Local Land Services

A guide to confinement feeding sheep and cattle in NSW

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Acknowledgments

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Local Land Services recognises the unique, diverse and enduring cultures of First Nations peoples in NSW and their strong, ongoing social, spiritual and cultural connection with their traditional lands and waters. We acknowledge the Traditional Custodians of the land and pay respect to Elders past, present and future.

Front cover: Cows being fed a total mix ration under hot wires on the ground. Photo credit David Weston.

Contents

Introduction

During prolonged dry periods, it is important to ensure producers have access to a range of information, tools, and resources to enable them to make informed management decisions.

This publication "***A guide to confinement feeding sheep and cattle in NSW***", developed by Central Tablelands Local Land Services aims to provide producers with best practice management protocols and recommendations when confinement feeding stock on-farm.

Principal authors Geoff Duddy (Sheep Solutions), Jeff House (Jeff House Livestock) and Brett Littler (Central Tablelands Local Land Services) have over 85 years' experience between them working with producers in prolonged dry periods and through this publication are able to provide practical tips and tools common to both sheep and cattle confinement feeding systems.

Confinement feeding is a temporary, proactive management strategy that has increasingly been incorporated into on-farm drought management programs.

Confinement feeding is a management strategy to help maintain livestock production during periods of limited feed availability and to help maintain groundcover across other parts of the property.

Yearling cattle locked up in multiple confinement pens. Photo Credit: Brian Cumming.

Confinement feeding is a temporary, proactive management strategy

Sheep in a confinement area being fed at a single trough from outside. Photo Credit: Phil Cranney.

Confinement feeding is a management strategy to help maintain livestock production

This guide looks to cover all aspects of confinement feeding systems in terms of design, management, nutrition, and animal welfare.

The feeding of livestock to meet market requirements or as a longer-term enterprise is generally considered to be lot feeding (or a feedlot). While we can learn a substantial amount from commercial lot feeding operations, especially regarding design and nutrition, it is not the intention of this publication to cover lot feeding.

When considering the use of confinement feeding in your sheep or cattle enterprise, you are encouraged to seek advice. Your Livestock Officer or Veterinarian at your nearest Local Land Services office can assist you.

Resources

Beef cattle feedlots: design and construction (Meat & Livestock Australia 2015)

National procedures and guidelines for intensive sheep and lamb feeding systems (Meat & Livestock Australia 2011)

Lambs on feed with multiple troughs on the ground. Photo credit: Sue Street.

Calves early weaned and fed a by-product feed, high in protein, and cereal hay. Small mobs contained for 5-7 days before moving into bigger pens. Photo credit: Brett Littler.

What is confinement feeding?

Cows being fed a total mixed ration under hot wires on the ground. Photo credit: David Weston.

Introduction

Confinement feeding is when stock are confined in either small paddocks or pens for full hand feeding and management during drought.

Confinement feeding areas can sometimes be referred to as sacrifice paddocks, drought-lots or stock containment areas.

Meat and Livestock Australia defines confinement feeding as a "drought feeding practice that aims to promote animal health and welfare while preserving groundcover and land condition across the majority of the property" (www.mla.com.au/research-and-development/feeding-finishing-nutrition/drought-feeding/confinement-feeding/).

The primary objectives of confinement feeding are to maintain flock or herd productivity and to reduce grazing pressure across the property.

All classes of livestock can be managed in confinement feeding areas.

Young or dry animals can be managed in either pens or small paddocks, while lambing ewes and calving cows are best suited to small paddocks.

For some classes of livestock, maintaining productivity can be achieved by maintenance feeding. This may be the case with dry sheep or cattle.

For breeding or young stock, confinement feeding should be at a level to ensure successful joining, pregnancy and growth. Survival feeding of young or breeding stock is generally not viable and has long term impacts on flock or herd productivity.

Maintaining a productive flock or herd is essential to allow enterprises to generate cash flow and recover quickly after drought.

Reducing grazing pressure by confining livestock to a smaller portion of the property, allows for the maintenance of groundcover and the associated benefit of reduced erosion.

When to start using confinement feeding areas will depend heavily on seasonal conditions, stock condition, your pasture base and soil type.

It is generally recommended that stock be removed from pastures before groundcover declines below 70% to minimise the potential for wind erosion, excessive run-off, water erosion, and to maximise plant growth and pasture response after rain.

The groundcover threshold may vary depending on topography, soil type and location, however, retaining an adequate groundcover is especially important for the persistence of perennial pastures.

Continuing to supplementary feed or full hand feed livestock in large paddocks with low feed availability and groundcover can result in severe overgrazing and the animals walking very large distances trying to graze. The extra walking can significantly increase the animals' energy requirements and makes supervision of the flock or herd more difficult.

An overhead photo of sheep being fed on the ground in a confinement feeding area. Photo credit: David Sykes.

Cows being fed PKE (Palm Kernel Expeller) in a tractor tyre feeder screwed into a piece of conveyor belt. Photo credit: Brett Littler.

Advantages of confinement feeding

There are many benefits of confinement feeding. It can be used to:

Reduce

- grazing pressure
- topsoil, groundcover and nutrient losses
- pasture damage/loss
- pasture re-establishment costs
- livestock daily energy requirements (stock requirements can drop by 10-15%)
- livestock welfare issues
- the spread of introduced weed seeds in purchased grain or fodder
- labour and running costs (for example less time travelling compared to feeding in paddocks).

Maintain

- core breeder base
- genetic base
- cash flow.

Improve

- monitoring of stock
- pasture response rates after rain
- stock liveweight and/or condition
- conception and weaning rates
- weaner/adult growth rates or feed conversion efficiencies (FCEs)
- dam and lamb/calf survival
- wool quality (for example staple strength, position of break, yields)
- management of stock back onto green feed after rain
- overall enterprise recovery after drought.

Lambs on feed with multiple troughs on the ground. Photo credit: Sue Street.

A good early weaning set up for lambs. Photo credit: Jill Kelly.

Negatives of confinement feeding

Like all systems, confinement feeding can also have negatives. These may include:

- the cost and quantities of feed required for full hand feeding
- infrastructure costs (for example fencing, troughing, feeders, water)
- the potential for an increased risk or incidence of health or disease issues
- negative environmental impacts for poorly located or designed facilities.

When considered, the advantages of confinement feeding generally far outweigh the negatives, however, careful planning and management are required for a successful outcome.

Confinement feeding when not in drought

While confinement feeding is traditionally associated with drought management, confinement feeding can be successfully utilised at other times.

The cost of establishing and maintaining confinement feeding facilities can be better justified when they fit into annual stock management programs.

In addition to drought management, confinement feeding areas can potentially be used:

- prior to or immediately following a seasonal break to allow pasture to establish and thicken prior to grazing
- when there are potential issues with pastures being toxic at different growth stages for example phalaris (staggers & sudden death)
- for yard weaning
- as a quarantine area when introducing new stock or feeding purchased fodder or grain as per your biosecurity plan
- to control livestock following a fire or other emergency
- as holding areas when shearing or crutching, weighing stock or prior to transport to slaughter
- as a hospital including sick or recovery pens
- when ‘flushing’ or seeking a short-term nutritional spike to improve conception rates prior to joining
- when joining to improve sire/dam contact, reduce required ram/bull numbers, and improve conception rates.

Key points

- Confinement feeding is when stock are confined in either small paddocks or pens during drought.
- Maintaining productivity is essential to allow enterprises to generate cash flow and recover quickly after drought.
- Young or dry animals can be managed in either pens or small paddocks, while lambing ewes and calving cows are best suited to small paddocks.

Confinement feeding -regulations and requirements

A well planned feeding area, however this area lacks slope in some locations and has a flow line running through it. Photo credit: Brett Littler.

Introduction

In NSW legislation, specifically the State Environmental Planning Policy (Primary Production and Rural Development) 2019 (SEPP), confinement feeding areas are referred to as stock containment areas and they generally do not require development consent.

The SEPP contains provisions for producers to undertake necessary farm management operations to intensively hold, feed and water livestock during or immediately following drought, flood, fire or other emergency events without the need for development consent from their local council.

The SEPP defines stock containment areas as fenced areas where livestock are temporarily held, fed and watered to protect soil and pasture resources on the property.

The policy states the difference between a confinement feeding (stock containment) area and a feedlot relates to their purpose and use. Confinement feeding areas are used on a temporary basis and can be in response to emergency events such as fire, flood, drought or management of animal disease.

Confinement areas do not involve the construction of permanent earthworks or new permanent structures that require development consent (such as sheds).

In contrast, feedlots are defined as confined or restricted areas that are operated on a commercial basis to rear and fatten cattle, sheep or other animals. The purpose of feedlots is for intensive feeding of stock for production of meat, fibre or milk and may involve permanent earthworks or structures.

The SEPP also provides exemptions outside periods of drought or emergency for the temporary agistment or housing (confinement) of livestock for routine husbandry purposes such as weaning, dipping, drenching, tagging, administering injections, breeding or containment prior to sale.

This confinement feeding area is on a bit of a slope, but the soil type makes it suitable. It is far enough away from any watercourse. Also, the producer has put a contour bank above the feeding area and has sediment traps below the feeding area to control runoff. Photo credit: Brett Littler.

Early weaned calves being fed next to the yards. This is close to feed and has access to other paddocks. Is away from creek and has a gentle slope. Photo credit: Brett Littler.

These exemptions apply to land located outside an environmentally sensitive area, and not within 100 metres of a natural watercourse or 500 metres of a residential zone or adjoining dwelling.

A confinement feeding area managed in accordance with this document, ***A guide to confinement feeding sheep and cattle in NSW***, may be constructed and operated without requiring development consent.

A confinement feeding area may be converted into a permanent feedlot; however, this will require obtaining development consent, generally from local council, to operate a feedlot as intensive livestock agriculture for a development able to accommodate 50 or more head of cattle or 200 or more sheep or goats.

Feedlots are outside the scope of this document.

Ewes and lambs in a paddock being fed with a creek running through it. Photo credit: Brett Littler.

Weaner cattle on self-feeders. Good set up but in close proximity to a dwelling. (Note. Dwellings should never be on the eastern side of a feeding area.)
Photo credit: Brian Cumming.

Well planned feeding area, however this area lacks slope in some locations and has a flow line running though it.
Photo credit: Brett Littler.

