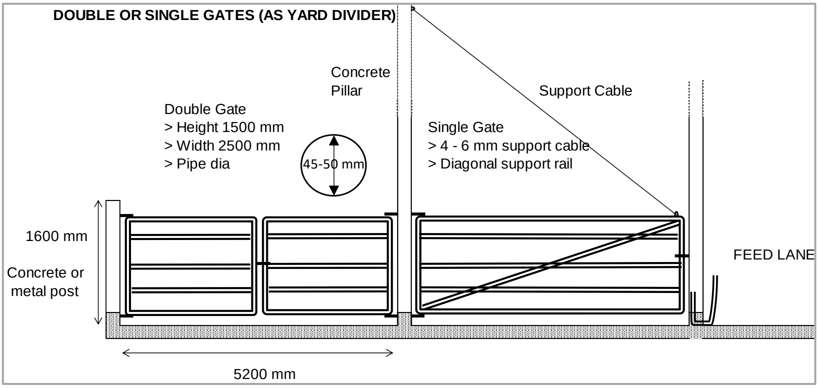


Figure A4.14: (Above and below) Illustrations of sliding gate and holding yard gates**.**



Appendix A5: Book values for nutrient requirements of cattle beef cattle.

Table A5.1: Comparison of book values for nutrient requirements for beef cattle breeder herd grazing pasture and on feedlot cattle (> 300 kg LW).

Class/age (months)	LW (kg)	ADG (kg)	DMI (kg/d)	CI (% LW)	CP (% DMI)	ME (TDN%) (MJ/kg DM)	Ca (% DMI)	P (% DMI)	Source
Steer (E)	200	0.5	5.8	2.9	9.9	8.8 (58)	0.24	0.22	US [80]
Steer (M)	200	0.5	5.0	2.5	7.4	8.0 (54)	0.39	0.26	UK [9]
Heifer (M)	200	0.5	4.1	2.0	7.1	9.0 (61)	0.30	0.17	UK [81]
Weaner (M)	200	0.5	4.8	2.4	8.7	11.0 (75)	0.19	0.18	MLA [82]
Weaner (M)	200	0.5	4.6	2.3	10.0	10.0 (67)	0.50	0.40	Notebook
(0-10)									
Steer (E)	250	0.7	5.8	2.3	10.7	10.5 (70)	0.31	0.28	US [80]
Heifer (E)	250	0.7	5.8	2.3	10.5	10.9 (72)	0.29	0.26	US [80]
Heifer (M)	250	0.5	4.9	2.0	8.5	10.0 (67)	0.32	0.18	UK [81]
Yearling (M)	250	0.5	5.75	2.3	7.3	9.4 (64)	0.30	0.25	MLA [82]
Yearling (M)	250	0.55	5.75	2.3	10.0	9.5 (64)	0.43	0.35	Notebook
(11-13)									
Steer (E)	300	0.9	8.1	2.7	10.0	10.5 (70)	0.27	0.23	US [80]
Heifer (E)	300	0.7	6.6	2.2	10.1	10.9 (72)	0.24	0.23	US [80]
Heifer (M)	300	0.75	7.1	2.3	7.4	9.4 (64)	0.24	0.16	UK [81]
Yearling (M)	300	0.75	6.6	2.2	9.4	12.1 (82)	0.26	0.21	MLA [82]
Yearling (M)	300	0.6	7.2	2.4	11.0	9.0 (61)	0.35	0.30	Notebook
(14-16)									
Steer (E)	350	0.9	8.0	2.3	10.0	10.9 (72)	0.25	0.22	US [80]
Heifer (E)	350	0.9	8.1	2.3	9.5	11.3 (77)	0.18	0.18	US [80]
Heifer (M)	350	0.75	6.5	1.9	7.7	7.9 (54)	0.23	0.15	UK [81]
Steer (M)	350	0.75	7.00	2.0	9.9	12.6 (85)	0.40	0.32	MLA [82]
Yearling (M)	350	1.1	8.2	2.35	11.0	10.0 (67)	0.35	0.3	Notebook
(17-18)									
Steer (E)	400	1.0	9.4	2.4	9.4	10.9 (72)	0.18	0.18	US [80]
Steer (M)	400	1.0	8.5	2.1	8.8	10.6 (71)	0.45	0.31	UK [9]
Heifer (E)	400	0.9	8.4	2.2	9.4	11.7 (79)	0.2	0.2	US [80]
Heifer (M)	400	0.75	7.9	2.0	7.2	9.2 (62)	0.29	0.23	UK [81]
Steer (M)	400	0.75	8.0	2.0	9.4	9.6 (65)	0.4	0.32	MLA [82]
Steer (M)	400	1.0	9.2	2.3	10.0	10.0 (67)	0.35	0.3	Notebook
(19-21+)									
Dry cow (E)	425	0.5	8.9	2.1	8.7	9.6 (65)	0.18	0.18	US [80]
Dry Cow (M)	425	> Maint.	8.1	1.9	8.0	8.0 (54)	0.20	0.20	Notebook
Preg. (3rd T.)	450	0.4	8.1	1.9	5.9	8.0 (54)	0.18	0.18	US [80]
Preg. (3rd T.)	450	> Maint.	9.8	2.3	8.5	8.5 (58)	0.20	0.20	Notebook
Nursing cow	425	> Maint.	9.05	2.1	9.2	8.0 (54)	0.18	0.18	US [80]
Nursing cow	425	> Maint.	10.6	2.5	10.0	8.0 (54)	0.30	0.20	Notebook
Bull (E)	500	0.7	12.2	2.5	8.8	9.2 (62)	0.18	0.18	US [80]
Bull (M)	500	Active	12.5	2.5	8.5	9.0 (61)	0.20	0.20	Notebook
Sales stock	425	0.3	10.0	2.0	8.0	8.0 (54)	0.12	0.12	Notebook

Early (E) and Medium (M) maturity breeds.
ME (MJ/kg) = (a) Mcal/kg x 4.184; (b) TDN (%) x 0.15104

Appendix A6: Calculation of Adult Equivalents (AEs).

Table A6.1: Calculation of AEs tailored for Brahman crossbred (*B. indicus*) cattle in SE Asian livestock operations.

LW (kg)		CI* (%)		DMI (kg)		ME (required) (MJ/kg DM)		ME (MJ/day)		AEs
[(425[1]	x	1.8)]	=	7.65	x	8	=	61[A]	A/A	1
[(450[2]	x	2.3)]	=	10.35	x	8.5	=	88[B]	B/A	1.4
[(425[3]	x	2.4)]	=	10.2	x	8.5	=	87[C]	C/A	1.4
[(500[4]	x	2.5)]	=	12.5	x	9	=	113[D]	D/A	1.8
[(200[5]	x	2.3)]	=	4.6	x	10	=	46[E]	E/A	0.8
[(300[6]	x	2.4)]	=	7.2	x	9	=	63[F]	F/A	1.1
[(350[7]	x	2.5)]	=	8.8	x	9	=	79[G]	G/A	1.3

*CI (Consumption Index, %) i.e. DMI kg/LW kg. 1. Dry cow. 2. In-calf cow 3rd trimester. 3. Mid-lactation + calf. 4. Bull. 5. Weaner. 6. Yearling. 7. Feeder on fattening rations.

Table A6.2: ME requirements and AE values for Brahman crossbred (*B. indicus*) breeding herds grazing native pastures in northern Australia. [82], [83], [84].)

CATTLE CLASS	LW (kg)	CI* (%)	DMI (kg)	ME (required) (MJ/kg DM)	ME (MJ/day)	AEs
Dry cow/Steer	450	2	9	8	73	1
Preg. (3T)	425	2	8.5	9	77	1.1
Lact.+calf	400	2.3	9.2	9.5	87	1.2
Bull	500	1.7	8.5	10	85	1.2
Weaner	200	2.3	4.6	7.5	35	0.5
Yearling	300	2.2	6.5	8	52	0.75
Feeder	350	2.3	8	9	72	1.2

*CI (Consumption Index,%) i.e. DMI kg/LW kg.

Appendix A7: Breeder Management Calendar Plan Example:

Table A7.1: Annual planning for 60 beef cow herd on 3 x 6 ha of improved pasture (4 cycles/year) while meeting feed requirements vs availability.

Year 2020	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall	WET SEASON					DRY SEASON					WET SEASON	
Breeder Mgt.		Bulls join herd (mating)					PT/Cull/Wean					
Herd Nos. (hd):												
Cows (1.3 AEs)	60	60	60	60	60	60	47	47	60	60	60	60
Bulls (1.8 AEs)	3	3	3	3	3	3	1	1	3	3	3	3
Y Heifers (1.1 AEs)	23	23	23	23	23	23	13	13	22	22	22	22
Y Bulls (1.1 AEs)	22	22	22	22	22	22	2	2	23	23	23	23
Weaners (0.8 AEs)	45	45	45	45	45	45	45	46	46	46	46	46
Calves (0.25 AEs)	48	48	48	48	48	48	24	24		8	20	20
Total AEs (no. hd x AEs)	181	181	181	181	181	181	121	122	170	172	175	175
Total MJ/month (req.)	342k[1]	320k	342k	331k	331k	331k	230k	231k	311k	325k	320k	330k
Feed availability:												
Pasture (6,7,8) 3 x 6 ha	6	7	8	6	7	8	6	7	8	6	7	8
Est. yield (kg DM/ha):	7500	6500	8000	7000	6000	7000	6500	5000	5500	5000	6000	7500
Total MJ/month (avail.):	360k[2]	364k	512k	336k	336k	448k	312k	280k	352k	240k	336k	480k
Pasture eaten:	95%	88%	67%	99%	99%	74%	74%	83%	88%	-35%	95%	69%
Extra feed req. (MJ)		Silage (70 t FM)				Hay (570 bales)				Shortfall		
Supplements: Bulls/Cows	Concentrates										Energy/Protein	
Lick blocks	Salt lick blocks + Phosphorous				Salt lick blocks + Urea/Sulphur						Salt + P	

Calculations:

> Total MJ/month (req.) = (181 AEs x 31 d x 61 MJ/AE) <u>342k</u>[1] MJ.

> Total MJ/month (avail.) = (7,500 kg DM/ha x 6 ha x 8 MJ/kg DM grass) <u>360k</u>[2] MJ.

> Pasture eaten = (342k/360k MJ) 95%. Note: Silage and hay made from leftover pasture in March, June, July.

1. 1k = 1000 units
2. Required (req.)
3. Available (avail.)

Appendix A8: On-farm abattoir facilities and plans.

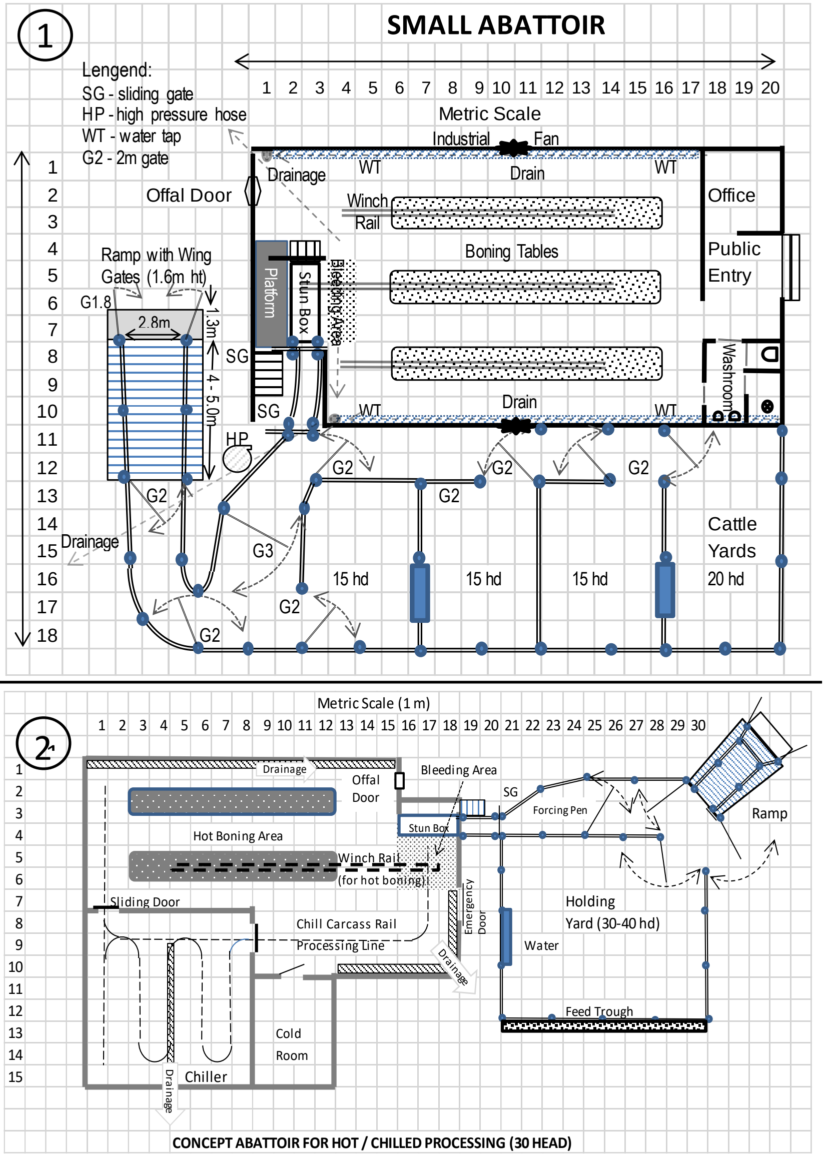
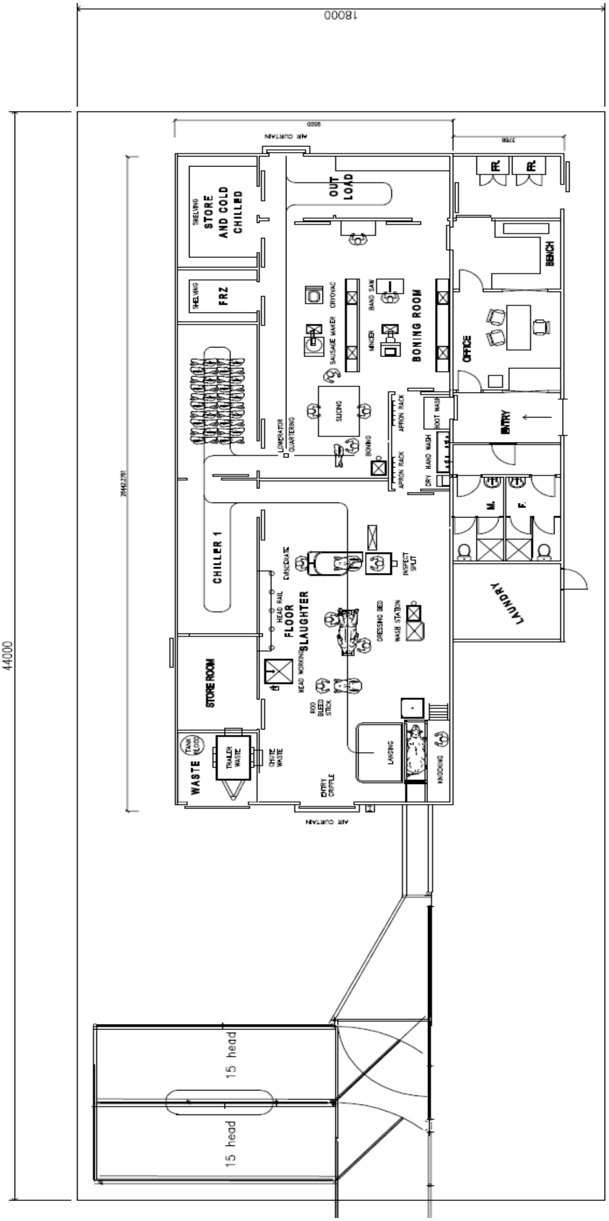


Figure A8.1: Plans (1-3) of small on-farm abattoirs (30-50 head per day) (see also next page).

(Appendix A8 cont.) ***Small abattoirs:***

3



(Appendix A8 cont.) ***Abattoir infrastructure:***

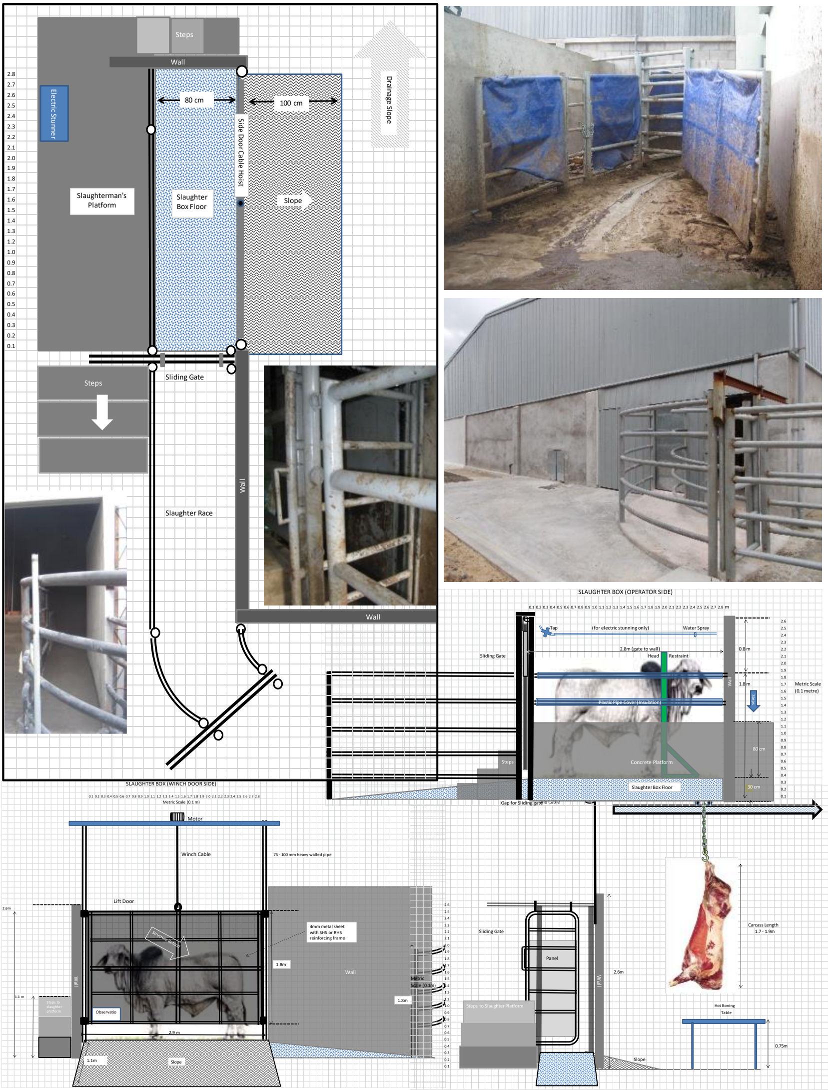


Figure A8.2: (Clockwise) plan view and photos of race, knocking box; forcing yard (photo); curved race into abattoir (photo); stunning side view of knocking box (illustration); side view of knocking box panel hoist and ramp (illustration); and entrance view of knocking box, ramp to slaughter floor (illustration), hoisted carcass.

(Appendix A8 cont.) ***Knocking box restrainer and cradle:***

Figure A8.3: Details of a knocking box restrainer and rack system to secure restraint.

Figure A8.4: Cradle for de-hiding the carcass in the absense of a hide puller.

Appendix A9: Some common cattle feeds and their utilisation in ration formulations.

Cassava (Manihot esculenta): Cassava is a staple human food reserve throughout the tropics. The dried roots consist of about 35% carbohydrate and can be processed to yield the same amount of starch. The leaves are often cooked and eaten. The raw tubers and fresh leaves are poisonous to eat by humans and livestock until processed. The toxic substance is prussic acid (hydrogen cyanide (HCN)) and is effectively rendered harmless by cutting, washing, boiling and drying. Bitter varieties of cassava have higher levels of prussic acid (>0.01%) in fresh tubers than sweeter varieties where the toxin is mainly confined to the peel. Because of its toxicity, cassava is often planted as a 'live' fence to protect other food crops from stray livestock.

Cassava stems and leaves: The aerial parts, which make up 45% of the plant, are cut at a height of 40 cm above the ground and wilted (<65% moisture) overnight before chopping. The stem/leaf mixture contains about 20% protein (dry basis) and is fibrous and may be fed up to 35% of the ration. Leaf meal is commercially manufactured as a protein source for pig and poultry rations.

Cassava root/tubers: These are an excellent energy source and can be fed up to 65% (DM basis) of cattle rations. The tubers are sliced thinly and dried until moisture content is reduced to 12%. The processed cassava chips are readily digested in the rumen, however since the tuber contains very little protein, the chips should be fed with urea (dissolved in water) or a protein source that also degrades easily in the rumen. It is advisable to substitute a portion (10-25% DM basis) of the cassava component in the ration with corn grain or cereal byproducts.

Cassava or tapioca waste (onggok): This is the residue after extraction of starch from the tuber. The wet waste should be dried (±85% DM) and coarsely broken up before feeding, and can be fed up to 60% of the ration (DM basis), together with urea or digestible protein (see *Cassava chips and tapioca waste,* pages 79-80 and Infobox 3.16, page 82 for more details):

Compound ration: A ration from the whole processed cassava plant consisting of (as fed basis) root products (33%) and aerial parts (34%), supplemented with corn grain (15%), urea (1%), protein meal (e.g. copra) (15%), minerals (2%), will produce moderate growth rates.

Table A9.1: Approximate feed value of cassava for cattle (DM basis).

Cassava *(Manihot esculenta)*	DM (%)	CP (%)	RDP (%)	CF (%)	ME MJ/kg)	Ca (%)	P (%)	Max Level (%DM)
Cassava Chips	88	3.0	80	4.3	12.8	-	-	65%
Tapioca Waste	90	2.0	90	3.0	12.0	0.60	0.20	50%
Stem/Leaves	24	6.5	~65	17.3	8.46	0.62	0.08	35%
Leaves	24	23.6	~65	14.5	11.0	0.81	0.16	20%

Cultivation: Cassava is favoured because of its ease of cultivation, drought resistance, and ability to yield on marginal land. An application of potassium sulphate is recommended to boost yields. Planting requires moist soils and continuing rains for good establishment. Stem cuttings (30-40 cm) from mature plants are planted vertically, 45^{o} angle or buried horizontally, at a spacing of about 1 m^{2}/plant. Depending on plant variety, the tubers may be harvested from 9-18 months with yields (fresh basis) ranging from 10-25 t/ha (3.5-9 t/ha DM basis). Processing of tubers should begin within a day or so after harvesting to avoid spoilage. Lower yields (i.e. 12.5 t/ha fresh or 2 t/ha DM basis) of aerial parts (stems and leaves) of the cassava plant can also be expected, and used in the ration after wilting and chopping up the stems.

Cotton (Gossypium spp.): Cotton is grown in the drier regions of SE Asia, (i.e. Indonesia, Philippines, Thailand etc.) mostly for domestic clothing industries. Apart from separating the cotton fibres from the flower bole, the milling process retrieves the seeds for crushing which produces oil (16%), hulls (26%), seed meal (45.5%) and lint (8.5%).

Whole cotton seeds: Leftover seeds, usually with lint attached, can be fed to cattle and buffalo. The oil in the whole seed is a readily available source of energy and the seed itself (e.g. solid contents and hull) consists of about 20% good quality protein. The seeds can be safely included in the feedlot rations at a rate of 10-15%.

Cottonseed meal: The seed meal is left over from oil extraction. Mechanical extraction (M) of oil from whole seeds (e.g. with hull) produces a meal of lower nutritional value than that from dehulled (decorticated) seeds and solvent extraction (S). Protein and oil content of the latter ranges from 30-50

% and 2-10% respectively. Meals from mechanical extraction should be limited to 15% of the ration (as fed) due to the high oil content, although higher amounts can be fed to lactating breeder cattle as a source of energy.

Figure A9.1: (Top to bottom) Delinted cotton seeds; cotton seed meal.

Cottonseed hulls: The hulls are high in fibre and used extensively in cattle rations to stimulate feed intake especially where forage is in short supply. The oil content is low, and the hulls usually form 25-30% of the ration (as fed), although much higher levels can be used without affecting palatability or growth rates. At these higher levels, a supplementary protein meal is required to compensate for the low protein levels in cotton seed hulls.

Gossypol: This is a toxin produced by the cotton plant to protect itself from pests. It is also toxic to monogastric animals (including humans) and young ruminants, and the above cotton feeds should not be fed to these groups of livestock. While older ruminants have some tolerance to gossypol (and the oil), the limits on the inclusion of whole cotton seeds and seed meals in the whole ration in this case should be used as guidelines (see Table A9.2).

Table A9.2: Approximate feed value of cotton byproducts for cattle (DM basis).

Cotton (Gossypol spp.)	DM (%)	CP (%)	RDP (%)	CF (%)	ME MJ/kg)	Ca (%)	P (%)	Max Level (%DM)
Seeds	90	17.8	-	16.0	13.2	0.15	0.67	15
Hulls	90	6.3	-	35.0	7.6	0.26	0.15	50
Seed meal (M)	92.4	39.3	50	16.6	10.9	0.22	1.18	15
Seed meal (S)	92.1	43.5	60	11.6	10.3	0.18	1.17	25

Table A9.3: Example of fattening ration (as fed) for feeders (375-425 kg LW).

Hay	10%	Urea	0.6%
Grain	70%	Ammonium sulphate	0.3%
Cotton seed	15%	Limestone	0.7%
Molasses	3%	Salt	0.2%

Rice (Oryza sativa): Rice is cultivated everywhere in SE Asia and in some regions more than one crop can be harvested in a year. Post-harvest provides a range of waste products for livestock consumption, including hay, straw, and byproducts from the rice processing industry. Rice bran and millings (see Figure A9.2) are important byproducts used in cattle feedlot rations and supplementary feed for productive breeders.

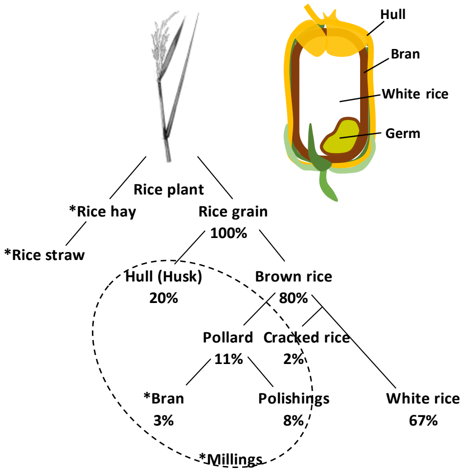


Figure A9.2: Proportion of byproducts from processing rice for human consumption, and illustration of rice grain parts. Main rice byproducts for cattle feed are marked with an asterisk (*), and millings include a mixture of byproducts within the circle.

Rice hay and straw: The hay is the sun-dried aerial part of the plant after threshing the rice, and the straw is the stem of the plant up to where it is cut for threshing. Some farmers grow a dense crop of rice for feeding their livestock or selling as stockfeed. The whole crop may be cut and baled before the rice grain is set, or is harvested leaving some grain on the hay, for feeding productive cattle. The hay is often used as a night feed for feeders or breeders in feedlots. Compared with rice hay, the straw has low nutritional value (see Table 3.10, page 76). It requires chemical treatment to increase digestibility and release more energy from structural carbohydrates (see Infobox: 3.15, page 78).

Rice bran and millings: Harvested rice grain passes through a series of processes to produce white rice for human consumption. Firstly, the hulls are removed resulting in brown rice which requires more cooking than white rice. Further processing releases the seed covering (bran), polishings (layer under the bran) and the germ (packed core of nutrients) (see Fig. A9.2). Pollard is a mixture of these components, and millings also include the hulls. Hulls are indigestible and the quality of millings depends on the amount of hulls in the mixture. Rice hulls are better used for covering the floors of cattle pens.

Basic Rations:

Table A9.4: Example of ration with high level of rice bran for feeders (375 kg LW, DMI 8.5 kg/d, 2.3% CI).

Ingredients	DMI (kg)	Ration (% FM)
Forage (i.e. grass, sugarcane tops)	1.2	37%
Corn grain	0.5	4%
Rice bran	3.8	33%
Protein meal (i.e. copra, palm kernel cake)	2.3	20%
Molasses	0.6	6%
Urea	0.03	0.25%
Limestone	0.21	1.5%
Salt	0.03	0.25%

Note: Fully processed rice bran reduces oil content and allows for extended storage and higher levels in feed.

Figure A9.3: (Top to bottom) Hand threshing the rice heads to release the grain (Philippines); bag of rice bran; rice hay (Indonesia).