Resources

Temporary arrangements for droughts and other emergency events – factsheet (NSW Department of Planning and Environment 2019)

State Environmental Planning Policy **(Primary Production and Rural Development) 2019** (NSW Government 2019)

Planning Guidelines Intensive Livestock Agriculture Development (NSW DPI 2019)

Key points

- The Primary Production and Rural Development SEPP defines stock containment areas as fenced areas where livestock are temporarily held, fed and watered to protect soil and pasture resources on the property.
- Confinement feeding areas may be referred to as stock containment areas and they generally do not require development consent.

Confinement feeding -site selection

Ewes in a feeding area with good slope and close to yards/facilities. Photo credit: Phil Cranney.

Introduction

Selecting a suitable site for a sheep or cattle confinement feeding area can be challenging. Consideration needs to be given to a range of requirements, while the integration of a confinement feeding area into the overall property layout and plan is crucial.

Time spent investigating alternative locations and selecting the most appropriate site is time well spent and likely to minimise long term issues.

Unfortunately, you are unlikely to have a site that meets all requirements or needs. Ultimately, most sites will have some degree of compromise.

The objective is to select a well-drained, sheltered site; close to feed storage, water supply and stock handling facilities, while minimising any negative environmental or amenity impacts.

There are several criteria that need to be considered, both for dry and wet conditions, when selecting a confinement feeding area.

While the area will predominantly be used during the dry conditions of drought, it must also be able to function after rainfall and even after the drought has broken, while pastures recover and produce sufficient quantity of feed.

Buffer or separation distances

The confinement feeding area needs to be located to ensure run-off does not cause contamination of any natural watercourses, water storages or neighbouring properties.

The impact of odour, dust, noise, insects and visual amenity on neighbours or the community also needs to be considered.

Buffer or separation distance is the distance between the confinement feeding area and the listed receptor, to minimise the risk of contamination or impact.

The minimum recommended buffer distances are:

- major watercourse 200 metres
- 'other' watercourse 100 metres
- property boundary 20 metres
- neighbouring dwelling 500 metres
- public road 200 metres

Confinement feeding areas should be located above the 1-in-100-year average recurrence interval flood height. If you are concerned about flooding please contact your local council.

A dual-sided feed trough. On the right is an addition/pen for the cattle yards where calves are early weaned. On the left is a confinement paddock where calves are let into after feeding. The feeder goes down the left to fill the trough. Photo credit: Brett Littler.

Topography

A sites topography will influence run-off drainage, potential for erosion and can impact animal health.

The selected site should have some slope to assist with run-off, avoid ponding and reduce the development of boggy conditions. A slope of between 2-4% is ideal for confinement pens.

Steep slopes (>4%) can be prone to erosion and increase stock feed requirements.

For either pens or small paddocks it is important to avoid flat areas or drainage lines, low in the landscape, that are likely to accumulate water.

Sites near the top of the slope are preferred, as they limit run-off water entering the area from above and generally provide good drainage. Levy banks can also be used to divert run-off around a potential site.

During periods of wet weather, a poorly drained site will become wet and boggy which:

- predisposes stock to health issues and diseases like foot abscess, scald, coccidiosis and salmonellosis
- increases an animals feed requirements
- generates odour
- increases feed and water trough contamination
- increases soiling/contamination of animals.

Ideally pens should be aligned so the slope is from front to back, ensuring run-off drains out the back of the pen and does not flow into adjacent pens.

Soil type

Medium clay loams are the preferred soil type. These are easily compacted, preventing groundwater contamination and infiltration.

Avoid siting confinement areas on sandy/light soils as these generally have high infiltration rates and therefore a greater groundwater contamination risk and are more prone to erosion by wind, rain and traffic.

Heavy, clay-rich soils tend to 'pug' when wet and dry slowly, increasing odour and animal health and welfare problems.

Access

The confinement area needs to be accessible for feed delivery and stock movements in all weather, particularly during wet or inclement weather.

The suitability of both the access road from the feed storage and mixing area, as well as the feed delivery area of the pen or small paddock need to be considered.

Use of existing compacted roads may be an option or the use of gravel may be required to prevent bogging or excessive dust.

Close to cattle yards and facilities but a very flat area and sandy soil make this a less than ideal location for a confinement feeding area. Photo credit: Brett Littler.

Sheep in a feeding area. Simple setup with large gates and easy access. Photo credit: Sue Street.

Proximity to facilities

Locating the confinement area close to existing feed storages and machinery sheds can greatly reduce the travel time when feeding and can also reduce access issues during difficult weather.

Being close to existing livestock yards reduces the distance sick animals must be moved if treatment is necessary and can make use of existing facilities such as loading ramps, races and cattle crushes.

Distance from the house or other residences on the property also needs to be considered. Close proximity makes monitoring of the stock easier and issues are likely to be picked up quickly.

However, the impact of dust, odour, noise, insects and the overall appearance of the confinement feeding area need to be considered.

Access to water

A guaranteed supply of good quality water to the confinement area is essential.

Water should be supplied to livestock through troughs as dams will rapidly become contaminated and may become boggy as water levels fall.

Stock access to creeks or waterways should not be permitted.

Shelter

Stock in confinement areas should be sheltered from prevailing winds during winter.

Vegetation shelter belts can be planted/located to protect the confinement area from the prevailing winter winds to minimise wind and dust related issues.

Be mindful of air flow during summer to minimise heat stress.

Residues

Care must be taken that confinement feeding areas are not located in areas with old buildings, orchards or other food production areas, power poles, sheep yards or dips that may be contaminated with persistent chemicals, for example arsenic or organochlorines.

Aspect

Confinement feeding areas should have a northerly aspect to maximise solar radiation and evaporation rates.

Avoid southerly aspects that remain wet during winter.

Trough lengthways with lambs feeding through cable fencing. Good for a total mixed ration. Photo credit: Geoff Duddy.

Good aspect and gentle slope make this site suitable. Photo credit: Phil Cranney.

Biodiversity and vegetation

Identify native vegetation on the site and options to retain or enhance cover and quality. If possible, avoid clearing these areas. Be aware of potential impacts down slope of nutrient build up and the negative impact this can have on native vegetation, especially trees.

Biosecurity

Before deciding on a confinement area site, consider any potential 'risk sources' such as nearby houses, roads, stock or waterbodies. The staff at your Local Land Services office can provide advice to mitigate biosecurity risks.

Confinement feeding areas should be included in your properties biosecurity plan.

Future expansion

Your confinement area site should take in to account the possibility of future expansion.

A rough rule of thumb is to have three times the pen area to allow room for laneways, working yards/areas and moving of machinery if needed.

Cultural heritage

Identify Aboriginal cultural heritage values on the site and options to avoid impacts. Local Land Services
can provide assistance to landholders. Cultural due diligence must be followed.

Waste disposal

Waste from confinement systems can include spoilt feed, manure, water and carcases. Consider whether:

- solid wastes can be removed, stockpiled or composted and reused on-farm
- water wastes can be controlled and isolated (ponds or dams) and/or reused (irrigation)
- carcases can be deep-buried or composted.

Resources

Beef cattle feedlots: design and construction *Site selection Section* (Meat & Livestock Australia 2015)

Managing Biosecurity in NSW (NSW DPI) - webpage www.dpi.nsw.gov.au/biosecurity/managing-biosecurity

National procedures and guidelines for intensive sheep and lamb feeding systems (Meat & Livestock Australia 2011)

Planning Guidelines Intensive Livestock Agriculture Development (NSW DPI 2019)

Key points

- Time spent selecting the most appropriate site, is likely to minimise long term issues.
- Select a well-drained, sheltered site, close to feed storage, water supply and stock handling facilities.
- The confinement area needs to be accessible in all weather.
- Locating the confinement area close to existing feed storages and machinery sheds can greatly reduce the travel time when feeding.
- Good quality water to the confinement area is essential.

Confinement feeding -stocking densities and mob sizes

Sheep with lots of space and above stocking density requirements. Photo credit: Sue Street.

Stocking densities

Stocking rate and stocking density are commonly used to describe the concentration of livestock within a set grazing or confinement area.

Stocking rate is a broad term used to describe the relative number of livestock, liveweight or dry sheep equivalents (DSEs) and the area on which they are managed over a given time period. It is generally used when looking at whole-farm grazing systems and is normally referred to as total head or number per hectare (ha).

The term **stocking density** is more commonly used to describe more intensive livestock management such as during confinement feeding. Stocking density generally refers to the specified area provided for a number of livestock, liveweight or DSEs. Densities are normally referred to as area (in m^2) available per animal.

As an example, if a producer runs 300 ewes on a 100-hectare property their stocking rate is 3 ewes per hectare (300 ewes/100 ha's = 3 ewes/ha).

If, due to drought conditions, these ewes are fed in a 50 metre by 30 metre confinement pen (1,500 m^2 per pen) then the stocking density is 5 m^2 per animal (1,500/300 = 5 m^2).

Stocking density recommendations within confinement systems vary across states and range from 2-5 m^2 per head for sheep and 9-25 m^2 per head for cattle.

On a state by state basis there appears to be far greater uniformity and agreement in terms of cattle stocking density recommendations. There has been a lack of definitive research in terms of stocking density impact(s) on social welfare, stress and livestock performance within sheep confinement systems.

The following density recommendations can be used as a minimum area per head guide. Lambing/calving within confinement pens is not recommended. Small paddocks are more appropriate.

Suggested minimum stocking densities within confinement systems:

- sheep or lambs 5 m^2
- weaner cattle 9-10 m^2
- yearling cattle 12-14 m^2
- dry cows 15-25 m^2
- ewes and lambs 100 m^2
- cows and calves 100+ m^2

Increasing stocking density, that is reducing the area per head, may help to reduce dust within the confinement area. As the number of stock in a given area increases, the quantity of urine and manure deposited on the pen surface increases, therefore adding moisture to the surface and reducing dust.

Increased stocking densities also reduce infrastructure costs, with less pen space/fencing required per animal. However, higher stocking densities can result in an increase in animal health related problems.

Sheep on a total mixed ration and being stocked at industry standard rate. Photo credit: Geoff Duddy.

Sheep with low stock density. Large mob numbers but with lots of space make this situation work.
Photo credit: Matthew Lieschke.

Mob sizes

As with stocking density recommendations, there has been limited research in terms of mob size effects on livestock performance within confinement feeding systems.

With sheep, mob size is generally dictated by confinement pen area, with most producers basing mob size on numbers able to be held when using a stocking density of 5 m^2 per sheep.