Soy(a)bean (Glycine max): Soy is one of the most important oilseed crops and staple foods for human consumption, however the forage (left over after harvesting) and byproducts of processing are readily used as livestock feed containing up to 50% protein (DM basis). The raw soya beans carry an anti-digestive trypsin inhibitor that reduces the ability of monogastric farm animals and young ruminants to digest the protein. The inhibiter must be destroyed by heat (e.g. boiling soybeans for 30 minutes) before feeding to pigs and calves, etc. Rations for older cattle can contain a limited amount of raw soybeans (14% DM basis) due to the inhibitor and the high fat content of the seeds. Cattle feedlot rations usually use the soybean meal left behind after the oil extraction process, which destroys the inhibitor and significantly reduces oil content.

Post-harvest forage: There remains considerable amounts of forage after harvesting soybeans. This can be hayed off and fed to cattle after removing any thick stemmy material.

<u>*Full fat soybean extruder:*</u> Soya seeds have a high protein and oil content, but do not store well unless dried to <15% moisture. The seeds can be processed through an extruder which heats and puffs out the contents of the seed to increase digestibility and extend the storage time of the product.

Figure A9.4: Full fat soybean.

<u>*Soybean meal:*</u> This is the byproduct of oil extraction and is normally fed to livestock. The protein content of the meal after solvent extraction is 40-50% but is limited to 10% of the ration (DM basis) due the residual oil.

Table A9.5: Approximate feed value of soybean for cattle (DM basis).

Soybean (*Glycine max*)	DM (%)	CP (%)	RDP (%)	CF (%)	FAT (%)	ME (MJ/kg)	Ca (%)	P (%)	Max Level (DM)
Hay	90	13.9	-	35.5	-	-	0.94	0.18	-
Whole seed	91	26.4	-	6.0	16-21	13.6	0.27	0.65	10%
Soy (full fat)	92	41.3	74	5.8	17.5	14.2	0.25	0.59	10%
Soybean meal	89	45.0	74	13	1.0	12.2	0.30	0.70	5-10%
Hulls	90	8-16	-	37	-	9.5	0.59	0.17	15%

Table A9.6: Performance of Ongole bulls (average 323 kg LW) on growing (G) and finishing (F) feedlot rations (DM basis) with soybean meal over 120 days [85].

INGREDIENTS/RATIONS	G1	G2	F1	F2
Forage (% DM basis):				
Elephant grass	4	4	4	4
Concentrate (% DM basis):				
Rice bran[1]	56	40	31	36
Soybean meal	8	6	5	4
Corn (cracked)	32	-	-	-
Tapioca waste	-	50	51	55
Urea	-	-	9[2]	1[3]
ADG (kg) over 120 days	0.801	0.710	0.531	0.317
FCR	7.5	9.0	10.4	17.9

1. Rice bran levels are very high in in G1 and G2 rations that could have resulted in excessive soft fat in the carcass. 2. Slow-release N from urea used in F1, may have affected result of F2. 3. Mixed with water.

Sugarcane: The industrial process involves cutting the leaves and pressing the stems to extract the sugar juice, leaving behind the wasted stems (bagasse). The extracted juice is subjected to a series of screening, heating, clarifying, filtering, evaporations, crystallising, and centrifuging treatments to produce various grades of sugar. The leftover from this process is molasses.

Sugarcane tops (leaves) are a good source of forage for cattle rations, but chopped fresh stem (with pith) is poorly digested. Bagasse is very fibrous and small amounts (10% ration DM) is fed as a ration filler. Small amounts of molasses are often included in rations to increase palatability, boost microbial activity, and as a carrier for urea. Fattening rations based on molasses is common in sugarcane growing areas, with the addition of a small amount of roughage (10-15% ration DM).

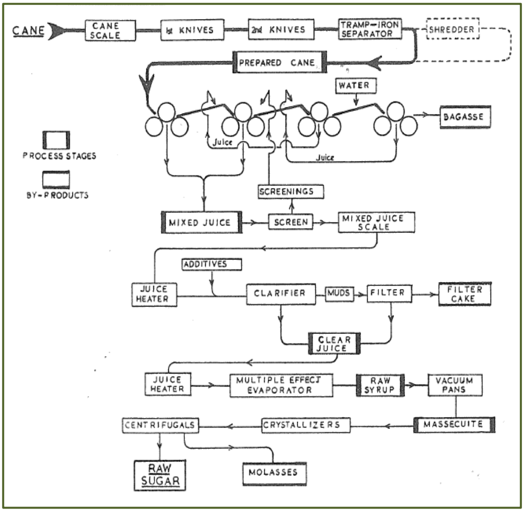


Figure A9.5: Flow chart of sugar processing factory [86].

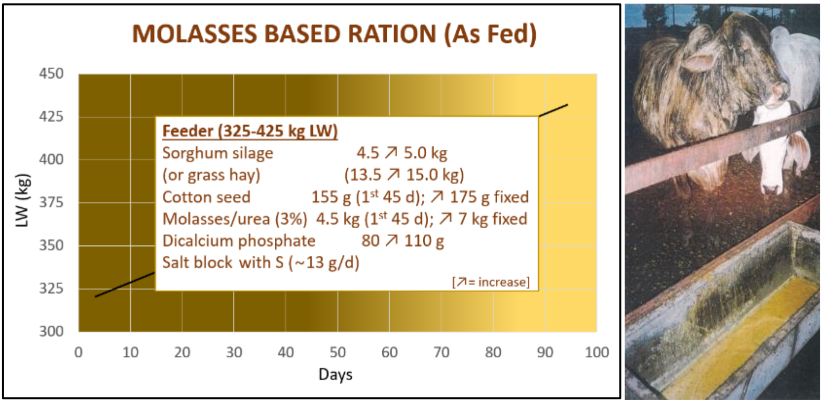


Figure A9.6: (Left to right) Molasses based ration; molasses trough (Philippines).

Table A9.7: Observations of feedlot rations and cattle performance based on sugarcane and its byproducts (% as fed) (Philippines). *Source:* Author

INGREDIENTS/RATIONS	A	B	C1	C2	D
Sugarcane & Byproducts:					
A. Sugarcane tops (leaves)	89	-	-	-	-
B. Sugarcane stalk (chopped)	-	85	-	-	-
C. Molasses/Urea 2.5% (ww)	5.7	6.0	39	36	-
D. Juice/0.4% NH_3 (ww)	-	-	-	-	81
E. Bagasse[1]	-	-	-	-	-
Forage:					
Cassava leaves (wilted)	-	-	-	60	-
Leucaena leaf	-	-	-	-	17.5
Sorghum silage	-	-	59	-	-
Supplements:					
Rice polishings	4.5	7.5	-	-	-
Cottonseed (whole)	-	-	1.0	-	-
Soybean meal	-	-	-	2.5	-
Fishmeal	-	-	-	-	1.5
Dicalcium phosphate (DCP)	-	-	0.1	0.25	-
Salt	0.15	0.15	-	0.25	-
Rock phosphate	0.14	0.14	-	-	-
Premix	0.01	0.01	-	-	0.3
Performance:					
ADG (kg/d)	0.84	0.61	0.94	0.94	1.02
Average weight (kg LW)	298	267	308	313	233
Breed	Zebu	Zebu	BraX[2]	Zebu	Zebu

1. Bagasse can substitute up to 10% of ration (as fed) as a fibre source.
2. Imported Australian cattle.

(Appendix A9 cont.) ***Rations for SE Asian feedlots:***

Table A9. 8: Formulated rations (1-3) for feedlots in the Philippines.

Philippines				
Ration 1: Australian feeders (310-450 kg)				
Daily Ration/hd	As fed	Conc.Ingr.	As fed	Ration
Forage:	(kg)	(%)	(%)	(%DM)
Corn chop	12.0		66%	32%
Concentrate:	[6.2]	(100%)→	[34%]	[68%]
Corn Bran	0.9	15%	5%	10%
Rice bran (D1)	2.3	36.5%	12.5%	26%
Copra meal	2.0	32%	11%	23%
Molasses	0.7	12%	4%	7%
Urea	0.07	1%	0.36%	0.8%
Limestone	0.15	2.4%	0.83%	1.9%
MCP[1]	0.01	0.24%	0.08%	0.19%
Salt	0.03	0.41%	0.14%	0.31%
Premix	0.00	0.08%	0.03%	0.03%
Totals	18.2	100%	100%	100%
Predicted ADG (kg) 1.0 (± 5%). 1.Monocalcium phosphate				

Figure A9.7: Copra pellets

Philippines				
Ration 2: Australian Feeders (325-425 kg)				
Daily Ration/hd	As fed	Conc.Ingr.	As fed	Ration
Forage:	(kg)	(%)	(%)	(%DM)
Corn chop	10.0		33%	28%
Pinapple pulp	15.0		50%	20%
Concentrate:	[5.0]	(100%)→	[16.7%]	[52%]
Corn Bran	1.6	32%	5%	16%
Rice bran	0.9	18%	3%	9%
Copra meal	1.5	30%	5%	15%
Cotton seed	0.5	10%	2%	5%
Leucaena leaf	0.25	5%	0.8%	3%
Urea	0.06	1.25%	0.21%	1%
Limestone	0.10	2.0%	0.33%	1%
DCP[1]	0.05	1.0%	0.17%	1%
Salt	0.05	1.0%	0.17%	1%
Premix	0.005	0.1%	0.02%	0%
Totals	30.00	100%	100%	100%
Predicted ADG (kg) 0.93 (± 5%). 1.Dicalcium phosphate				

Philippines				
Ration 3: Australian feeders (325-425 kg LW)				
Daily Ration/hd	As fed	Conc.Ingr.	As fed	Ration
Forage:	(kg)	(%)	(%)	(%DM)
Sugarcane tops	8.0		53%	28.0%
Concentrate:	[7.1]	(100%)→	[47%]	[70%]
Corn Bran	0.70	9.9%	5%	7.9%
Tapioca meal	0.45	6.4%	3%	5.1%
Copra meal	1.65	23.4%	11%	18.6%
Soybean hulls	0.60	8.50%	4%	6.7%
Biscuit waste	1.4	19.5%	9%	15.9%
Silage[1]	1.1	15.6%	7%	6.2%
Molasses	0.95	13.5%	6.5%	8.9%
Urea	0.09	1.27%	0.6%	1.1%
Limestone	0.09	1.27%	0.6%	1.12%
Salt	0.03	0.35%	0.17%	0.31%
TCP[2]	0.03	0.35%	0.17%	0.31%
Totals	15.1	100%	100%	100%
Predicted ADG (kg) 1.0 (± 5%).				
1. Bags of chopped sugarcane tops fermented with corn				
(10%), copra meal (10%), and molasses (10%)				
2. Tricalcium phosphate.				

(Appendix A9 cont.) ***Rations for SE Asian feedlots:***

Table A9.9: Formulated rations (1-2) for feedlots in Indonesia.

Indonesia

Ration 1: Australian feeders (325-425 kg LW)

Daily Ration/hd	As fed (kg)	Conc.Ingr. (%)	As fed (%)	Ration (%DM)
Forage:				
Sugarcane tops	7.5		52%	28.0%
Concentrate:	[6.8]	(100%)→	[48%]	[72%]
Rice Bran	2.25	33.0%	16%	24.1%
Onggok/Tap.waste	2.7	40.0%	19%	27.6%
Copra meal	1.25	18.0%	9%	14.0%
Molasses	0.40	6.00%	2.8%	3.5%
Urea	0.14	2.0%	0.94%	1.62%
Salt	0.03	0.35%	0.17%	0.6%
Premix	0.02	0.25%	0.12%	0.5%
Totals	14.3	100%	100.0%	100%

Based on 375 kg LW, DMI 8.3 kg/d. Predicted ADG (kg) 1.1 (± 5%).

Indonesia

Ration 2: Australian feeders (325-425 kg LW)

Daily Ration/hd	As fed (kg)	Conc.Ingr. (%)	As fed (%)	Ration (%DM)
Forage:				
Corn chop	5.0		39%	16%
Concentrate:	[7.7]	(100%)→	[61%]	[84%]
Rice Bran	0.5	6.5%	4%	6%
Onggok/Tap.waste	3.0	39.0%	24%	34.0%
PKC(m)[1]	3.0	39.0%	24%	34.0%
Molasses	1.0	13.00%	8%	9%
Urea	0.10	1.3%	0.8%	1.30%
Salt	0.03	0.4%	0.24%	0.4%
Limestone	0.02	0.25%	0.16%	0.25%
Premix	0.01	0.13%	0.08%	0.13%
Totals	12.7	100%	100%	100%

Based on 375 kg LW, DMI 8.0 kg/d. Predicted ADG (kg) 1.1 (± 5%).

1. Palm kernel cake (mechanical expeller)

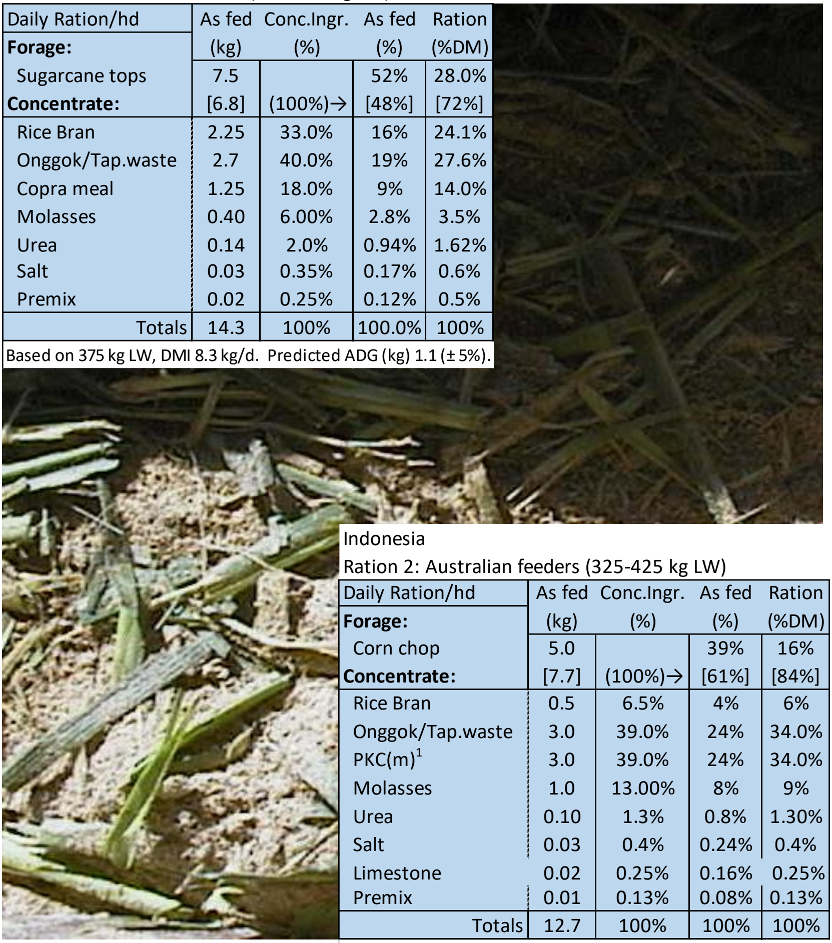


Figure A9.8: Sugarcane tops and rice bran mix.

(Appendix A9 cont.) ***Rations for SE Asian feedlots:***

Table A9.10: Formulated rations (1-2) for feedlots in Thailand.

Thailand				
Ration 1: Australian feeders (315-425 kg LW)				
Daily Ration/hd	As fed	Conc.Ingr.	As fed	Ration
Forage:	(kg)	(%)	(%)	(%DMI)
Guinea grass (hay)	2.0		13%	21%
Pineapple pulp	3.9	Mixed[1]	25%	6%
Brewers grains	3.9	together	25%	10%
Concentrate:	[5.85]	(100%)→	[37%]	[63%]
Corn grain (cracked)	0.8	14.0%	5%	9%
Tapioca chip	1.6	27.0%	10%	18%
Palm kernel cake	2.25	38.0%	14%	24%
Sunflower meal	0.5	8.50%	3.0%	5.5%
Molasses	0.6	10.3%	3.8%	5.5%
Urea	0.03	0.50%	0.19%	0.4%
Salt	0.03	0.50%	0.19%	0.4%
Limestone	0.10	1.7%	0.64%	1.2%
Premix	0.02	0.30%	0.13%	0.25%
Totals	15.70	100%	100%	100%
Based on 370 kg LW, DMI 8.2 kg/d. Predicted ADG (kg) 1.0 (± 5%).				
1. Mixed together and fed separately.				

Figure A9.9: Piles of pineapple waste (left) and palm kernel cake (right) ready for feeding cattle at the feedlot (Thailand).

Thailand				
Ration 2: Australian feeders (315-450 kg LW).				
Daily Ration/hd	As fed	Conc.Ingr.	As fed	Ration
Forage:	(kg)	(%)	(%)	(%DMI)
Corn chop	10.0		51%	30.5%
Corn cob (chopped)	0.5		3%	5.5%
Brewers grains[1]	4.0		21%	10%
Concentrate:	[5.1]	(100%)→	[26%]	[55%]
Tapioca chip	2.0	39%	10%	22%
Sunflower meal	0.5	10%	2.5%	5.5%
Palm kernel cake	1.5	29%	8%	16%
Leaf meal	0.35	7%	2%	4%
Molasses	0.55	11%	2.8%	5.0%
Urea	0.03	0.6%	0.13%	0.30%
Salt	0.03	0.6%	0.13%	0.30%
DCP[2]	0.10	2.0%	0.50%	1.2%
Premix	0.02	0.4%	0.08%	1.3%
	19.58	100%	100%	100%
Based on 383 kg LW, DMI 8.2 kg/d. Predicted ADG (kg) 1.0 (± 5%).				
1. Fed separately. 2. Dicalcium phosphate.				

Figure A9.10: Ruzi grass (*Brachiaria ruziziensis*) is a creeping perenial and wide spread in Thailand. It is usually harvested every 45 days as a forage source for cattle rations.

(Appendix A9 cont.) ***Rations for SE Asian feedlots:***

Table A9.11: Formulated rations (1-3) for feedlots in Vietnam.

Vietnam				
Ration 1: Australian feeders (325-425 kg LW).				
Daily Ration/hd	As fed	Conc.Ingr.	As fed	Ration
Forage:	(kg)	(%)	(%)	(%DMI)
Elephant grass	5.0		26%	13%
Concentrate:	[14.5]	(100%)→	[74%]	87%
Corn grain (Cracked)	1.0	7%	5%	11%
Wheat pollard	0.5	4%	2.5%	5%
Tapioca chip	1.0	7%	5%	11%
Tapioca waste	2.0	14%	10.5%	22%
Brewers grains[1]	8.0	56%	42%	20%
Cottonseed (whole)	0.9	6%	5%	10%
Molasses	0.65	5%	3.5%	6.0%
Urea	0.04	0.25%	0.2%	0.40%
Salt	0.30	0.18%	0.13%	0.30%
Limestone	0.06	0.42%	0.30%	0.75%
Premix	0.02	0.11%	0.08%	0.20%
Total	19.5	100%	100%	100%
Based on 375 kg LW, DMI 8.2 kg/d. Predicted ADG (kg) 1.0 (± 5%).				
1. Feed separately if too wet.				

Ration 2: Australian slaughter stock (375-425 kg LW).				
Daily Ration/hd	As fed	Conc.Ingr.	As fed	Ration
Forage:	(kg)	(%)	(%)	(%DMI)
Elephant grass	12.0		65.5%	33%
Concentrate:	[6.6]	(100%)→	[34.5%]	67%
Rice bran	4.5	68%	24%	46%
Palm kernel cake	2.0	30%	11%	20%
Salt	0.03	0.5%	0.16%	0.30%
Limestone	0.05	0.8%	0.27%	0.60%
Premix	0.02	0.30%	0.11%	0.22%
Total	18.6	100%	100%	100%
Based on 400 kg LW, DMI 8.2 kg/d. Predicted ADG (kg) 1.0 (± 5%).				

Ration 3: Australian slaughter stock (> 425 kg LW).				
Daily Ration/hd	As fed	Conc.Ingr.	As fed	Ration
Forage:	(kg)	(%)	(%)	(%DMI)
Elephant grass	12.0		70%	40%
Concentrate:	[5.1]	(100%)→	[30%]	[60%]
Rice bran	3.0	59%	17.5%	36%
Rice hulls	1.0	19.60%	6%	12%
Palm kernel cake	1.0	19.6%	11%	12%
Salt	0.03	0.59%	0.2%	0.40%
Limestone	0.05	0.97%	0.3%	0.53%
Premix	0.02	0.39%	0.10%	0.22%
Total	17.1	100%	100%	100%
Based on 425 kg LW, DMI 7.6 kg/d. Predicted ADG (kg) 0.5 (± 5%).				
Note: This is a holding ration prior to turn off.				

Figure A9.11: Chopping sugarcane stems (limited to 10% of ration as fed).

Note: Fillers such as corn cobs (without grain) and rice hulls can replace 75% of concentrate in a short-term holding ration (i.e. 2-3 weeks).

(Appendix A9 cont.) ***Rations for SE Asian feedlots:***

Table A9.12: Formulated rations (A and B)) for feedlots in Malaysia.

Malaysia				
Ration A: Australian growing feeders (325-375 kg LW).				
Daily Ration/hd	As fed	Conc.Ingr.	As fed	Ration
Forage:	(kg)	(%)	(%)	(%DMI)
Signal grass	3.0		23%	36%
Passion fruit skins	6.0		45%	12%
Concentrate:	[4.3]	(100%)→	[32%]	[52%]
Tapioca waste	1.5	66%	11%	18%
Palm kernel cake	2.5	30%	19%	30%
Molasses	0.15	2.2%	1.0%	1.5%
Urea	0.05	0.7%	0.40%	0.70%
Salt	0.04	0.6%	0.30%	0.54%
Limestone	0.08	1.2%	0.60%	1.00%
Premix	0.01	0.3%	0.08%	0.15%
Total	13.3	100%	100%	100%

Based on 325 kg LW, DMI 7.4 kg/d. Predicted ADG (kg) 0.8 (± 5%).

Figure A9.12: Passion fruit skins are a byproduct of the fruit processing industry, and can be sourced for most of the year as an energy rich cattle feed. The table below gives the approximate feed value of passion fruit byproduct.

DM (%)	15
CP (%)	6.7
CF (%)	30
ME (MJ/kg)	11.5
Ca (%)	0.35
P (%)	0.13

Figure A9.13: Signal grass (*Brachiaria decumbens*) grown as a forage source for feedlot rations (see *Tropical grasses and legumes*, page 138, for feed values).

Ration B: Australian fattening feeders (375-425 kg LW).

Daily Ration/hd	As fed	Conc.Ingr.	As fed	Ration
Forage:	(kg)	(%)	(%)	(%DMI)
Signal grass	2.7		29%	28%
Concentrate:	[6.5]	(100%)→	[71%]	[72%]
Corn grain (cracked)	0.8	12%	9%	8.5%
Wheat pollard	0.8	12%	9%	8.5%
Palm kernel cake	4.5	69%	49%	50%
Molasses	0.25	4.0%	2.7%	2.2%
Urea	0.05	0.8%	0.50%	0.6%
Salt	0.03	0.45%	0.30%	0.40%
Limestone	0.10	1.5%	1.00%	1.20%
Premix	0.01	0.15%	0.10%	0.12%
Total	9.2	100%	100%	72%

Based on 375 kg LW, DMI 8.2 kg/d. Predicted ADG (kg) 1.0 (± 5%).

(Appendix A9 cont.) ***Rations for SE Asian feedlots:***

Table A9.13: More rations formulated for SEAsian feedlots.

INGEDIENTS / LW RANG	Ration A (Starter) <275 kg LW	Ration B (Grower) 275-415 kg LW	Ration C (Fattening) 315-420 kg LW	Ration D (Fattening) 275-425 kg LW	Ration E (Fattening) 325-425 kg LW	Ration F (Backgrounding) >230 kg LW
Roughage:						
Forage maize/Corn chop	15% (18%)	12% (11%)				
Elephant/Napier grass			56% (25%)			37% (15%)
Rice straw				20% (21%)		
Passion fruit (skins)					72% (29%)	
Energy Concentrate:						
Corn grain (cracked)					2.5% (6%)	1% (2%)
Corn millings	2% (8%)	3.5% (12%)				
Corn (extruded)				4.8% (5%)		
Wheat pollard	0.5% (2%)	1% (3%)		28% (28%)	5% (12%)	
Wheat bran	1.0% (5%)	2.2% (7.5%)				
Rice bran						11% (16%)
Tapioca waste/Onggok						31% (45%)
Sago rasps			18% (30%)			
Pineapple pulp	65% (37%)	51% (23%)				
Protein meals:						
Palm kernel cake (M)*	2% (7.5%)	3.3% (11%)	25% (44%)		20% (51%)	
Copra meal				32.4% (33%)		
Soy (full fat)				4.8% (5%)		
Soy waste	0.7% (3%)	1.2% (4%)				
Brewers spent grains	13% (13.5%)	24% (20%)				
Kapok seed meal						3% (5%)
Leaucana leaf meal						3% (5%)
Additives:						
Molasses	0.80% (3%)	1.60% (4.5%)		10% (8%)		11% (10%)
Urea	0.15% (0.7%)	0.24% (0.54%)	0.18% (0.35%)			1% (2%)
Limestone	0.31% (1.5%)	0.32% (1.2%)	0.71% (1.4%)		0.45% (1.25%)	
Salt	0.12% (0.6%)	0.11% (0.45%)	0.18% (0.35%)	0.18% (0.35%)	0.03% (0.25%)	
Premix	0.05% (0.25%)	0.13% (4%)			0.05% (0.13%)	
	100%	100%	100%	100%	100%	100%
* Mechanical extraction	Malaysia	Malaysia	Sago	Philippines	Malaysia	Indonesia

Table A9.14: Some feedlot words translated into Indonesian and Vietnamese.

English	Indonesian	Vietnamese
Water; Feeder cattle	Air; Sapi bakalan	Nước uống;
Beef cattle, Heifer, Bull	Sapi potong, Betina, Jantan	Thịt bò, Gia súc, Bò nam
Forage maize (75 days)	Jagung (75 hari)	Cây ngô (75 ngày)
Elephant grass	Rumput gaja	Cỏ voi
Sugarcane tops	Pucuk tebu	Lá cây/Đường mía
Rice bran, Wheat pollard	Dedak padi, Polard	Chất thải bột sắn
Tapioca waste	Onggok	Bánh cọ dầu, Bã dừa
Palm kernel cake, Copra	Bunkil sawit, Bunkil kelapa	Mật mía
Molasses, Urea	Tetes, Urea	Muối, đá vôi; Urê
Salt, limestone	Garam, kapur	Cám gạo, bụi hột lúa mì

Appendix A10: A simple spreadsheet program for ration formulation.

This Excel spread sheet enables feedlot rations to be formulated and evaluated against nutrient requirements (input from reference tables or from experience, or a combination of both); as well as estimated productivity and feed costs.

A data base of feed composition is linked to the formulation program that counts the total nutrients of the ration, based on DMI intake of the animal. The actual formulation input is guided by a basic knowledge of feed categories and their limits (see ***Ration formulation,*** page 75). The results can be analysed against predetermined nutrient requirements, percentage of ingredients in the concentrate mix, various feed costs parameters, and expected growth rate. As a spread sheet, it is easy to add, alter, delete, or recode parts of the program to suit the user. The following pages provide basic coding information to manually set up the spreadsheet on a computer.