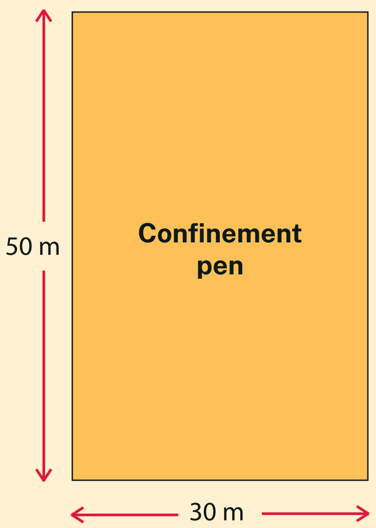
Smaller mob sizes help with management, feeding and monitoring of the animals and may reduce social stress and shy feeder numbers in young stock (lambs, weaner cattle). Older, mature stock can be run in larger groups without significant stress or negative impacts on production provided there is adequate feed and water trough space per animal. Confinement areas should not be used for lambing or calving.

Rectangular pens may be a better option than square pen designs when running larger mob sizes and/or using internal pen feed troughing as they allow for longer, unbroken runs of feed troughing. Ensure there is sufficient room for the feed-out vehicle to comfortably manoeuvre and turn within the pen.

Suggested mob sizes within confinement systems:

- lambs — maximum of 350
- ewes, wethers — up to 500
- weaner cattle — 50-100
- cows, yearling cattle — 100-200

Examples of how to work out mob size numbers based on pen area and recommended stocking densities are shown below.



Confinement area = 1,500 m^2

	Area/head	Number/pen
Sheep / lambs	5 m^2	300
Ewes and lambs	100 m^2+	15
Weaners	10 m^2	150
Yearlings/cows	15 m^2	100
Cows and calves	100 m^2+	15

Sheep at a high stocking density soon after being put in. Dust will diminish over time at this density. Photo credit: Phil Cranney.

Calves on a total mixed ration. The stocking density is high enough to control the dust. Photo credit: Brian Cumming.

Key points

- Stocking density recommendations within confinement systems range from 2-5 m^2 per head for sheep and 9-25 m^2 per head for cattle.
- Increased stocking densities reduce infrastructure costs, with less pen space/fencing required per animal, however higher stocking densities can result in increased animal health or environmental issues.
- Smaller mob sizes help with management, feeding and monitoring of the animals and may reduce social stress and shy feeder numbers.

Confinement feeding -pen design

A multiple pen feeding system with the feeding area at the front and separated from the pens. Stock are let into the troughs after they are filled and then returned after they have finished. Photo credit: Phil Cranney.

Introduction

Ultimately the design of confinement pens should look to:

- minimise environmental impacts (odour, erosion, groundwater contamination, dust, etc), water contamination, heat and social stress
- optimise stock health, animal welfare and safety
- maximise management ease (stock movements, stock monitoring, machinery movements), stock and feed (trough) space allocations and feed use efficiencies.

Pen design will depend on:

- area available
- number of pens
- stock numbers per pen
- stocking density
- trough/feeder space per head
- pen slope
- movement to and from the pen
- location of shade/shelter
- capital input
- labour and equipment
- personal preference/experience.

Ideally pens should slope from the front to the rear of the pen to facilitate good drainage and to provide a comfortable environment for the animals.

The pen surface should also be free of any holes or major depressions that will hinder drainage.

If shade is to be installed in confinement pens, pen orientation can be important. Rows of pens running north-south generally makes the design and function of shade structures easier.

Feed toughing is generally in the front/top section of the pen and water troughs are installed in the rear/lower section of the pen. Maximising the distance from the feed trough to the water trough minimises the contamination of the water from feed carried in the mouth of the animals after feeding.

The provision of multiple feed troughs for each pen can reduce the incidence of bullying and the incidence of shy feeders.

When determining the sizing of pens, you need to consider mob sizes, stocking density and required feed trough length.

For example, if you are constructing a pen for 500 ewes at 5 m^2 per ewe, the total pen area will need to be 2,500 m^2. A pen 40 m wide by 62.5 m deep would provide this area.

If you were constructing a pen for 100 weaner cattle at a stocking density of 10 m^2 per head, the total pen area would need to be 1,000 m^2. If you wished to use the front fence of the pen as a feed trough and the weaners needed 30 cm per head of linear trough space, the pen dimensions would need to be 35 m wide (to allow for 30 m of trough length and a gateway) by approximately 30 m deep.

Simple conveyer belt trough along the front of feeding area. This is set up for a total mixed ration and feeding from the outside. The lane way is used to move the livestock as well. Photo credit: Brett Littler.

A feeding setup with a lane way outside but need to access pen to feed stock. Photo credit: Sue Street.

Pen design incorporating feed troughs

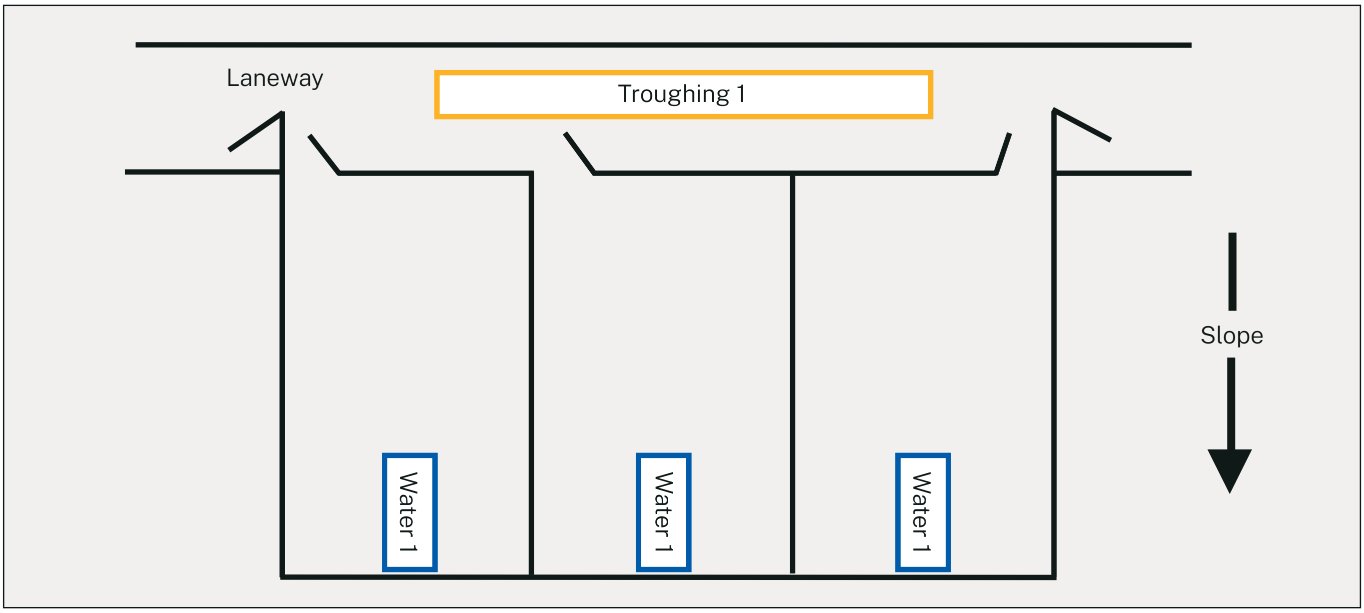
Examples of pen design and infrastructure options are shown in the figures below, as well as the advantages and disadvantages of each design. The examples of feed troughing and water locations should be considered independently, and the best option for each selected to suit the requirements of your confinement feeding area.

Providing laneways to and from confinement feeding areas allow for easier stock movement to and from the pens and can be used as a central feeding area, reducing need for troughing within pens.

When designing the laneway, ensure adequate width to allow for the movement of equipment and/or vehicle access to each of the pens. Wide gateways in the laneway and to the pens will make this easier.

In some situations a double gate in the corner of the pen can allow access between pens and the laneway which will allow more space for machinery and stock movement.

Figure 1: Feed troughing in the laneway and water located at the rear of the pen.



Feed troughing location 1

Located in a separate feeding pen/laneway.

Advantages include:

- double-sided access
- reduced need for troughing within each pen
- reduced cost for troughing
- feeding out is easier because no stock in laneway at time of feeding
- eliminated risk of stock deaths from being run over by vehicle.

Disadvantages include:

- increased feed-out time. As pens are fed at staggered intervals total feed-out time will be dictated by pen numbers and time stock require to finish feeding.

Water location 1

Located at right angles to the downslope fence line.

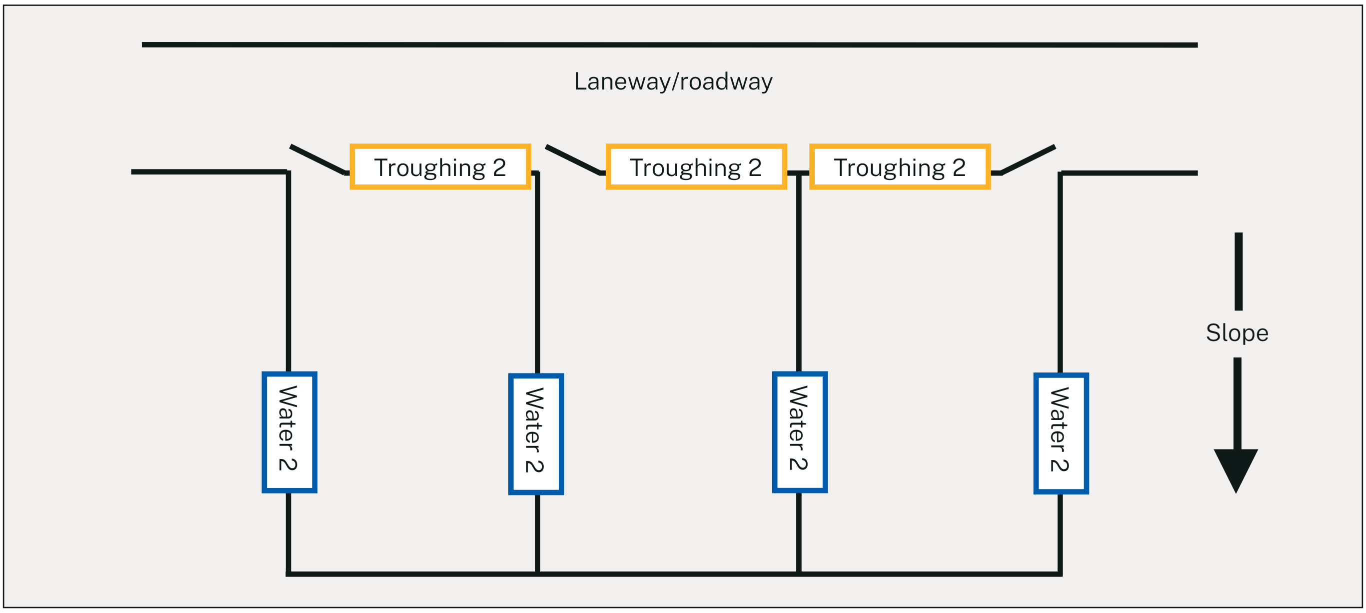
Advantages include:

- maximum distance from feed source (minimising contamination with feed)
- double sided access
- greater control of drainage and/or cleaning waste – trough bung located on external fence line and drains outside pen.