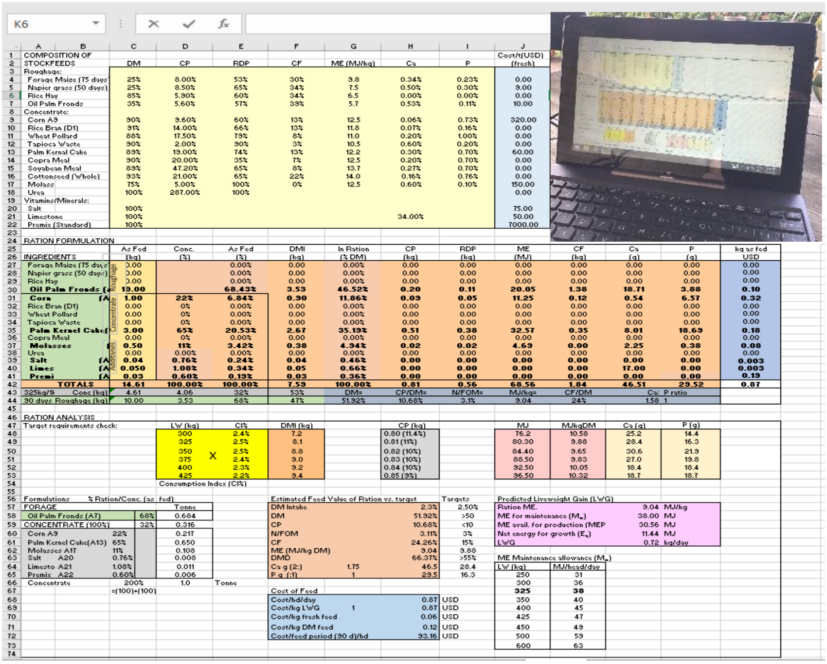
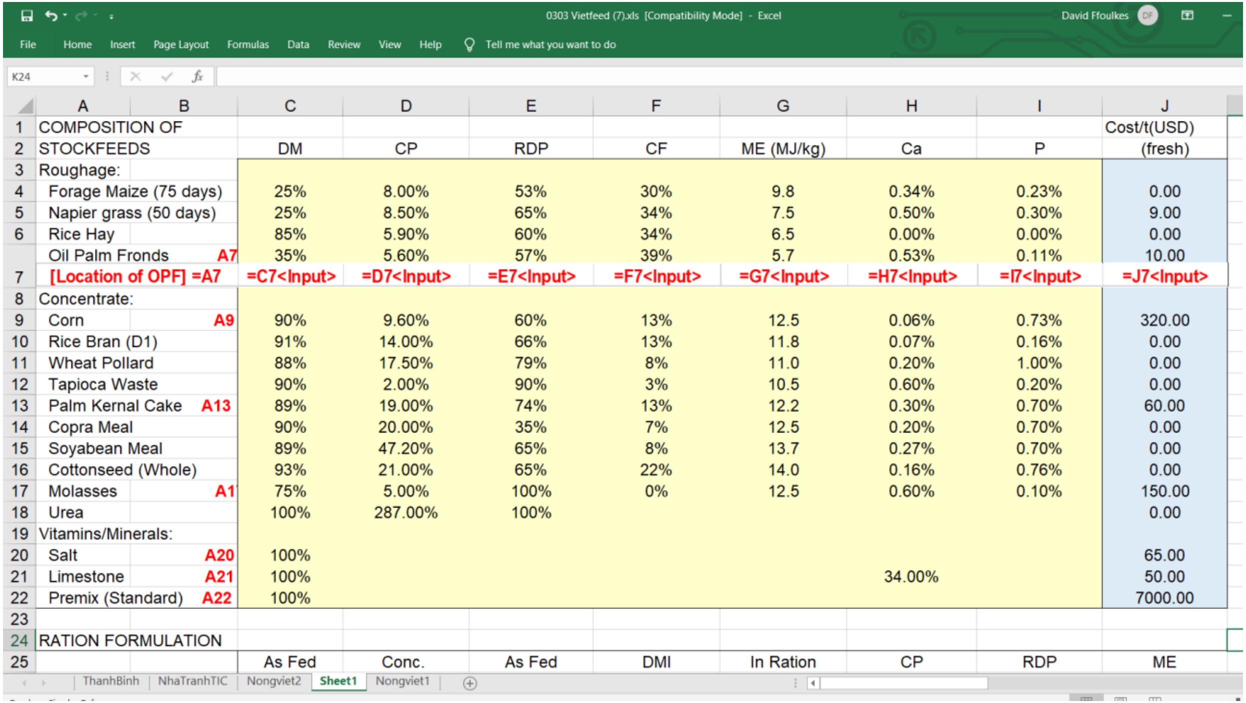
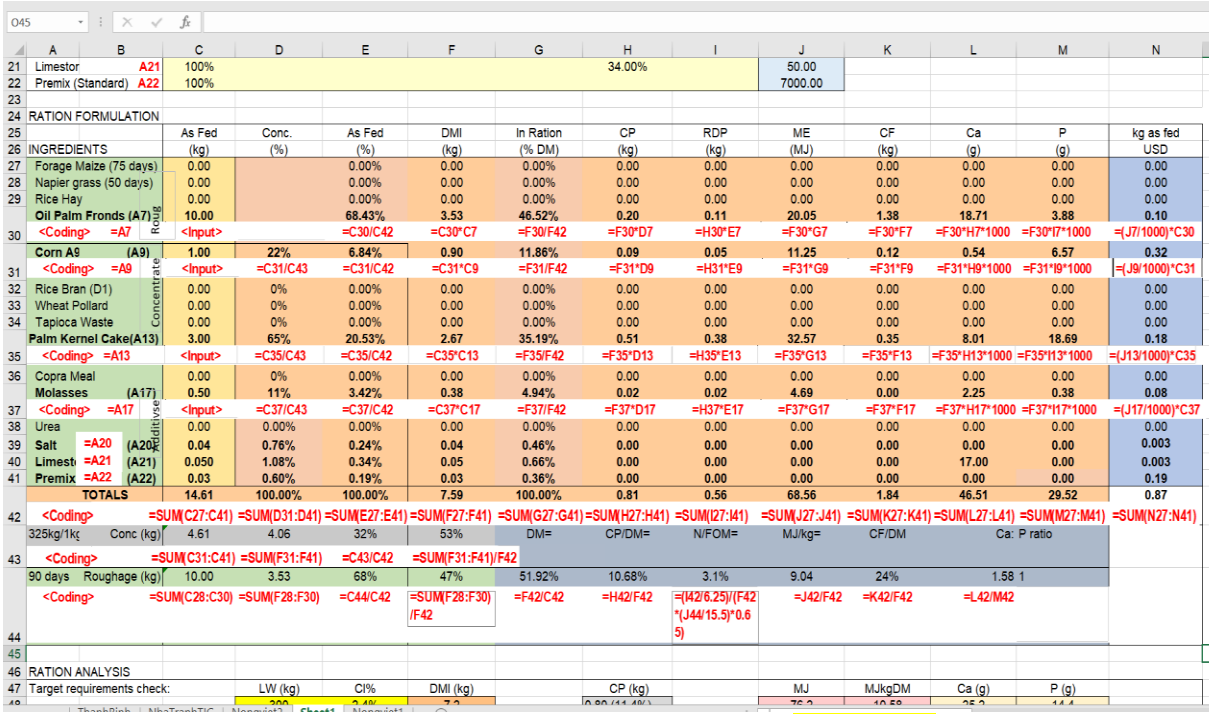


Figure A10.1: Ration formulation program using an Excel spreadsheet.



	A	B	C	D	E	F	G	H	I	J
1	COMPOSITION OF									Cost/t(USD)
2	STOCKFEEDS		DM	CP	RDP	CF	ME (MJ/kg)	Ca	P	(fresh)
3	Roughage:									
4	Forage Maize (75 days)		25%	8.00%	53%	30%	9.8	0.34%	0.23%	0.00
5	Napier grass (50 days)		25%	8.50%	65%	34%	7.5	0.50%	0.30%	9.00
6	Rice Hay		85%	5.90%	60%	34%	6.5	0.00%	0.00%	0.00
	Oil Palm Fronds	A7	35%	5.60%	57%	39%	5.7	0.53%	0.11%	10.00
7	[Location of OPF] =A7		=C7<Input>	=D7<Input>	=E7<Input>	=F7<Input>	=G7<Input>	=H7<Input>	=I7<Input>	=J7<Input>
8	Concentrate:									
9	Corn	A9	90%	9.60%	60%	13%	12.5	0.06%	0.73%	320.00
10	Rice Bran (D1)		91%	14.00%	66%	13%	11.8	0.07%	0.16%	0.00
11	Wheat Pollard		88%	17.50%	79%	8%	11.0	0.20%	1.00%	0.00
12	Tapioca Waste		90%	2.00%	90%	3%	10.5	0.60%	0.20%	0.00
13	Palm Kernal Cake	A13	89%	19.00%	74%	13%	12.2	0.30%	0.70%	60.00
14	Copra Meal		90%	20.00%	35%	7%	12.5	0.20%	0.70%	0.00
15	Soyabean Meal		89%	47.20%	65%	8%	13.7	0.27%	0.70%	0.00
16	Cottonseed (Whole)		93%	21.00%	65%	22%	14.0	0.16%	0.76%	0.00
17	Molasses	A1	75%	5.00%	100%	0%	12.5	0.60%	0.10%	150.00
18	Urea		100%	287.00%	100%					0.00
19	Vitamins/Minerals:									
20	Salt	A20	100%							65.00
21	Limestone	A21	100%					34.00%		50.00
22	Premix (Standard)	A22	100%							7000.00
23										
24	RATION FORMULATION									
25			As Fed	Conc.	As Fed	DMI	In Ration	CP	RDP	ME

Figure A10.2: Excel spreadsheet of feed composition data base for ration formulation. Coding (red) shows the input coordinates for oil palm fronds and its composition. The other ration ingredients in this example (i.e. A9, A13, A17, A20, A21, A22) each have their own coding according to their listed position.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
21	Limestor	A21	100%					34.00%		50.00				
22	Premix (Standard)	A22	100%							7000.00				
23														
24	RATION FORMULATION													
25			As Fed	Conc.	As Fed	DMI	In Ration	CP	RDP	ME	CF	Ca	P	kg as fed
26	INGREDIENTS		(kg)	(%)	(%)	(kg)	(% DM)	(kg)	(kg)	(MJ)	(kg)	(g)	(g)	USD
27	Forage Maize (75 days)		0.00		0.00%	0.00	0.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	Napier grass (50 days)		0.00		0.00%	0.00	0.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	Rice Hay		0.00		0.00%	0.00	0.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Oil Palm Fronds (A7)	Roug	10.00		68.43%	3.53	46.52%	0.20	0.11	20.05	1.38	18.71	3.88	0.10
30	<Coding> =A7		<Input>		=C30/C42	=C30*C7	=F30/F42	=F30*D7	=H30*E7	=F30*G7	=F30*F7	=F30*H7*1000	=F30*I7*1000	=(J7/1000)*C30
	Corn A9	(A9)	1.00	22%	6.84%	0.90	11.86%	0.09	0.05	11.25	0.12	0.54	6.57	0.32
31	<Coding> =A9	Concentrate	<Input>	=C31/C43	=C31/C42	=C31*C9	=F31/F42	=F31*D9	=H31*E9	=F31*G9	=F31*F9	=F31*H9*1000	=F31*I9*1000	=(J9/1000)*C31
32	Rice Bran (D1)		0.00	0%	0.00%	0.00	0.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	Wheat Pollard		0.00	0%	0.00%	0.00	0.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	Tapioca Waste		0.00	0%	0.00%	0.00	0.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Palm Kernel Cake(A13)		3.00	65%	20.53%	2.67	35.19%	0.51	0.38	32.57	0.35	8.01	18.69	0.18
35	<Coding> =A13		<Input>	=C35/C43	=C35/C42	=C35*C13	=F35/F42	=F35*D13	=H35*E13	=F35*G13	=F35*F13	=F35*H13*1000	=F35*I13*1000	=(J13/1000)*C35
36	Copra Meal		0.00	0%	0.00%	0.00	0.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Molasses	(A17)	0.50	11%	3.42%	0.38	4.94%	0.02	0.02	4.69	0.00	2.25	0.38	0.08
37	<Coding> =A17	Additives	<Input>	=C37/C43	=C37/C42	=C37*C17	=F37/F42	=F37*D17	=H37*E17	=F37*G17	=F37*F17	=F37*H17*1000	=F37*I17*1000	=(J17/1000)*C37
38	Urea		0.00	0.00%	0.00%	0.00	0.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	Salt =A20	(A20)	0.04	0.76%	0.24%	0.04	0.46%	0.00	0.00	0.00	0.00	0.00	0.00	0.003
40	Limest =A21	(A21)	0.050	1.08%	0.34%	0.05	0.66%	0.00	0.00	0.00	0.00	17.00	0.00	0.003
41	Premix =A22	(A22)	0.03	0.60%	0.19%	0.03	0.36%	0.00	0.00	0.00	0.00	0.00	0.00	0.19
	TOTALS		14.61	100.00%	100.00%	7.59	100.00%	0.81	0.56	68.56	1.84	46.51	29.52	0.87
42	<Coding>		=SUM(C27:C41)	=SUM(D31:D41)	=SUM(E27:E41)	=SUM(F27:F41)	=SUM(G27:G41)	=SUM(H27:H41)	=SUM(I27:I41)	=SUM(J27:J41)	=SUM(K27:K41)	=SUM(L27:L41)	=SUM(M27:M41)	=SUM(N27:N41)
	325kg/1kg	Conc (kg)	4.61	4.06	32%	53%	DM=	CP/DM=	N/FOM=	MJ/kg=	CF/DM	Ca: P ratio		
43	<Coding>		=SUM(C31:C41)	=SUM(F31:F41)	=C43/C42	=SUM(F31:F41)/F42								
	90 days	Roughage (kg)	10.00	3.53	68%	47%	51.92%	10.68%	3.1%	9.04	24%	1.58 1		
	<Coding>		=SUM(C28:C30)	=SUM(F28:F30)	=C44/C42	=SUM(F28:F30)/F42	=F42/C42	=H42/F42	=(I42/6.25)/(F42*(J44/15.5)*0.65)	=J42/F42	=K42/F42	=L42/M42		
44														
45														
46	RATION ANALYSIS													
47	Target requirements check:			LW (kg)	CI%	DMI (kg)		CP (kg)		MJ	MJkgDM	Ca (g)	P (g)	

Figure A10.3: Ration Formulation Frame: Input ration ingredients (as fed) in the yellow column according to guidelines (see Figure 3.9, page 75), while checking that total DM feed intake (DMI column) represents the calculated requirements according to LW (see Ration Analysis frame). Make adjustments to As Fed inputs until CP, ME, Ca, P etc., are close to target requirements in the Ration Analysis frame (Figure A10.4.)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	90 days	Roughage (kg)	10.00	3.53	68%	47%	51.92%	10.68%	3.1%	9.04	24%	1.58	1	
44	<Coding>		=SUM(C28:C30)	=SUM(F28:F30)	=C44/C42	=SUM(F28:F30)/F42	=F42/C42	=H42/F42	=(I42/6.25)/(F42*(J44/15.5)*0.65)	=J42/F42	=K42/F42	=L42/M42		
45														
46	RATION ANALYSIS													
47	Target requirements check:			LW (kg)	CI%	DMI (kg)		CP (kg)		MJ	MJkgDM	Ca (g)	P (g)	
48				300	2.4%	7.2		0.80 (11.4%)		76.2	10.58	25.2	14.4	
				325	2.5%	8.1		0.81 (11%)		80.30	9.88	28.4	16.3	
49			<Coding>	<Input>	<Input>	=D49*E49		<Input>		<Input>	=J49/F49	=(F49*1000)*(0.35%)	=(F49*1000)*(0.2%)	
50				350 X	2.5%	8.8		0.82 (10%)		84.40	9.65	30.6	21.9	
51				375	2.4%	9.0		0.83 (10%)		88.50	9.83	27.0	19.8	
52				400	2.3%	9.2		0.84 (10%)		92.50	10.05	18.4	18.4	
53				425	2.2%	9.4		0.85 (9%)		96.50	10.32	18.7	18.7	
54				Consumption Index (CI%)										
55														
56	Formulations	% Ration/Conc. (as fed)				Estimated Feed Value of Ration vs. target			Targets	Predicted Liveweight Gain (LWG)				
57	FORAGE			Tonne		DM Intake	<Coding>	=F42/D49 2.3%	2.50%	Ration ME.	<Coding> =J44	9.04 MJ/kg		
58	Oil Palm Fronds (A7)		68%	0.684		DM	<Coding>	=G44 51.92%	>50	ME for maintenance (M_m)	<Coding> =K67	38.00 MJ		
59	CONCENTRATE (100%)		32%	0.316		CP	<Coding>	=H44 10.68%	<10	ME avail. for production (MEP)	<Coding>	30.56 MJ =J42-L58		
60	Corn A9	22%		0.217		N/FOM	<Coding>	=I44 3.11%	3%	Net energy for growth (E_g)	<Coding>	11.44 MJ =(L59*(0.0435*L57))/1.05		
61	Palm Kernel Cake(A13)	65%		0.650		CF	<Coding>	=K44 24.26%	15%	LWG	<Coding>	0.72 kg/day		
62	Molasses A17	11%		0.108		ME (MJ/kg DM)	<Coding>=J44	9.04	9.88			=L60/(6.28+(0.3*L60)+(0.0188*D49))		
63	Salt A20	0.76%		0.008		DMD <Coding>	=(((H62+0.72)/0.147)/100)	66.37%	>55%	ME Maintenance allowance (M_m)				
64	Limestor A21	1.08%		0.011		Ca g (2:)	<Coding> 1.75 =G64 =L42	46.5	28.4	LW (kg)	MJ/head/day		Note: D49 is the	
65	Premix A22	0.60%		0.006		P g (:1)	<Coding> 1 =M42	29.5	16.3	250	31		325 kg LW used	
66	Concentrate		200%	1.0	Tonne					300	36		for this example.	
67			=(100)+(100)			Cost of Feed				325	38		Choose LW from	
68	<Coding>=A7		=E30	=C58*1		Cost/hd/day	<Coding> =N42	0.87	USD	350	40		D48-D53 (or input	
69	<Coding> CONC... (100)%		=100%-C58	=C59*1		Cost/kg LWG	<Coding> <Input>1 =N42/1	0.87	USD	400	45		manually), accord-	
70	<Coding>=A9		=E31	=C60*1		Cost/kg fresh feed	<Coding> =N42/C42	0.06	USD	425	47		ing to DMI target	
71	<Coding>=A13		=E35	=C61*1		Cost/kg DM feed	<Coding> =H70/G44	0.12	USD	450	49		used for the form-	
72	<Coding>=A17		=E37	=C62*1		Cost/feed period (90 d)/hd	<Coding>	93.16	USD	500	59		ulation.	
73	[Similar coding for A20, A21, A22 etc.]						=(((325+425)/2)*E51)*90)*H71			600	63			
74	<Coding> Concentrate		=SUM(C58:C65)	=SUM(D60:D65)										

Figure A10.4: Ration analysis frame; 1st line of boxes include predetermined target nutrient requirements according to input data (i.e. 325 kg LW x 2.5% CI). 2nd line of boxes summarises the ration formulation, compares feed values against targets, and predicts LW gain based on enargy available for growth from ration ME intake by the animal (for guidance only) [87]. The 'cost of feed' box provides a range of parameters. The estimation of total feed cost per head is based on the mid-way point of the feeding period in terms of LW (e.g. 325 kg (start) + 425 kg (finish))/2 =375 kg LW), and estimated daily feed intake (DM basis) and cost, multiplied by feeding period of 90 days.

Appendix A11: More examples of budget projections.

Table A11.1: Budget sheet for feedlotting a batch of feeders in SE Asia.

BUDGET PROJECTION FOR:		**Feedlot of 500 head Australian commercial cattle.**							
Sales	Input		Output						Per head
Turnoff weight	430	kg LW traded at		$3.25	/kg LW			Sales	$1,397.50
			Break-even	$2.90	/kg LW				
Purchases									
Average weight	320	kg LW at	$2.75						$880.00
Production costs									
Average LW gain	1.1	kg LW/day							
Feeding period	100	days							
Total LW gain	110	kg			FEED COSTS				
Mid-way point:	50	days							
LW	375	kg	B.						
Daily intake (2.5%LW)	9.38	kg DM	kg As fed		Cost/t	$ As fed			
A. Forage (30%DMI)	2.813	kg DMI	11.25	at	$25	$0.28			
Energy feed (38.5%DMI)	3.609	kg DMI	4.01	at	$250	$1.00			
Protein meal (28%DMI)	2.625	kg DMI	3.09	at	$305	$0.94			
Additives (3.5%DMI)	0.092	kg DMI	0.12	at	$1,000	$0.12			
		Total	18.47	kg/hd/day		$2.35	/hd/day		
						Total feed cost/head			$234.83
Labour									$30.00
Vet, treaments (tag, injections, lice)									$15.00
Losses (2%)									$18.00
Utilites									$2.50
Interest on purchase and operational costs ($500/head @ 5.5%)									$16.80
Commission (e.g. industry levy) 3% of sales.									$42.00
Transport									$10.00
								Costs	$1,249.13
A. i.e. 30% (DMI) x 9.38 kg DM								Profit	$148.37
B. Look up a feed's DM% (see page 76) for equation;								Returns	12%
i.e. DMI forage ÷ 25% (Maize forage DM)								B/C $1:	$1.12

Note: The beak-even value of the finished cattle is (Costs/Turnoff wt. =) $2.90 kg/LW, or 35c more than purchase price. For every cent increased above break-even price per kg LW is $4.30 profit. In this case the trade price generated a $148 profit per head and 12% return. Sales of 490 head would return about $73,500.

(Appendix A11: cont.)

Table A11.2: Example of budget projections for a smallholder feedlot receiving 25 imported Australian Brahman cross feeders as part of a local government initiative. Sales incuded composted bags of manure.

	UNITS					UNIT COST		TOTAL COST
SALES (A)								
Cattle	25	head	@	425	kg LW	MYR 8.50	/kg LW	MYR 90,312.50
Compost	200	bags	@	50	kg/bag	MYR 85.00	/bag	MYR 17,000.00
							TOTAL	MYR 107,312.50
PURCHASE (B)								
Weaners	25	head	@	250	kg LW	MYR 6.02	/kg LW	MYR 37,640.63
						USD 1.65		
OPERATIONAL (C)								
Import Costs for	25	head	@			MYR 50.00	/unit	MYR 1,250.00
Transport for	25	head	@			MYR 35.00	/unit	MYR 875.00
Drugs for	25	head	@			MYR 10.00	/unit	MYR 250.00
Feed Costs (Backgrounding) - 150 days @ ADG=0.6 kg:								
Napier	110	MT	@			MYR 250.00	/MT	MYR 27,500.00
PKC	2	MT	@			MYR 450.00	/MT	MYR 900.00
Molasses	1	MT	@			MYR 550.00	/MT	MYR 550.00
Feed Costs (Finishing) - 90 days @ ADG=1.0 kg:								
Napier	27	MT	@			MYR 250.00	/MT	MYR 6,750.00
Molasses	2.3	MT	@			MYR 550.00	/MT	MYR 1,265.00
Concentrate	13.5	MT	@			MYR 500.00	/MT	MYR 6,750.00
Wages	1	men	@	225	days	MYR 25.00	/man days	MYR 5,625.00
Utilities (water/electricity/fuel)				225	days	MYR 7.50	/day	MYR 1,687.50
Credit Cost for	250	days	@	7.5%	Interest	MYR 37,640.63	loan	MYR 1,933.59
							Total	MYR 55,336.09
							Profit	MYR 14,335.78
							Returns	15%

Appendix A12: Examples of company tailored SOPs (*Source:* Author)

1. ***Disembarkation:*** Transport cattle from ship to ranch safely and with minimum stress to stock.

- All necessary documentation is prepared prior to arrival and relevant authorities are contacted about arrangements for the arrival of the ship and disembarkation of cattle.
- Arrangements are made with suitable transport company to provide sufficient trucks for transporting cattle and drivers are briefed on best practice for handling and transporting livestock.
- Inform the Harbourmaster about requirements for disembarkation, including restricting access to quay for unauthorised personnel.
- Ensure that cattle waiting to be unloaded have access to feed and water. Consider unloading ship's rations (cubes) immediately (i.e. before cattle) for consumption by cattle on arrival at feedlot.
- Ensure that receival yards have chopped grass or cubes (from ship) in feed troughs and clean water prior to arrival of cattle.
- Separate sick or injured cattle into a hospital pen.
- Quarantine new arrivals in the receival yards for 14 days (or as required by Quarantine authority) for disease observation and rest prior to processing.
- Ensure that all animals have continuous access to good quality roughage such as chopped Napier grass and concentrate feed and cool clean water.
- Pregnancy Tested In-Calf (PTIC) breeder cattle should be observed for signs of calving and removed to a calving pen when the udder is full and vulva has swelled and exudes mucus.

Prosedur Operasi Standar untuk Program Pembiakan Sapi.

1. ***Disembarkasi*****:** Angkut sapi dari kapal ke ranch dengan aman dan dengan stres seminimal mungkin untuk ternak.

- Semua dokumen yang diperlukan sudah dipersiapkan sebelum kedatangan ternak dan otoritas yang bersangkutan telah dihubungi untuk persiapan-persiapan kedatangan kapal dan disembarkasi:
- Persiapan dilakukan dengan perusahaan angkutan yang tepat yang dapat menyediakan cukup truk untuk mengangkut sapi. Sopir diberi informasi mengenai praktek terbaik dalam menangani dan mengangkut ternak.
- Informasikan Kepala Pelabuhan mengenai kebutuhan-kebutuhan untuk disembarkasi, termasuk akses terbatas ke dermaga/ pangkalan bagi personel yang tidak berwenang.
- Pastikan agar sapi yang sedang menunggu untuk diturunkan mendapat akses makanan dan air. Pertimbangkan untuk membongkar ration kapal (cubes) secepatnya (mis. sebelum sapi) untuk konsumsi sapi ketika tiba di feedlot.
- Pastikan agar di dalam bak pakan di kandang penerima terdapat potongan rumput atau cubes (dari kapal) dan air bersih sebelum sapi tiba.
- Pisahkan sapi yang sakit atau luka ke dalam kandang penyembuhan (*hospital pen*).
- Ternak yang baru tiba di kandang penerima dikarantina selama 14 hari (atau sebagaimana disyaratkan oleh Otoritas Karantina) untuk observasi penyakit dan istirahat sebelum diproses.
- Pastikan agar semua ternak secara terus menerus mendapat akses pakan berserat berkualitas baik seperti potongan rumput Napier (Gajah), pakan konsentrat dan air bersih.
- Betina Bunting Teruji/Pregnancy Tested In-Calf (PTIC) Heifer harus diobservasi untuk tanda-tanda melahirkan dan dipindah ke kandang tempat melahirkan ketika ambing/dada penuh dan vulva telah membengkak dan merembeskan lendir (exudes mucus).

2. *Cow / Calf Operations (Intensive):* Managing the reproductive process from parturition to conception in yards.

- Pregnant breeders near to calving are held in a sheltered calving stall or yard with at least $9m^2$ per cow and calf.
- Rations consisting of roughage and concentrate feed (Reconditioning Ration) are fed twice daily and night feed of good quality of rice hay is also provided.
- Cows should have continuous access to cool clean water.
- Ensure that newly born calves receive colostrum from its dam.
- Ensure the yards are kept clean on a daily basis.
- Calves should have access to roughage by 3 weeks of age to help development of digestive tract. A high protein creep feed (Calf Ration) (accessed by calf only) can also be provided after 3-4 weeks.
- Ensure that calves also have access to cool clean water. Check side of water trough is not too high for calf to reach the water.
- Wean calf at 3-4 months and move to weaner pen; feed roughage and Starter and ensure cool clean water is continuously accessible.
- Move the calf's mother to the mating pen with one bull to 20-25 cows.
- Continue to feed Reconditioning ration.
- Weigh and pregnancy test cows monthly and move pregnant cows to holding yards.
- Change bulls every 3 months.

3. *Cow / Calf Operations (Semi-intensive):* Managing the reproductive process in paddocks with calf weaning and pre-mating supplementation in yards.

2. *Kegiatan Induk/Anak Sapi (Intensif):* Mengelola proses reproduksi dari kehamilan sampai kelahiran di kandang.

- Induk bunting yang mendekati saat melahirkan ditaruh di kandang melahirkan atau kandang terlindung dengan padatnya paling sedikit $9m^2$ per betina dan anak.
- Ransum yang terdiri dari pakan hijaun dan konsentrat (Ransum Rekondisi) diberikan dua kali sehari dan juga disediakan makanan malam yang terdiri dari jerami padi berkualitas baik.
- Induk harus terus menerus mendapat akses air bersih.
- Pastikan agar anak sapi yang baru lahir mendapat kolostrum dari induknya.
- Pastikan kandang dalam keadaan bersih setiap hari.
- Anak sapi harus mendapat akses pakan berserat ketika berusia 3 minggu untuk menolong perkembangan saluran pencernakan. Sesudah 3-4 minggu juga dapat disediakan pakan protein tinggi (Ransum Pedek/Creep Feed) (hanya dapat diakses oleh anak sapi).
- Pastikan agar anak sapi juga mendapat akses air bersih. Periksa agar sisi bak air tidak terlalu tinggi sehingga anak sapi dapat menjangkau air.
- Anak sapi disapih ketika berusia 3-4 bulan dan pindahkan ke kandang penyapihan; beri pakan hijauan dan Starter dan pastikan agar akses air bersih selalu tersedia.
- Pindahkan induk anak sapi ke kandang kawin dengan satu jantan untuk 20-25 betina.
- Teruskan memberi makan ransum Rekondisi.
- Timbang dan tes kebuntingan induk setiap bulan dan pindahkan induk bunting ke kandang terpisah.
- Ganti pejantan setiap 3 bulan.