Disadvantages include:

- exclusion bars required to stop animals from standing in and contaminating troughs.

Figure 2: Feed troughing at the front of pen and water located in pen fence lines.



Feed troughing location 2

Located along laneway fence line at front of the pen.

Advantages include:

- no need to enter pens when filling troughs
- eliminated risk of stock deaths from being run over by vehicle.

Disadvantages include:

- trough length and space allocation may be limiting depending on available fence line distance for troughing and stock numbers per pen (can be overcome by making pens wider and not as deep)
- single-side access. Can lead to social stress and an increase in shy feeders if inadequate trough space per head
- greater cost in terms of troughing per animal.

Water location 2

Located within pens along internal fence line(s).

Advantages include:

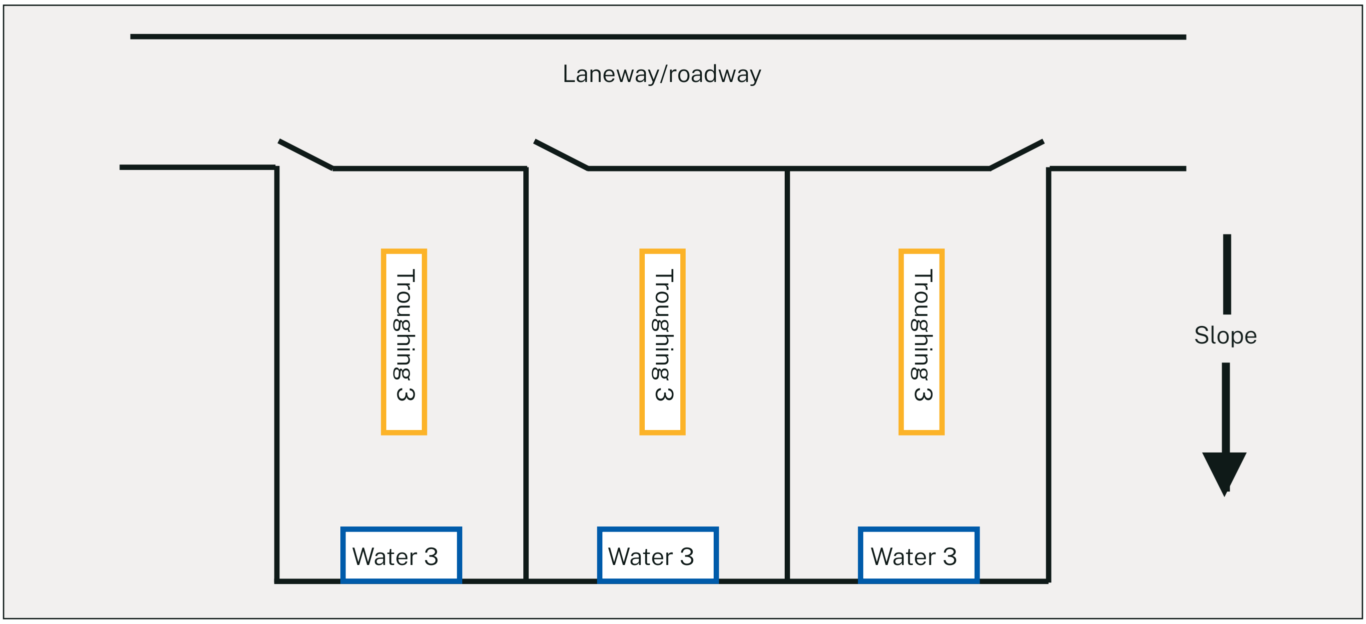
- greater stock access if water along two fence lines, providing two water points in each pen
- animals spread out more in the pen during hot weather.

Disadvantages include:

- additional cost due to extra water trough required (4 troughs for 3 pens)
- drainage and/or cleaning waste left within pens unless 'piped' to outside of pen.

A feeding setup with a lane way outside but need to access pen to feed stock. Photo credit: Sue Street.

Figure 3: Feed troughing in each pen and water located at the rear of the pen.



Feed troughing location 3

Located within pens.

Advantages include:

- double-sided access
- greater stock access per metre of troughing
- reduced social stress and shy feeder issues if adequate trough space per head
- trial work has shown that more sheep begin eating earlier compared to sheep with single-side access troughing.

Disadvantages include:

- need to enter pen to feed out – access in wet weather
- laneway and gates need to be wide enough to allow vehicle access to pen
- stock are in pen when feeding-out – increased risk of stock deaths from being run over by vehicle.

Note: The disadvantages of feeding stock while they are in the pen can be eliminated by using a pen rotation system where one extra pen is constructed. The extra pen allows feed to be delivered into an empty pen and then the stock moved into the pen to access the feed. While this eliminates the risk of stock deaths from being run over by vehicles and the general challenge of feeding in a pen with stock, it significantly increases the fencing costs and requires an additional water point.

Water location 3

Located along the downslope fence line.

Advantages include:

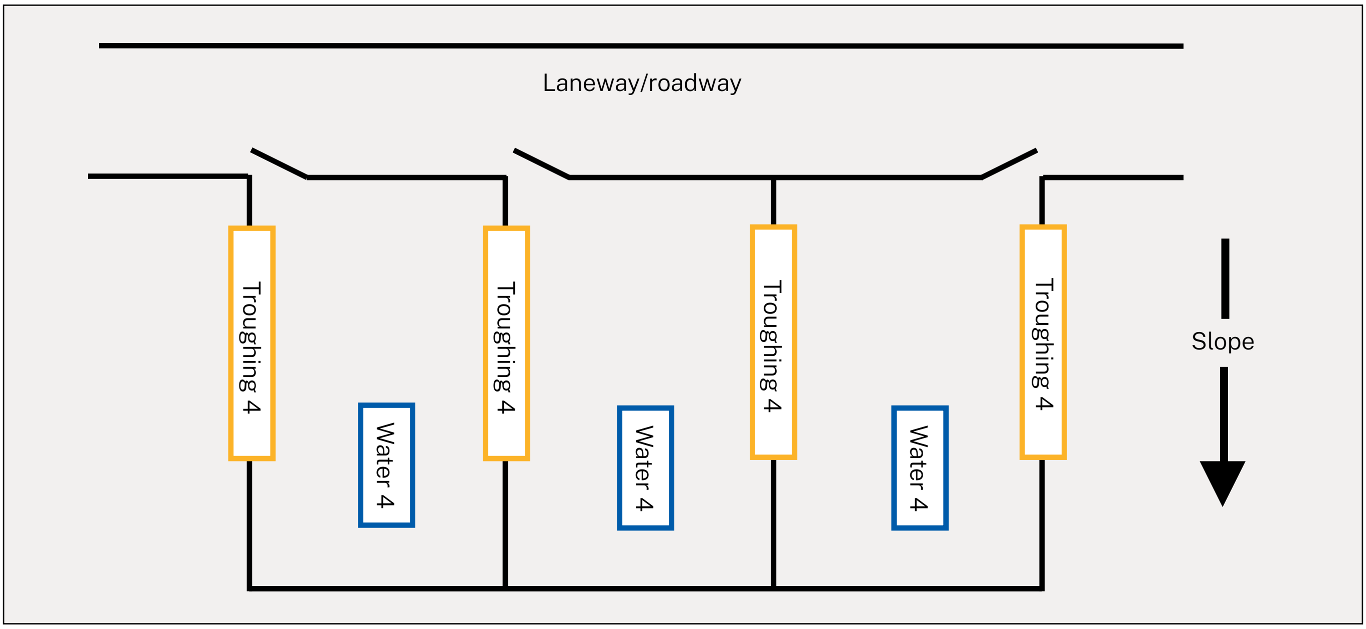
- maximum distance from feed source (minimizing contamination with feed)
- greater control of drainage and/or cleaning waste – can be directed away/outside of pens.

Disadvantages include:

- if set 'along' the external fence line, stock can access a single side only
- drainage from the bottom of the pen is restricted
- greater risk of water being contaminated with mud/manure in wet weather.

This is an early weaning setup for calves. It is attached to the yards. The calves can be let into the pen and are educated to feed in the trough before being let out into the bigger pen. Cattle can eat from both sides. Photo credit: Brett Littler.

Figure 4: Feed troughing along the pen fence line in each pen and water located within the pen.



Feed troughing location 4

Located within pens along internal fence line(s).

Advantages include:

- greater stock access if troughing along 2 fence lines within each pen
- reduced social stress and shy feeder issues if adequate trough space per head
- if used as part of a pen rotation system pens can be vacant when feeding out.

Disadvantages include:

- need to enter pen to feed out – access in wet weather
- laneway and gates need to be wide enough to allow vehicle access to pen
- stock are in the pen when feeding-out. Increased risk of stock deaths from being run over by vehicle.

Note: The disadvantages of feeding stock while they are in the pen can be eliminated by using a pen rotation system where one extra pen is constructed. The extra pen allows feed to be delivered into an empty pen and then the stock moved into the pen to access the feed. While this eliminates the risk of stock deaths from being run over by vehicles and the general challenge of feeding in a pen with stock, it significantly increases the fencing costs and requires an additional water point.

Water location 4

Located within confinement pens.

Advantages include:

- double-sided access.

Disadvantages include:

- drainage and/or cleaning waste left within pens unless 'piped' to outside of pen
- exclusion bar required to stop animals from standing in and contaminating troughs
- obstacle when cleaning pen.