3. *Kegiatan Induk/Anak Sapi (secara semi-intensif):* Mengelola proses reproduksi sapi induk di paddock dengan suplemen pra kawin, dan menyapihkan anak di kandang.

- Pregnant breeders and bulls are run together on pasture.
- The herd is yarded every 3 months and cows in their 3rd term of pregnancy are moved to a calving paddock.
- Cows in the calving paddock receive supplementary feed (Reconditioning ration)) and are closely managed.
- Calves are weaned at 3-4 months of age and moved to weaner pens in the feedlot.
- The calf's mother is moved to the paddock with one bull and 20-25 cows for mating.
- Weigh and pregnancy test cows monthly
- Change bull every 3 months.

4. *Heifer management:* Maximise reproductive capacity of 1st and 2nd calf heifers.

- Segregate heifers and males weaners into separate pens when they reach 170 kg LW.
- Grow out heifers until they reach 300 kg LW and move into heifer mating pens with a young bull (less than 500 kg LW) and 20-25 x 1st calf heifers and 2nd mating cows.
- Feed both heifers and bulls Finisher rations.
- Weigh and pregnancy test heifers monthly and move pregnant heifers into the paddock.
- Change bull every 3 months.

5. *Records:* Good records allow accurate selection and culling of breeder stock to improve reproduction efficiency and herd performance.

- All cows and bulls should be permanently identified by a number (eartag).
- Record birth dates and cow number. Actual birth weights can be substituted by an observed scoring system: Light, Medium or Heavy.

- Induk bunting dan pejantan dilepas bersama-sama di ladang pengembalaan.
- Kelompok dikandangkan setiap 3 bulan dan induk sapi yang bunting term ke-3 dipindah ke paddock tempat melahirkan.
- Induk di paddock tempat melahirkan mendapat pakan suplemen (ransum Rekondisi) dan diperlakukan dengan ketelitian.
- Anak sapi disapih pada usia 3-4 bulan dan dipindah ke kandang penyapihan di feedlot.
- Induk anak sapi dipindah ke paddock untuk kawin dengan satu jantan dan 20-25 induk sapi.
- Timbang dan tes kebuntingan induk setiap bulan
- Ganti pejantan setiap 3 bulan.

4. *Manajemen heifer:* Maksimalkan kapasitas reproduksi heifer sesudah kelahiran pertama dan kedua.

- Pisahkan weaner heifer dan jantan dalam kandang-kandang terpisah ketika mereka mencapai 170 kg LW.
- Besarkan heifer sampai mereka mencapai 300 kg LW dan pindahkan ke dalam kandang kawin heifer dengan satu pejantan muda (kurang dari 500 kg LW) dan 20-25 heifer (kawin ke-1 dan ke-2).
- Heifer dan pejantan diberi Finisher ration.
- Timbang dan tes kebuntingan heifer setiap bulan dan pindah heifer bunting ke paddock.
- Ganti pejantan setiap 3 bulan.

5. *Records:* Record atau catatan yang baik akan menghasilkan informasi atas seleksi dan penyisihan ternak yang akurat untuk meningkatkan efisiensi reproduksi dan kinerja produksi kelompok pembibitan sapi.

- Semua sapi induk dan pejantan harus diidentifikasi secara permanen dengan nomor (*eartag*).
- Catat tanggal lahir anak dan nomor induk.
- Berat lahir pedet sebenarnya dapat diganti dengan sistem observasi skor, misalnya: Ringan, Sedang, atau Berat.

- At weaning, record live weight (LW), body condition score (BCS) of males/female weaners and scrotal circumference (SC) of young males.
- Calculate the pre-weaning average daily gains (ADG) in kg/day of all weaners.
- At weaning, record LW and BCS of cows.
- Maintain a birth record history of each breeder using a card system or computer program like Excel or other software.

6. *Selection and Culling:* Replacement of breeders and bulls that are no longer productive. General criteria for culling cows are as follows:

- Age limit (e.g. 10 years)
- Failure to breed or long calving interval.
- Failure to raise a calf.
- Abnormal characteristics (e.g. temperament, physical defects, disease, eye problems, udder malformation, prolapse etc).

General criteria for selecting bulls are as follows:

- Bulls should be unrelated to breeders.
- 3-5 years of age with sound body structure.
- High grade breed (e.g. 75% or more Brahman crossbred preferably sourced from similar climate).
- Good testicular size with a circumference of 30 cm or more.
- Normal penis/sheath structure.
- Meets fertility standards (sperm count and viability, libido).
- High growth rate potential (from performance records).

- Pada saat menyapih, catat bobot hidup (live weight; LW), skor kondisi badan (body condition score; BCS) dari sapi jantan/betina dan ukuran keliling kantung testis (scrotal circumference; SC) sapi jantan muda.
- Hitung anka rata petumbuhan harian (ADG) pra-penyapihan dalam kg/day dari setiap anak penyapih.
- Pada saat menyapih, catat LW dan BCS dari induknya.
- Simpan catatan sejarah kelahiran pedet dari masing-masing sapi induk dengan menggunakan sistem kartu atau program computer, misalnya Excel atau software lainnya.

6. *Seleksi dan Penyisihan:* Penggantian induk dan pejantan yang tidak produktif lagi. Kriteria umum untuk penyisihan induk adalah sebagai berikut:

- Batasan umur (mis. 10 tahun)
- Kegagalan untuk berkembang biak atau *calving interval* panjang.
- Kegagalan untuk membesarkan/menjaga anak
- Karakteristik abnormal (mis. temperamen, cacat fisik, penyakit, problem mata, malformasi/cacat ambing, prolapse dll).

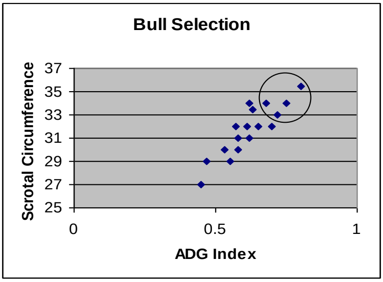
Kriteria umum untuk seleksi pejantan adalah sebagai berikut:

- Berusia 3-5 tahun dengan struktur badan yang baik
- Ras mutu tinggi (mis. 75% atau lebih kawin silang Brahman, lebih disukai yang berasal dari iklim serupa)
- Ukuran kantung testis yang baik dengan ukuran keliling 30 cm atau lebih.
- Struktur penis/kelopak normal
- Memenuhi standar fertilitas (hitungan sperma dan viabilitas, libido).
- Potensi tingkat pertumbuhan yang tinggi (dari catatan kinerja).

7. *Monitor Kinerja Pejantan*: Pantau kinerja jantan muda sebagai calon pengganti pejantan dalam kelompok sapi (*herd bull*), khususnya,

7. *Bull Performance Monitoring:* Monitor the performance of young bulls as candidates for herd bull replacements, particularly progeny of heifers recently shipped from Australia as a source of new genetic material.

- Record LW, BCS, and SC of the young males at 12 months after weaning and cull any males (i.e. send to feedlot for fattening) with abnormal testicles such as uneven, hard, unduly bifurcated testicles or single testicle etc.
- Calculate the post-weaning average daily gain (ADG) in kg/day.
- Calculate an ADG index:
  = [ADG (pre-weaning) + (3 x (ADG (post-weaning))]/4
  Example:
  = [0.6 kg + (3 x 0.8 kg =) 2.4 kg]/4
  = 3.0/4
  = 0.75
- Sort the bulls in descending order of values for ADG Index together with SC.
- Make a graph of ADG Index (x-axis) vs SC (y-axis) and label each point with identification number (ID) of bull.
- Select those bulls with the highest ADG Index and highest SC (preferable > 33 cm) (see example in graph below)



- In addition, the above selected bulls must be physically normal, well-muscled, and good temperament.

progeny/keturunan dari betina bunting yang baru dikirim dari Australia, sebagai sumber materi genetik baru.

- Catat LW, BCS, dan SC dari sapi jantan muda pada 12 bulan setelah disapih dan afkir jantan apa saja yang punya testis ganjil, misalnya tidak rata, kaku/keras, *bifurcated* berlebihan atau satu testis saja (misalnya, kirim ke feedlot untuk digemukkan).
- Hitung ADG selama 12 bulan pasca-penyapihan dalam *kg/day*.
- Hitung Indeks ADG:
  = [ADG (pra-penyapihan) + 3 x (ADG (pasca-penyapihan))]/4
  Misalnya:
  = [0.6 kg + (3 x 0.8 kg =) 2.4 kg]/4
  = 3.0/4
  = 0.75
- Sortir pejantan dengan nilai urutan yang tata terun menurun untuk Indeks ADG bersama dengan nilai SC.
- Buat grafik Indeks ADG (x-axis) vs ukuran SC (y-axis) dan label setiap titik dengan nomor identifikasi (ID) pejantan.
- Pilih pejantan dengan Indeks ADG dan SC tertinggi (SC > 33 cm lebih disulkai) (lihat contoh grafik dibawah).
- Sebagai tambahan, pejantan pilihan di atas harus normal secara fisik, otot baik, dan temperamen baik.
- Hanya bandingkan 10-20% yang terbaik dari masing-masing kelompok sapih yang lahir dengan perbedaan 2-3 bulan satu sama lainnya.
- Juga lebih baik jika jantan muda diberi pakan berdasar ransum hijauan yang ditambah suplemen 1-2 kg konsentrat di tempat feedlot selama 12 bulan masa perbandingan.

8. *Manajemen Penggembalaan:* Maksimalkan pertumbuhan padang rumput untuk menurunkan biaya operasi.

- Perlu segera dilaksanakan evaluasi daya tampung ternak (stocking rate), satu ekor sapi per maksimal, 3ha rumput efektif yang tersedia. Sisa ternak diberi makanan feedlot, disisihkan atau dijual.

- Only compare the best 10-20% of each weaner group of animals born within 2-3 months of each other. It is also better if the young bulls are fed on a roughage based diet supplemented with 1-2 kg concentrate in the feedlot during the 12 month comparison.

8. *Grazing Management:* Maximise the growth of pasture to reduce operational costs.

- Immediate need to implement stocking rate of 1 head/3 ha maximum of effective pasture available. Balance of stock to be feedlot fed, culled or sold.
- Set up rotational grazing system of 1 month grazing / 2 months rest with 3 paddocks (i.e. only 1 in 3 paddocks is stocked at any one time, with other 2 paddocks rested for 2 months).
- Observe cattle condition and pasture height and move cattle sooner if it is observed that pasture availability is low or cattle are in poor body condition. Individual animals in poor condition can be drafted off and taken to feedlot (with calf) for special attention.
- Increase paddock subdivision if grazing is not even, by fencing smaller areas or increasing group size and rotating paddocks more frequently.
- Aim for target growth rate of calves of 0.6 kg/day minimum and maintenance of body condition in cows while lactating.
- Fertilize paddocks on a yearly basis to maintain production of forage.
- Rehabilitate the cut-and-carry pasture with improved pasture (such as *Brachiaria decumbens* (Signal grass), *Digitaria milanjiana* (Jarra grass), mixed with Stylo legumes). This will provide better quality and higher quantities of harvested forage for feedlot rations.
- Fertilize the harvested paddocks after each cut.

- Bangun sistim merumput secara rotasi. Untuk 3 paddock satu bulan merumput/2 bulan istirahat (mis. hanya 1 paddock dari 3 yang digunakan selama satu bulan, baru pindah ke paddock lainnya, dan selanjutnya).
- Pantau kondisi sapi dan ketinggian rumput. Segera pindahkan sapi jika terlihat persediaan rumput rendah dan badan sapi dalam kondisi buruk. Setiap ekor sapi yang berkondisi buruk dapat di*drafted off* dan dibawa ke feedlot (bersama anak kalau ada) untuk mendapatkan perhatian khusus.
- Tingkatkan subdivisi paddock jika sapi merumput tidak merata dengan cara memagar area yang lebih kecil atau meningkatkan ukuran kelompok dan dengan lebih sering merotasi paddock.
- Bidik target tingkat pertumbuhan anak sapi paling sedikit 0.6kg/hari dan jaga kondisi tubuh induk selama menyusui.
- Pupuk paddock yang ditanam *improved pasture* setiap tahun untuk memelihara produksi rumput.
- Rehabilitasi rumput yang di-*cut-and carry* dengan rumput jenis *improved pasture* (seperti *Brachiaria decumbens* (Signal), *Digitaria milanjiana* (Jarra), dicampur dengan legume Stylo). Tindakan ini akan menghasilkan kualitas rumput yang lebih baik dan jumlah hijauan yang dipanen untuk ration feedlot akan lebih banyak.
- Pupuk paddock setiap kali selesai memanen.

9. *Suplementasi di paddock*: Pastikan agar tingkat pertumbuhan sapi dimaksimalkan dengan cara memberi suplemen mineral.

- Menyediakan suplemen yang mengandung phosphorus (apakah berbentuk blok untuk dijilat atau mineral lepas untuk dijilat ditempat teduh) yang beri sebanyak 25 g/ekor per hari.
- Ambil sampel yang mewakili rumput dan tanah (kedalaman 10 cm) untuk analisa phosphorus (P). Jika P kurang dari 15 ppm dalam tanah dan 0.2 dalam daun maka perlu diberikan suplemen P dan mineral lain yang ditemukan berkekur-angan.
- Contoh suplemen P: Campur rock phosphate atau dicalcium phosphate dengan garam.

9. *Supplementation in the paddocks:* Ensure that cattle growth rates are maximised by providing supplementary phosphorus (either as lick block or loose mineral lick under shelter) at a rate of 25 g/head daily.

- Provide mineral supplement in the paddock to some growing / lactating cattle group and monitor for 2 years. Move supplement with herd rotation.
- Take representative samples of pasture and of soil (down to 10 cm depth) for analysis of phosphorus (P). If P is less than 15 ppm in soil and 0.2 in leaf, then it is necessary to provide supplementary P, together with other minerals found to be deficient.
- Examples of P supplementation; mix rock phosphate or dicalcium phosphate with salt.

10. *Weed Management:* Maximise pasture growth potential by minimising the competitive effect of weed invasion.