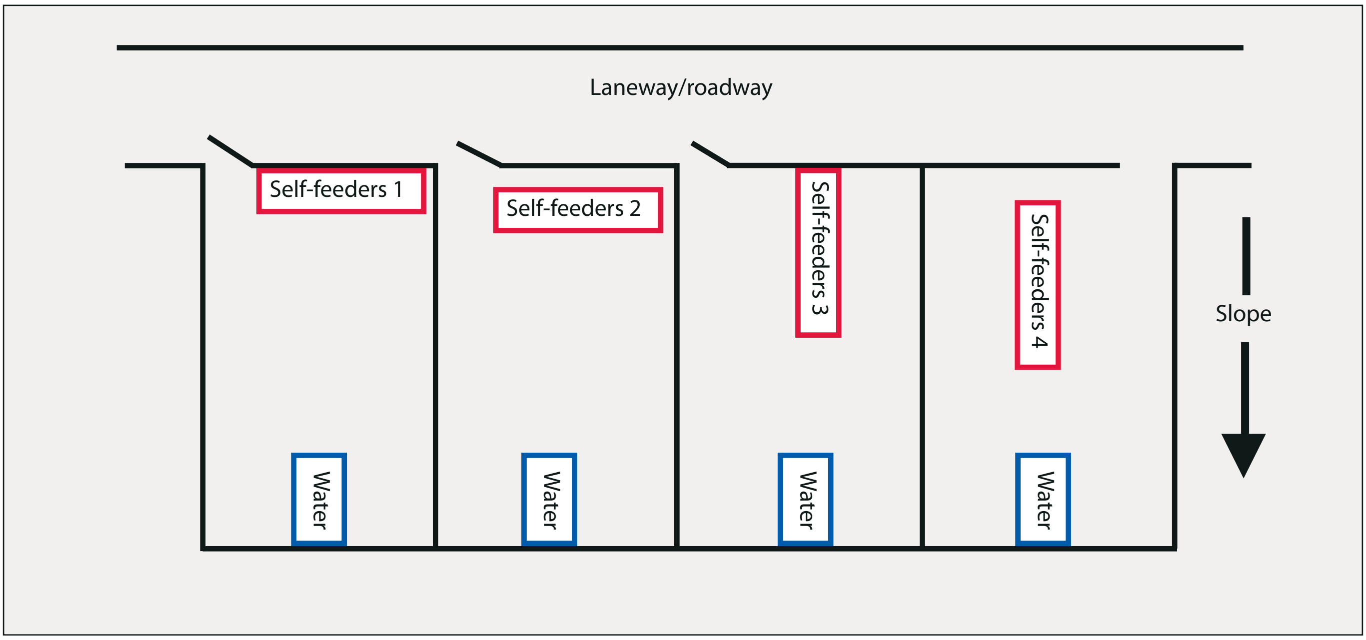
Auto feeder system for sheep. A two-trough system that was adapted into a 4-pen system. The 2 other pens still have self-feeders. Photo credit: Sue Street.

Pen design incorporating self-feeders

The use of self-feeders can eliminate the need to feed stock on a daily basis and therefore reduce the overall time spent feeding animals in confinement areas. However, the animals will still need to be checked on a daily basis.

The example below shows various positions for self-feeds in the confinement feeding pen and outlines the advantages and disadvantages of using self-feeders.

Figure 5: Pen design incorporating self-feeders.



Self-feeder location 1

Located within confinement pen along a laneway fence line.

Advantages include:

- no need to enter pens when filling feeder
- eliminated risk of stock deaths from being run over by vehicle.

Disadvantages include:

- single-side access
- feed-out equipment requires elevator high enough to fill from outside pen.

Self-feeder location 3

Located within confinement pen set at 90° to the laneway fence line.

Advantages include:

- double sided access to feeder, increasing trough space per feeder
- no need to enter pens when filling feeder
- eliminated risk of stock deaths from being run over by vehicle.

Disadvantages include:

- feed-out equipment requires an elevator high enough to fill from outside pen and reach the length of the feeder
- can be difficult to evenly fill the self-feeder from the end.

Self-feeder location 2

Located within confinement pens parallel to laneway fence line.

Advantages include:

- double sided access to feeder, increasing trough space per feeder
- no need to enter pens when filling feeder
- eliminated risk of stock deaths from being run over by vehicle.

Disadvantages include:

- feed-out equipment requires an elevator high enough to fill from outside pen and reach the feeder.

Self-feeder location 4

Located within confinement pens.

Advantages include:

- can be 'spread' throughout pens, reducing social stress/bullying and shy feeder numbers
- double sided access to feeder, increasing trough space per feeder.

Disadvantages include:

- need to enter pen to feed out. Access can be difficult in wet weather
- laneway and gates need to be wide enough to allow vehicle access to pen
- stock are in the pen when feeding-out. Increased risk of stock deaths from being run over by vehicle.

Trim deck used as trough in the middle of the pen. It is on the ground. Have to enter the pen to feed out.
Photo credit: Matthew Lieschke.

This is an early weaning setup for calves. It is attached to the yards. The calves can be let into the pen and are educated to feed in the trough before being let out into the bigger pen. Cattle can eat from both sides.
Photo credit: Brett Littler.

Key points

- Pens should slope from the front to the rear of the pen to facilitate good drainage and to provide a comfortable environment for the animals.
- The provision of multiple feed troughs for each pen can reduce bullying and shy feeders.
- When sizing pens, consider mob sizes, stocking density and required feed trough length.
- Self-feeders have several advantages and disadvantages to be considered, as well their positioning within the pen.

Confinement feeding -infrastructure

A total mixed ration fed onto a conveyor belt trough. Note the adjustable steel cable holder. This enables different classes of stock to be fed. Photo Credit: Sue Street.

Introduction

If possible, look to incorporate confinement pens in and around existing infrastructure such as fences, laneways, working yards, sheds, feed storages (hay sheds, silos, silage pits), roads and reticulated water systems to reduce costs.

Confinement pens do not need to be elaborate – they just need to be functional!

Aim to keep it simple!

Feeding systems

Some form of feed bunk or troughing is required in confinement feeding areas to separate the feed from the ground. Trail feeding, on the ground is NOT recommended for confinement feeding as the risk of livestock ingesting soil is considerable and the quantity of feed wasted is substantial.

Cows and calves being fed on the ground with a total mixed ration. Note the degree of waste on the ground. Photo credit: Brett Littler.

Table 1: Advantages and disadvantages for a range of materials commonly used for feed troughing.

Material	Advantages	Disadvantages	Indicative cost
Shade cloth (polyethylene or polypropylene)	Lightweight, easily assembled Ration dust and fines fall through Water won't pool in trough base	Limited life expectancy	<$3
Tractor tyres	Durable Readily available Low cost Good linear trough space per tyre	Height of sides for smaller stock Care steel belting does not get exposed and/or ingested by animals Sheep tend to jump into tyre and soil the feed	-
Poly belt/tarp (polyethylene)	Light (2 kg per m^2) and sturdy Wide range of widths and thicknesses Environmentally stable and flexible Easily fixed to timber/steel frames	Heat may be an issue in summer months	<$9
Plastic/PVC (polyvinyl chloride)	Reasonably light and sturdy Wide range of widths and thicknesses Environmentally stable and flexible	Can become brittle with time	<$9
Conveyor belt (nylon ply, solid woven or steel cord threaded rubber options)	Sturdy, environmentally stable Can be split width wise and lengthways Longevity	Can be difficult to split Reasonably difficult to work with	<$12
Galvanised steel (Corrugate, Trim deck, 'C' section, 'W' strap etc)	Sturdy Longevity	Heat may be an issue in summer months Reasonably difficult to work with	<$15
Concrete	Sturdy Longevity	Expensive Heavy to move, handle	>$50

Feed bunks/troughing

Troughing can be made using a wide range of materials, many of which are listed in Table 1. Longevity, durability and cost must be considered when deciding on the material used.

When using troughing within your confinement pens, it's important to consider:

- cost per lineal metre
- durability/expected longevity of the troughing material
- cleaning ease - open ends will facilitate easier cleaning and better drainage
- including drainage holes along the trough length in case of wet weather.

Recommended trough space allocations (once-daily feeding) and specifications are:

- Sheep – 350-450 mm wide
  - double side access 15+ cm/head
  - single side access 30+ cm/head
- Cattle - 550-600 mm wide
  - weaners 30 cm/head
  - yearlings 40 cm/head
  - adult cattle 60 cm/head

These recommended trough space allocations are significantly more than are usually allowed for in commercial feedlots. This is because commercial feedlots are feeding animals at or near their potential daily feed intake capacities. They will usually have feed available in the troughs for a large portion of the day and only expect about a third of the animals to be eating at any one time.

In confinement feeding areas, stock may be fed only a limited amount of feed for maintenance once per day. It is important that sufficient space is provided so all animals can feed at the same time, ensuring all animals get their allocated feed and aiming to limit the number of shy feeders.

Trough space allocation may be reduced if feeding a grain or pelleted ration out more than once daily and/or alternate feed (hay, silage or straw) is available separately. If animals are being fed a larger quantity of feed, and feed is available for a longer part of the day, trough space allocations may be reduced.

It is important that animals are monitored daily, to identify and remove any shy feeders and poor performers. These animals may need to be fed separately, in smaller groups, with larger trough space allocations to successfully get them onto feed and maintain production.

Self-feeders

Self-feeders have the advantage of feed being available 24/7 and have a reduced labour requirement, as less time is spent feeding out compared to trough feeding systems. Self-feeders do not generally need to be filled every day and may allow twice a week feeding if their capacity is sufficient.

The constant availability of feed may lead to greater intake, weight gain and feed conversion efficiencies, however, if feeding for maintenance this may not be the required outcome.

Self-feeders are relatively expensive; however, less linear feeding space is required per head and they are reasonably robust.

There are numerous self-feeder systems available commercially.

Cows and calves being fed on the ground with a total mixed ration. Note the faecal contamination of the feed. Photo credit: Brett Littler.

Sheep being fed a total mixed ration with a Keenan mixer. Photo credit: Geoff Duddy.

Most sheep-based systems utilise a 'lick' mechanism to semi-regulate daily grain and/or pellet intakes. The 'lick' mechanism is designed to minimise gorging/overeating of grain or pellets and therefore minimise acidosis risk. Regardless of testimonials and anecdotal evidence, no 'lick' style feeder has consistently shown that they can accurately deliver maintenance and/or survival only amounts within confinement feeding systems.

There are a limited number of self-feeders available that can efficiently deliver total mixed rations. The roughage component of total mixed rations restrict their ability to "flow" through self-feeders and can result in the grain and roughage separating or the ration bridging in the feeder and not being available to the stock. Self-feeders that can handle total mixed rations generally have a large opening or tray at the bottom, making the limiting of feed intake almost impossible.

Total mixed rations are more commonly used within cattle confinement systems and bunk style troughing remains the primary feeding system used. Self-feeders may be used when higher intakes are acceptable, however, troughs are still usually required to start cattle on feed.

Self-feeders can make it difficult to change grains or ration mix quickly.

Recommended self-feeder space allocations for rectangular feeders are:

- Sheep: 3-5 cm/head (100-120 head per 2.4 metre feeder).
- Cattle: 7-10 cm/head (50-70 head per 2.4 metre feeder).

For round silo type self-feeders, experience has shown that it is possible to increase the number of animals per linear metre. For all types of feeders, it is better to provide more space than less.

Fences

Sheep

Most confinement pens for sheep can be erected quickly and relatively cheaply.

Commonly used materials include:

- standard 7/90/30 (*) hinge joint or ring lock fencing. Using narrower width wire (for example 15 cm width) may result in sheep getting their heads stuck
- steel posts – spacings generally between 3-5 m
- wooden posts (treated) – spacings generally between 3-5 m
- 'carry' wires (plain) – options for bottom, middle (belly) and top. If end assemblies are robust belly wires can be omitted
- strained plain, barbed or off-set electric wire at the base of each fence line pen are optional
- a barbed top wire is unnecessary.

A total mixed ration with conveyor belt trough. Light cable with tensioners. Photo credit: Geoff Duddy.

Cattle

Confinement pen fencing for cattle needs to be slightly more robust than that for sheep. They should be a minimum of 1,200 mm high, preferably 1,500 mm or higher.

Commonly used materials include:

- existing hinge joint or ring lock fence, reinforced with off-set electric wires. Be careful of such fence types as cattle, particularly calves, may become entangled. These fences are particularly suited to small paddock confinement areas
- 5-6 plain wires. May be reinforced using internal, off-set electric wire(s)
- 3-line electrified fence
- steel cable - the more elastic 'curly' type is preferred as it does not require a turnbuckle for tensioning, straight wire cable need turnbuckles to be installed on strainer posts to allow periodic re-tensioning
- bore casing, pipe, railway iron and/or heavy gauge, capped RHS (rectangular hollow sections) or SHS (square hollow sections) posts can be used – these should be hydraulically rammed and/or concreted.

Rail/wire spacings should be close enough to restrain small calves and prevent adult cattle attempting to get through.

Barbed wire is unnecessary and is not recommended for confinement areas due to potential hide damage.

(*) refers to the wire specifications where 7 refers to the number of horizontal wires, 90 is a roll's height (in cm) and 30 is the width (in cm) between vertical wires.

Laneways

A good lane system will help during feed-out and when moving stock to or from the confinement area.

Lanes should be between 4-6 m wide to facilitate stock flow and allow machinery access and should be constructed with cable or plain wire. Avoid the use of barbed wire or electric wires if possible.

Gateways

Wide gateways are preferred. The turning circle and width of feed-out vehicles needs to be considered. Gateway design should allow easy access to pens and feed-out areas. Wide gates also encourage good stock flow in and out of pens, reducing stress on the animals.

Roads

Internal roads need to be sufficiently formed to allow all weather access to the confinement feeding area. Generally compacted gravel roads 4-6 m wide are sufficient for one-way traffic. Gravel roads should have a crossfall of around four per cent to aid in the drainage of water off the road surface.

Thought should also be given to areas where feed delivery vehicles may need to turn after delivering feed. Turning circles should be as large as practical. Depending on the vehicle, a turning circle should have a minimum radius of about 10 m.

Feeding cattle being fed in a raised trough. This a feed out trailer that has been adapted with a soft cover to ensure minimal wastage into the trough. Photo credit: NSW DPI.

Sheds and feed storage

When establishing a confinement feeding area, thought needs to be given to the equipment and quantity of feed that will be required to feed your livestock.

Traditionally, existing sheds, grain and roughage storages are used for confinement feeding.

The location of these existing resources will have a significant impact on the time taken to prepare and deliver feed to the confinement area.

Ideally these should be close together, especially if you are preparing total mixed rations, where all the ration components are combined in a mixer. Having to travel distances to source individual ingredients will add a large amount of time to the feed preparation process.

The use of commodity sheds, where the individual components can be stored in adjacent, open bays can greatly speed up the mixing process.

Again, these storage facilities do not need to be elaborate, however they do need to keep the commodities dry and allow access in any weather. Existing machinery or even hay sheds can be suitable with temporary bays constructed using straw bales.

Early weaning with self-feeders in the pen. Photo credit: Jill Kelly.

Working yards

Situating confinement feeding areas close to existing stock yards will eliminate the need for additional stock handling facilities to be built.

If the confinement feeding area is a significant distance from your existing stock yards, some basic handling facilities may be required to be setup to assist with the treatment of sick or injured animals, especially with cattle.

A simple portable yard setup with a race will be sufficient in most cases. A cattle crush would ideally also be included in the yards.

The provision of a small holding yard that can be used as a hospital pen for shy feeders, poor doers, sick or recovering animals is also beneficial.

Cattle being fed in a concrete trough. The electric wire stops them from pushing through and can be adjusted. Photo credit: Brian Cumming.

Side trough belt. Photo credit: Geoff Duddy.

Resources

Beef cattle feedlots: design and construction *Site design Section* (Meat & Livestock Australia 2015)

Key points

- Look to incorporate confinement pens in and around existing infrastructure to reduce establishment costs.
- Confinement pens do not need to be elaborate – they just need to be functional!
- Feed bunk or troughing are recommended in confinement feeding areas.
- Recommended trough and self-feeder space allocations are provided for different classes of stock.

Confinement feeding -feed requirements

A mix of grains, additives and cottonseed. Care will need to be taken to avoid sorting with sheep. Photo credit: Jill Kelly.

Livestock feed requirements in confinement

When confinement feeding, it is critical that the animal's energy, protein, vitamin, mineral and roughage requirements are met. Daily dry matter or 'as fed' intakes and requirements will depend on animal liveweight, age, feed quality and the animals physiological state (for example dry, pregnant, lactating).

Actual intakes will also be affected by factors such as water quality, mineral deficiencies, feed-trough allocations, environmental issues (temperature, wind, rain, humidity), feed palatability, health issues and social standing/stress.

In general sheep and cattle will consume between 1-3% of their liveweight on a daily basis.

Young, liveweight lambs and calves on a high grain or pelleted diet with minimum roughage may consume 5% of their liveweight. Consumption will decrease (as a percentage of liveweight) as they mature.

Guidance about minimum daily feed requirements, for both sheep and cattle can be found in the publication *Managing Drought*, NSW DPI (2019). Please refer to the Full hand feeding of beef cattle and Full hand feeding of sheep sections of that publication for further information. Note that allowances need to be made for waste, pregnancy, lactation and cold stress.

When confinement feeding, it is important to know the actual quality of the different feeds making up the ration.

It is important that you buy, and feed, based on the actual feed quality, energy and protein value. Feeds should be compared on a dry matter basis, as the water content of feeds has no nutritional value but can greatly influence the quantity of feed that needs to be fed and therefore the price.

Feed tests are a relatively cheap and reliable way to obtain actual dry matter, energy and protein values of the different feeds either grown on farm or purchased in. Knowing the actual quality of your feed allows the use of apps or on-line feed calculators to formulate balanced rations and quantities to be fed. Additional information about how to interpret feed tests is included in the ***Confinement feeding – resources*** chapter of this guide.

Refer to the ***Confinement feeding – budget tools and calculators*** chapter of this guide for apps and on-line calculators that can assist with formulating least-cost rations and other calculations.

Be particularly mindful of feeding high rates of low quality, fibrous feeds. High roughage diets of low energy value are difficult to digest and stock may not be able to consume enough to meet their requirements.

Ewes eating a total mixed ration after filling in a simple trough. Photo credit: NSW DPI.

Early weaned calves. These calves are being fed a by-product concentrate and are on adlib cereal roughage.

Sheep have selected out the grain from the pellets. Photo credit: Jill Kelly.

Energy

The most important indicator of feed quality. Energy in feed is used for maintenance, growth, muscle development and fat storage. It is measured in megajoules of energy per kilogram of feed dry matter (referred to as Metabolisable Energy = MJ/kg DM).

The 'form' in which grains or any feed type store their energy will dictate the energy available within a ration. In terms of energy value:

- carbohydrates (starch, sugars, cellulose) generate between 15-18 MJ/kg DM
- oil with 36-40 MJ/kg DM is an energy dense component.
- A feed's oil component is usually described as 'ether extract' or 'crude fat' on a feed test. Due to potential negative impacts on rumen function, digestibility and palatability, no more than 7-8% of oil is recommended within a ration and 5% for younger animals. All feeds contain oil to varying degrees.

Protein

Protein is needed for muscle development, appetite and wool production. Inadequate protein will lead to a reduction in gut bacteria, digestion slows down, and intake drops. Pulses and meals are usually cheaper per unit of protein than cereal grains.

Two sources of protein are available for the ruminant to use — protein from feed and microbial protein.

Feed crude protein sheep and cattle ingest is either digested in the rumen or may 'bypass' breakdown and pass on to the lower gut. Rumen microbes break down most protein into ammonia, amino acids and peptides, which are used along with energy from carbohydrate digestion for growth and reproduction.

A healthy rumen with a good balance of microbes leads to greater protein intake when these are "washed" out of the rumen into the abomasum.

Minimum protein and energy requirements for varying livestock production states are outlined in the table below.

Table 1. Minimum protein and energy requirements for various production states for sheep and cattle.

Production state	Crude protein CP %	Metabolisable energy (MJ/kg DM)
Maintenance	7	8
Lactation and late pregnancy	12+	12+
Growth	12+	10+
Finishing (depending on age)	12 – 15	11 – 12

More detailed information about other critical components of feed requireents can be found in the following chapters:

Roughage/fibre: refer to ***Confinement feeding - fibre requirements***

Minerals: refer to ***Confinement feeding - minerals***

Vitamins: refer to ***Confinement feeding - vitamins***

Feed mix for lambs. Lupins are used to increase overall protein and balance the ration for the lamb's growth and development. Photo credit: Geoff Duddy.