- Implement a weed management plan to remove all weed seeding plants from all paddocks within the next 12 months.
- Each paddock should be weeded every 3 monthly or more frequently to ensure seed production is stopped entirely for the future
- Replant paddocks that have suitable arable soils with improved fertilized pasture species (e.g. Signal or Jarra and Stylo).
- Weed management will need to use all necessary management options (physical removal, chemical control, slash and burn etc.) to allow for a systematic approach to eradication.
- Plants carrying seed must be removed to a quarantine area for destruction by fire or deep burial.
- This material needs to be carefully removed on the same day as cut down to avoid seed falling and spreading to unaffected areas.
- Ranch staff should treat weeds as their greatest enemy that need to be eliminated at all costs. Hand pulling of weeds when first seen can have a significant impact on getting rid of the weed problem in the paddocks.

10. *Manajemen Gulma:*
Maksimalkan potensi pertumbuhan rumput dengan meminimalkan efek bersaing invasi gulma.

- Laksanakan rencana manajemen gulma dengan cara menyingkirkan semua tanaman gulma dari paddock dalam waktu 12 bulan ke depan.
- Masing-masing paddock harus dibersihkan dari gulma setiap 3 bulan atau lebih sering untuk memastikan produksi biji dapat betul-betul hilang di kemudian hari.
- Tanam kembali paddock yang mempunyai jenis tanah yang cocok dengan spesies rumput yang baik dan subur (mis. rumput Signal atau Jarra dan legume Stylo).
- Manajemen gulma perlu memakai semua opsi penting manajemen (penyingkiran gulma secara fisik, kontrol dengan zat kimia, babat dan bakar dll.) untuk memberikan pendekatan yang sistimatik terhadap eradikasi.
- Tanaman gulma mengandung biji harus disingkirkan ke area karantina untuk dimusnahkan dengan cara dibakar atau dikubur dalam-dalam.
- Gulma tersebut harus disingkirkan dengan hati-hati pada hari yang sama ketika mereka dipotong untuk menghindari jatuhnya biji yang dapat menyebar ke area yang belum tercemar.
- Staf di ranch harus memperlakukan gulma sebagai musuh terbesar yang perlu diberantas dengan cara apapun.
- Mencabut gulma dengan tangan ketika pertama kali terlihat dapat memberikan dampak berarti untuk menghilangkan problem gulma di paddock.

Appendix A13: Logistics of transporting cattle from ship to feedlot.

Table A13.1: Working out number of trucks and timing required for moving cattle from ship to feedlot.

Truck No.	Start time	Loading	Journey	Unloading	Return	ETA return
Truck 1	7.00 AM	15 min.	3 hours	30 min.	2 h 30 min.	1.15 PM
Truck 2	7.15 AM	15 min.	3 hours	30 min.	2 h 30 min.	1.30 PM
Truck 3	7.30 AM	15 min.	3 hours	30 min.	2 h 30 min.	1.45 PM
Truck 4	7.45 AM	15 min.	3 hours	30 min.	2 h 30 min.	2.00 PM
Truck 5	8.00 AM	15 min.	3 hours	30 min.	2 h 30 min.	2.15 PM
Truck 6	8.15 AM	15 min.	3 hours	30 min.	2 h 30 min.	2.30 PM
Truck 7	8.30 AM	15 min.	3 hours	30 min.	2 h 30 min.	2.45 PM
Truck 8	8.45 AM	15 min.	3 hours	30 min.	2 h 30 min.	3.00 PM
Truck 9	9.00 AM	15 min.	3 hours	30 min.	2 h 30 min.	3.15 PM
Truck 10	9.15 AM	15 min.	3 hours	30 min.	2 h 30 min.	3.30 PM
Truck 11	9.30 AM	15 min.	3 hours	30 min.	2 h 30 min.	3.45 PM
Truck 12	9.45 AM	15 min.	3 hours	30 min.	2 h 30 min.	4.00 PM
Truck 13	10.00 AM	15 min.	3 hours	30 min.	2 h 30 min.	4.15 PM
Truck 14	10.15 AM	15 min.	3 hours	30 min.	2 h 30 min.	4.30 PM
Truck 15	10.30 AM	15 min.	3 hours	30 min.	2 h 30 min.	4.45 PM
Truck 16	10.45 AM	15 min.	3 hours	30 min.	2 h 30 min.	5.00 PM
Truck 17	11.00 AM	15 min.	3 hours	30 min.	2 h 30 min.	5.15 PM
Truck 18	11.15 AM	15 min.	3 hours	30 min.	2 h 30 min.	5.30 PM
Truck 19	11.30 AM	15 min.	3 hours	30 min.	2 h 30 min.	5 45 PM
Truck 20	11.45 AM	15 min.	3 hours	30 min.	2 h 30 min.	6.00 PM
Truck 21	12.00 AM	15 min.	3 hours	30 min.	2 h 30 min.	6.15 PM
Truck 22	12.15 AM	15 min.	3 hours	30 min.	2 h 30 min.	6.30 PM
Truck 23	12.30 AM	15 min.	3 hours	30 min.	2 h 30 min.	6.45 PM
Truck 24	12.45 AM	15 min.	3 hours	30 min.	2 h 30 min.	7.00 PM
Truck 25	1.00 PM	15 min.	3 hours	30 min.	2 h 30 min.	7.15 PM
	6 hours					6 hours
Calculations:						

1. Estimated loading time at port:	**15 min.**
2. Estimated truck return time (i.e. port to feedlot return)	**6 h 15 min**
3. Number of trucks required (i.e. 1 truck every 15 min = 4 trucks/hour):	**25 trucks**
4. Average LW of cattle class; all feeders	**325 kg**
5. Truck loading density for feeders (see Infobox 4.1, page 204)	**32 hd**
6. Total head transported by 25 trucks (25 x 32 hd=) in 1 cycle (6 h)	**800 hd**
7. Total head to be discharged from ship	**2000 h**
8. Number of cycles (25 trucks/6 h = 800 hd); (2000/800 hd =)	**2.5 (15 h)**
9. Estimated total discharge time (6 h x 2.5 cycles)	**15 hours**

Note: It is advisable to have an extra truck available in case of a breakdown.

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Figures

Photo sources: Photos not belonging to the author or his associates have mainly been sourced from the Wikimedia Creative Commons (CC) collection, unless cited otherwise.

Tables

Infobox

Notes:

8. Measurements and conversions:

Water flow rates into drinking troughs: The outflow rate of reticulated water into drinking troughs is determined by water pressure, length of pipe line, pipe diameter, and friction. Gravity fed water pressure depends on the height of the water supply tank above the trough (e.g. 10 m), called the water head. If the water pump that fills the above supply tank is positioned at the same level as the water trough (i.e. same water head of 10 m (100 kPa[49])), it needs to be able to pump against the water head pressure (called the pump head), plus a desired flow rate, and also take into account pipe friction (i.e. 10% loss of head for PVC piping). This means that a water head of 10 m reduces to 9 m (i.e. less pressure), and a 10 m pump head needs more pressure for the water to reach the equivalent of an 11 m head (110 kPa). See Table 8.1 for examples of flow rates (accounting for friction) for different water trough locations.

Table 8.1: Examples of flow rates into cattle water troughs from supply tanks.

Water head[1] (m)	**Pipe length (m)**	**Pipe diameter (mm/inch)**	**Trough flow rate (L/min)**
10	100	19 / ¾	21
··	500	··	8
··	1000	··	6
20	100	32 / 1¼	124
··	500	··	50
··	1000	··	34
30	100	50 / 2	506
··	500	··	209
··	1000	··	142
1. Water head pressure conversions: 1 Bar = 0.1 MPa = 100 kPa[46] = 14.5 psi[46]			

Infobox 8.1: Measurements and converions

Weight measurements:

Metric Tonne, MT 1 tonne (t) = 1000 kg 1 tonne = 0.984 ton	Kilogram (kg) 1 kg = 1000 g 1 kg =2.205 lb 100 kg = 1 quintal	Gram (g) 1 g =1000 mg 1 g = 0.035 oz	Milligram (mg) 1 mg = 0.001 g 1 mg = 1000 ug (ug = microgram)
Long Ton (ton) 1 long ton = 20 cwt 1 long ton = 1.02 t	Hundred Wt. (cwt) 1 cwt = 8 stone (st) 1 cwt = 50.8 kg 1 cwt = 112 lb	Pounds (lb) 1 lb = 0.454 kg 1 lb = 454 g	Ounces (oz) 1 lb = 16 oz 1 oz = 28.3 g

[49] Kilopascal (kPa) and Pounds-per-Square Inch (psi) are units of pressure, e.g. from water or pump head pressure. Megapascal (MPa).

Length and distance measurements:

Kilometers (km) 1 km = 1000 m 1 km = 0.621 miles	Metre (m) 1 m = 100 cm 1 m = 1.094 yd 1 m = 3.28 ft 1 m = 39.37 in	Centimetre (cm) 1 cm =10 mm 1 cm = 0.0328 ft 1 cm = 0.394 in	Millimetre (mm) 1 mm = 0.001 µ (micron) 1 mm = 0.039 in
Mile 1 mile = 1760 yd 1 mile = 8 furlong (f) 1 mile = 1.609 km	Yard (yd) 1 yd = 3 ft 1 yd = 36 in 1 yd = 0.914 m	Foot (ft) 1 ft = 12 in 1 ft = 30.48 cm	Inch (in) 1 in = 2.54 cm 1 in =25.4 mm

Volume measurements:

Megalitre (ML) 1 ML = 1000 m^3 1 m^3 = 1 x 10^6 cm^3 1 m^3 water = 1 tonne 1 m^3 = 2.75 bu	Litre (L) (fluid) 1 L = 1000 ml 1 L = 0.224 gal 1 L = 1.76 pt 1 L = 4.0 cup AU	Millilitre (ml) (fluid) Cubic cm (cc, cm^3) 1 cm^3 =1 ml (fluid) 1 ml = 0.061 in^3	Cups (fluid) 1 cup[1] = 10 oz 1 cup[1] = 284 ml
Gallon (gal) 1 gal = 4 qt 1 gal = 8 pt 1 gal = 4.47 L (water)	Bushel (bu) 1 bushel = 8 gal 1 bushel = 0.364 m^3	Quart (qt) 1 qt = 2 pt 1 qt = 1.136 L	Pint (pt) 1 pt = 0.5 qt 1 pt = 0.568 L

Land area measurements:

Square km (km2) 1 km^2 = 100 ha 1 km^2 = 0.386 $mile^2$	Hectare (ha) 1 ha = 10,000 m^2 1 ha = 2.47 acre	Metre square (m^2) 1 m^2 = 10,000 cm^2 1 m^2 =10.76 ft^2	Centimetre^2(cm^2) 1 cm^2 = 0.155 in^2 2.5 cm (rain) = ~25 Lw/m^2
Square mile ($mile^2$) 1 $mile^2$ = 640 acres 1 $mile^2$ = 2.59 km^2 1 $mile^2$ = 259 ha	Acre 1 acre = 4840 yd^2 1 acre = 0.405 ha 1 acre = 4047 m^2	Square yard (yd^2) 1 yd^2 = 9 ft^2 1 yd^2 = 1296 in2 1 yd^2 = 0.836 m^2	Square feet (ft^2) 1 ft2 = 144 in^2 1 ft2 = 0.093 m^2 1 ft2 = 929 cm^2

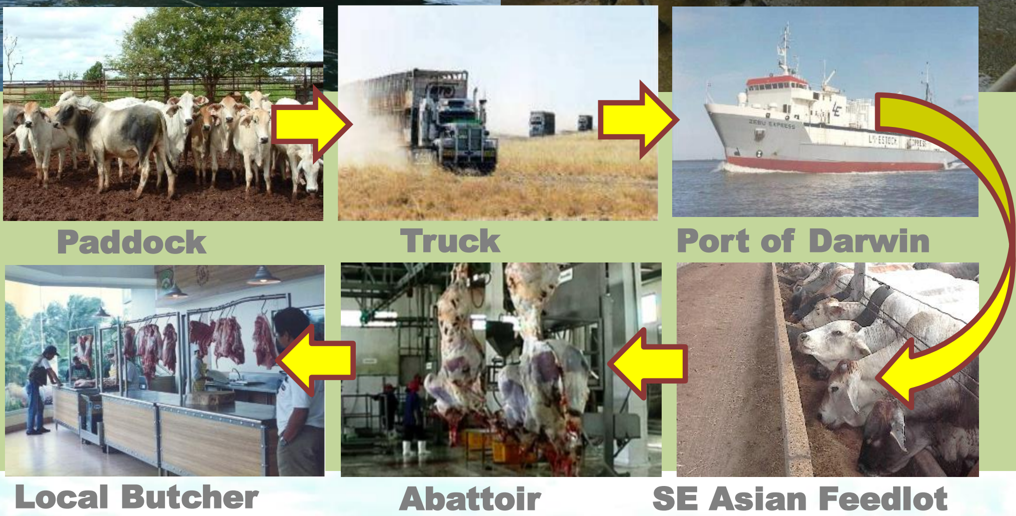
Conversions:

- (500 1b/acre)/0.892 = (561 kg/ha).
- (200 kg/acre) x 2.47 = (494 kg/ha).
- (16.54 lb DMI/1 lb LWG)/2.205 = (7.5 kg DM/1 kg LWG).
- (15 gal water/770 lb LW)/0.223 = (67 L/350 kg LW).
- 50 miles/hour = 80 km/hour;
- 100 km/hour = 62.5 miles/hour.
- $^oF \rightarrow {}^oC$: (30^oF – 32) x 5/9 = -1.1^oC.
- $^oC \rightarrow {}^oF$: (30^oC x 9/5) + 32 = 86^oF.

- Fuel: (282.5)/30 m.p.g. (miles/gal.) = 9.4 L/100 km ↺
- 1 ha [(10^7 cm^2)/(25 cm x 25 cm (spacing)= 625 cm^2)] =160,000 plants/ha.
- Area of circle = πr^2 • Circumference of circle = $2\pi r$.
- Area of triangle (sides a, b, c) = ½bh.
- Volume (m^3) of cylinder (e.g. water tank) = $\pi r^2 l$. (m)
- Volume of sphere = 0.5326 x d^3.

Note: π = 3.142; r = radius; l = length; d = diameter; b =base length (e.g. cm), h = 90^o height from base (b).


NORVANTES


Paddock
Truck
Port of Darwin
SE Asian Feedlot
Abattoir
Local Butcher

TROPICAL BEEF PRODUCTION AND HUSBANDRY OF AUSTRALIAN CATTLE AND BUFFALO IN SE ASIA

David Ffoulkes

TECHNICAL SERVICES NOTEBOOK