Ewes eating whole grain off the ground. Photo credit: NSW DPI.

Cottonseed being fed to cattle in a cut out tractor tyre with a base of conveyor belting. Photo credit: Brett Littler.

Resources

NSW Managing Drought Guide (NSW Department of Primary industries 2019)

Key points

- When confinement feeding, an animal's energy, protein, vitamin, mineral and roughage requirements need to be met.
- Feed requirements will depend on animal liveweight, age, feed quality and the animals' physiological state.
- It is important to know the actual energy and protein content of feeds being fed.
- Feeds need to be compared on a dry matter basis.
- High roughage diets of low energy value are difficult to digest, and stock may not be able to consume enough to meet their requirements.

Confinement feeding -feed: grains

A total mixed ration with grain in prefab feed trough with hinged lid. Photo credit: Geoff Duddy.

Grains

Cereal grains (eg. wheat, triticale, barley, sorghum, corn and oats) will be the primary feed used within most confinement feeding systems. Cereal grains are a concentrated source of energy, with much of that energy stored as starch. They provide protein, vitamins, minerals and some fibre.

Pulses (e.g. lupins, peas, beans) as well as processed meals (e.g. canola, cottonseed, soybean) are used primarily to improve protein levels within a ration. Pulses are higher in protein than cereal grains but on an energy basis they are usually more expensive than cereals.

Processing grains

There is generally no advantage in cracking, rolling or flaking cereal grains when feeding to sheep or lambs. Trial work has repeatedly shown that feeding whole grain can increase intake and growth rates; improve feed conversion efficiency and reduce acidosis risk. There may be some advantages in processing pulse grains to minimise 'sorting' and wastage of grains.

Some degree of processing will improve grain utilisation when confinement feeding cattle. Improvements in digestibility of 8-15% are possible. Grain processing usually involves either grinding (hammer mill, disc mill) or rolling dry or tempered (water added) grain.

If grinding or dry rolling the grain, the target is to mechanically crack or break the seed coat without creating too many fine particles. Fine grinding or powdering, which can often occur with hammer mills or disc mills, can reduce animal performance and greatly increase the acidosis risk.

Grain poisoning or 'acidosis' is a common health issue when feeding high grain rations. It is caused by the accumulation of lactic acid within the rumen following the breakdown of highly fermentable carbohydrates such as starch.

Over processed grain increases the risk due to the smaller particle sizes increasing the starch availability and fermentation rate in the rumen.

Tempering is the process of adding water (8-13%) to whole grain 8-24 hours prior to processing with a roller mill. The aim is to increase the moisture content of the grain to 20-23% before processing. Tempering the grain has the effect of dramatically reducing fine particles, allowing a more consistent roll and reducing the energy cost of milling.

A mix of grain and an additive pellet. The mesh above is used to limit intake and reduce selectivity.
Photo Credit: Geoff Duddy.

Calves being fed grain on conveyer belting.
Photo Credit: Brian Cumming.

Cattle fed tempered rolled grain have a lower risk of acidosis and achieve better weight gains and feed conversion efficiencies than cattle fed rolled dry grain, however the additional labour, skill and infrastructure costs need to be considered if choosing to feed a tempered ration to confinement fed cattle.

Dry rolling is generally the most appropriate and cost-effective method for processing white grains (wheat, barley, triticale), while sorghum and corn may require additional processing to improve utilisation. In a mixed ration, whole oat grain is well digested by cattle and does not require any processing.

Whether grains are processed or not, slowly introduce grain to stock to allow the rumen environment time to adapt to the increase in acid production. Adequate 'effective' fibre (ensuring a stable, active rumen) and buffers minimising acidosis risk should also be considered.

Pre-training and backgrounding

Sheep and cattle are 'neophobic' (scared of new things). Pre-training of lambs or calves prior to weaning can lead to a lifetime recognition and increased acceptance of grain(s) and of infrastructure (such as feed, water and supplement troughs, self-feeders and hay racks). Doing so also leads to improved grain uptake rates and fewer shy feeders.

'Backgrounding' is where stock are grouped together in an effort to acclimatise them to a confinement and/or intensive feeding system. It can reduce stress by allowing social pecking orders to be established well before entering confinement pens. Backgrounding improves feed intake, reduces health issues and allows 'poor doers' or 'shy feeders' to be removed early.

Cows being fed a processed grain mix in a tractor tyre. Photo Credit: Jeff House.

Grain quality

There is considerable variation in quality within grain types and between years. A feed analysis providing energy, protein, dry matter and digestibility values is recommended prior to starting confinement feeding.

Table 1 lists average energy, protein, starch, fibre and oil values for a number of grains or grain-based feeds. Note that energy values per kilogram of dry matter vary little between grains. Where the energy comes from in terms of starch or oils does however vary and can have major implications in terms of acidosis risk in particular.

For example, wheat with 13.5 MJ ME/kg DM consists of ~76% starch and between 1-2% oil and is recognised as the most likely grain to cause acidosis. Oats (12 MJ ME/kg DM) has ~90% the energy value of wheat. It contains however only 55% the starch of wheat but has more oil (7-10%). Oil has approximately 2.25 times the energy value of starch – hence the greater than expected energy value of oats.

Table 1: 'Average' energy, protein, starch, fibre and oil contents of the common cereal and pulse grains.

Grain	Energy (Mj/kg DM)	Protein (%)	Starch (%)	Fibre (%)	Oil (%)
Wheat	13.5	13 %	76%	2-3%	1-2%
Triticale	13.0	13%	76%	2-3%	2-3%
Corn	13.0	8%	76%	2-3%	2-3%
Sorghum	13.0	12%	70%	3-5%	3-4%
Barley	13.0	12%	61%	5-7%	1-2%
Oats	12.0	10%	42%	12-25%	7-10%
DDG *	12.5	25%	6%	6-8%	4-5%
Cottonseed	13.0	22%	38%	18-24%	12-16%
Lupins	13.0	35%	<10%	10-15%	5-9%
Peas	12.5	25%	48%	9%	0.5%
Beans	12.5	25%	37%	11%	1.5%

* DDG = Dry Distiller Grains. A nutrient rich co-product of dry-milled ethanol production.

Grain specifics

Wheat and triticale

- Most dangerous of cereals due to high starch and low fibre levels. Introduce slowly.
- Highest in protein of cereal grains.
- High gluten levels in wheats may lead to 'pasty' digesta.
- Limit to 40% of ration if possible (30% if a durum wheat) and/or ensure adequate fibre and buffers.
- Triticale is highly attractive to weevils and will need controlling if stored for any length of time.

Barley

- One of the most common grains used in livestock feeding.
- Similar energy value to wheat, but the possibility of digestive upsets is lower due to lower starch, higher oil and higher fibre contents.
- Six-row barleys have higher protein content. Two-row barleys contain more starch and less protein and are preferred for brewing (barley with more than 11.5% protein causes beer cloudiness).
- Phosphorus content is lower than wheat or oats, requiring less calcium supplements when looking to balance calcium to phosphorus ratio (Ca:P).
- Higher in potassium than other feed grains. Could impact on magnesium availability and absorption.
- Palatable and the highest in vitamin A and E of cereal grains.
- Storage (weevils) may be a problem.

Sorghum and corn

- Lower levels of starch fermentation in rumen but higher fermentation in small intestine compared to other cereals. This 'bypass starch' component generally leads to more energy (glucose) being produced compared to starch digested in the rumen but may cause 'hind-gut' acidosis.
- Low to variable protein contents.
- Low sulphur in corn may need correcting, particularly if feeding to wool-based sheep breeds.
- Tannins in sorghum seed coat may 'reduce' protein availability and fibre digestion.
- Sorghum tends to shatter when processed and produces more fines and increasing the risk of acidosis.

Oats

- Generally safer due to higher fibre levels and lower starch levels.
- Reasonable energy levels due to oil component.
- Digestibility's may be low (particularly Coolabah, Echidna and Mortlock varieties) due to high lignin content in hulls (lignin digestibility <40%).

Dry distiller grains (DDG)

- By-product of ethanol production.
- Low starch, reducing acidosis risk. Majority of energy obtained from sugars and oil.
- Highly degradable protein. Can be an issue in terms of ammonia production.
- As with all cereals low in calcium relative to phosphorous.
- Low sulphur content and deficient in lyseine and methionine.
- Few to no anti-nutritionals.
- Commonly fed as is or in pelleted form.

Cottonseed

- Generally safer due to higher fibre levels and lower starch levels.
- Difficult to feed in feeders, usually fed as part of total mix ration or ad-lib.
- Intake generally 'self-limiting' due to effect of high oil content on rumen function.
- Calcium to phosphorus ratio (Ca:P) imbalance as with cereal grains.
- Adequate magnesium but its high potassium levels may reduce magnesium availability and absorption.

Lupins

- Safe feed as high fibre, low starch levels.
- Energy from oil (5-9% depending on variety) helps keep total energy available high.
- May be intake or palatability issues with 'narrow leaf' varieties due to alkaloids that impart a bitter taste. Soaking overnight before use can reduce bitterness.
- Recommendation is no more than 40% in a ration as have been known to cause yellowing of carcases and soft fat problems.
- Soaking or processing of lupins for cattle will increase utilisation and reduce waste.

Peas and faba beans

- Generally safer than most cereal grains although a high percentage of their starch is digested in the hindgut so there is an acidosis risk.
- Similar starch component as oats so considered as a reasonably safe grain in terms of acidosis risk. Take care however if cracking as doing so increases the surface area of starch available to bacterial breakdown and will increase acidosis risk.
- May be some issues with tannins (affect protein availability); trypsin inhibitors (trypsin is an enzyme that helps stock to digest protein) and protease inhibitors (these reduce the activity of trypsin). Generally, not a major concern though as both peas and beans have high initial protein contents and low inclusion rates, reducing impacts on intake.

Key points

- There is generally no advantage in cracking or rolling cereal grains when feeding to sheep or lambs.
- When feeding cattle, some degree of processing will improve grain utilisation.
- Slowly introduce grain to stock to allow the rumen environment time to adapt.
- Adequate 'effective' fibre and buffers can reduce acidosis risk.
- Pre-training of lambs or calves prior to weaning can lead to a lifetime recognition and increased acceptance of grain and confinement feeding infrastructure.

Confinement feeding -feed: pellets

Grain has been selected out of the mix, leaving the pellets behind. This is more of an issue with sheep and can occur for a number of reasons. Photo credit: Jill Kelly.

Introduction

Pellets can be an effective and convenient addition, or in some cases, alternative to grain-based rations.

During the pellet manufacturing process feed ingredients are:

- moistened and mixed together
- 'conditioned' with steam which coagulates/ binds ingredients and aids in breaking down the outer layer of starch granules. This increases the digestibility of the feed
- forced through a die press, cut to size, cooled and dried to ~90% dry matter.

Types of pellets

Fibre only

Made principally from 100% forage plants (for example grass, legumes). It may include some additives. Roughage-based pellets are less likely to cause acidosis than grain-based pellets.

Complete feed pellet

Composed of feed elements to provide energy (usually cereal grains, mill run, grain by products) and protein (pulses, meals, urea), roughage and additives (vitamins, minerals, buffers).

Most of these pellets are cereal grain based, using cracked or semi-processed grain. Cracking grain increases the surface area of starch molecules and access by rumen bugs, ultimately increasing the risk of acidosis. Adequate buffers, fibre and management protocols must be in place to minimise acidosis risk when using pellets as a complete feed.

Concentrated feed pellet

Principally a supplement looking to correct a deficiency and/or improve intake and performance of stock. May constitute from 1-5% of intake. Can be included within a ration or offered free choice.

Premix feed pellet

Pellets composed of feed additives only. These may include trace elements, vitamins, minerals or ionophores. Generally, less than 1% of an animal's intake. May be included within a ration or offered free choice.

Pellet manufacturers should provide a complete list of pellet components and provide guidance if there are any withholding periods that need to be observed when feeding pellets to livestock. It is essential that no restricted animal material (RAM) is included in the pellets and they are suitable to be fed to sheep or cattle. Pellet manufacturers should be able to provide documentation guaranteeing the pellets are free of RAM and suitable for sheep or cattle.

Very small pellets are harder for stock to sort out. Not suitable for trail feeding for cattle as large amounts of waste. Photo Credit: Brett Littler.

Medium sized pellets. These are a by-product of ethanol production and have had some grain added to make a pellet. Photo Credit: Brett Littler.

Pellet sizes

Pelleted feeds are available in a variety of sizes (diameters) and lengths.

They generally range from between 5-10 mm (for sheep) and up to 25 mm in diameter for cattle. They are also known as nuts or cubes.

Larger pellets (compared to smaller diameter pellets made from the same ingredients):

- will tend to have more fibre (to aid the drying process)
- may have slightly lower digestibility
- may have an increase in chewing/rumination time and production of saliva (reducing acidosis risk)
- may be more prone to powdering.

Larger pellets are more easily sorted out of a mix for sheep but will be more easily picked up by cattle if trail or dump feeding. Photo Credit: Brett Littler.

Pellets – advantages and disadvantages

Advantages of pellets may include:

- Ease of use – no need for specialised handling/ feed out equipment.
- Reasonably easy to estimate feeding rates.
- They provide a 'complete' and 'balanced ration' in terms of meeting an animal's energy, protein, vitamin and mineral requirements.
- They may reduce acidosis and other health risk issues (depending on additives included in the pellets).
- Pellet manufacturers can use a range of feed elements including 'difficult to feed' and/or 'poor quality' products (eg millrun, hulls, husks, antibiotics, ionophores).
- A decrease in feed wastage, dust/fines or spoilage (compared to grain/hay fed separately).
- Reduced selection or substitution of feed grains.
- Improvements in animal performance.

Disadvantages when using pellets may include:

- Increased engorgement/acidosis risk.
- Palatability and potentially digestibility issues.
- Powdering issues. Depends on quality of feed components included in the pellet/handling and pellet size. The smaller the pellet the more force is needed, leading to an increase in temperature due to friction. This ultimately strengthens the pellet = less powdering.
- Shorter retention time within the digestive tract. May lead to increased intakes without consistent or equivalent improvements in production = lowered feed conversion efficiencies.
- A higher cost per unit of crude protein (CP) and metabolisable energy (ME) than grain/hay rations (due principally to the cost of pelletising).
- A decrease in eating/chewing time, reducing saliva production, increasing acidosis risk and potentially boredom. Sheep and cattle under normal grazing conditions may have upwards of 30,000+ jaw movements a day. Confined animals on diets with less effective fibre/roughage will have fewer jaw movements and may seek stimulation through bark chewing, hair or wool pulling.
- Heat during the pelleting process may decrease the availability of amino acids destroy some vitamins.

When using a concentrate or pre-mix pellet, be mindful of sheep and lambs 'sorting' or selecting against these pellets.

A word of caution: Be careful!

If feeding a pellet only ration – most manufacturers will recommend additional roughage be provided to maintain rumen function. Fibre has many roles but unfortunately fibre within pellets is ground and, in most cases, is not of sufficient length to be 'effective fibre' necessary for stimulation of the rumen and production of saliva/natural buffers.

If tempted to feed cattle pellets to sheep and vice versa – cattle pellets frequently contain higher concentrations of some additives or elements that can cause health issues or death in sheep. For example, copper rates within cattle pellets are usually higher than sheep requirements and may cause copper poisoning if fed to sheep.

If changing between pellet batches, even if sourced from the same pellet manufacturer, a sudden change from one pellet source to another can cause digestive upsets, liveweight loss and/or death. The issue is generally caused by a change in the primary grain source used between pellet batches. Avoid issues by pre-ordering all pellet requirements well in advance.

If possible, check with the pellet manufacturer to see if a change to the pellet ingredients was made between batches.

If changing pellets is unavoidable, start the change before running out of the first pellet source. Gradually introduce the new feed by replacing 20% of the old feed with the new pellet (on a weight basis). If stock scour or have digestive problems during the changeover period, hold the ration constant and provide extra roughage until faeces return to normal.

Pellets sometimes do not handle much processing and can easily powder and lead to increase waste and increased risk of acidosis. Photo Credit: Brett Littler.

Key points

- Pellets can be an effective and convenient addition, or in some cases, alternative to grain-based rations.
- Pellet manufacturers should provide a complete list of pellet components and provide guidance if there are any withholding periods that need to be observed when feeding pellets to livestock.
- When using pellets, either a concentrate or a pre-mix, sheep can have a tendency to sort the ration, often leaving the pellets behind and not consuming pellets at the recommended rates.

Confinement feeding -feed: alternate and by-products

Cows and calves eating cottonseed. This feed is relatively safe and can be fed infrequently. Photo credit: Brett Littler.

Introduction

A wide range of alternate and by-products feeds can be fed to sheep and cattle.

By-product stock feeds include 'any plant material not produced primarily for livestock consumption, such as waste fruit, vegetables and fibre crops, including peel, pulp, pressings, stem and leaf material'.

Alternate feeds include grain by-products, cottonseed, oilseed meals, tallow or molasses.

Before purchasing or feeding alternate or by-product feeds producers should consider:

- the feed's energy, protein and/or roughage value on a 'dry matter' basis compared to traditional feed types
- the feed's ability to meet the animals' requirements
- any digestibility, palatability (for example moulds, off-taste, rancidity or odours), poisoning, impaction or choking risks
- feed availability, practicalities of handling and feeding out, wastage levels and any neophobia issues (where stock may be wary of new feedstuffs and require training before accepting the feed)
- contaminant risks such as weed seeds
- mineral imbalances and/or long-term health issues
- chemical residues (if stock are to be sold within 60 days of being fed by-products, producers must tick 'Yes' to the relevant question on the LPA NVD/Waybill)
- toxicity issues
- extremely high moisture levels make levels of supplementation unrealistic.

Alternate and by-product feeds can be defined as energy, protein and/or roughage rich feed sources. Some may meet two or more of these specifications.

Feeding restricted animal material is illegal under the *NSW Biosecurity Act 2015*. This feed ban is in place to minimise the risk of bovine spongiform encephalopathy (BSE or mad cow disease) occurring in Australia.

Almond hulls can be fed in a mix or on their own. They are good in energy but have low protein. They are a good roughage when unprocessed as in this photo.
Photo Credit: Sue Street.

Cottonseed used in the mix to better balance the ration.
Photo Credit: Jill Kelly.

Food wastes

Generally, these are seconds or products that have had a production issues or are outside of used by dates making them unfit for sale.

Table 1 describes the nutritional breakdown of these or selected food waste products.

Table 1: Nutritional information for common types of food waste products.

Food wastes	Dry matter %	Crude protein %	Acid detergent fibre %	Digestible dry matter %	Metabolisable energy MJ/kg DM
Biscuits	84	8	13	76	11
Bran/pollard	91	17	17	77	12
Bread	69	17	3	89	13
Cereals	93	12	6	83	13
Corn Flakes	95	8	4	83	13
Muesli	98	6	11	77	12
Nutrigrain	92	24	4	90	14

Bakery waste:

- bread, doughnuts, cakes etc are reasonable energy sources, high in fat and low in fibre
- can cause acidosis (high starch, low fibre), shelf life may be limited and may present as a choking risk
- **Feeding restricted animal material is illegal under the *NSW Biosecurity Act 2015*. This feed ban is in place to minimise the risk of bovine spongiform encephalopathy (BSE or mad cow disease) occurring in Australia.**

Cereal waste:

- generally high energy, mid to low protein feeds with reasonable fibre levels
- starch contents may pose an acidosis risk
- can be difficult to handle.

Fruits and vegetables

These are usually by-products of processing or are second grade material. There can also be issues making them not suitable for sale or human consumption.

Table 2 describes the nutritional breakdown of these or selected fruit and vegetable products.

Table 2: Nutritional information for common types of fruit and vegetables products.

Fruit and vegetables	Dry matter %	Crude protein %	Acid detergent fibre %	Digestible dry matter %	Metabolisable energy MJ/kg DM
Apples	49	2	9	78	12
Apple pulp	20	5	27	64	10
Banana	57	7	13	76	11
Carrots	13	10	11	70	12
Citrus pulp	18	8	25	67	10
Grape marc	51	13	61	39	6
Grape stalks	38	9	46	50	7
Lemon/orange pulp	14	9	21	69	10
Lemon peel & pulp	10	8	24	67	10
Oranges	13	7	14	70	12
Orange peel	43	9	24	68	10
Orange peel & pulp	14	8	20	70	11
Potatoes	12	10	3	70	13
Pumpkin	23	15	29	66	10
Turnip tops	10	16	25	70	10

Carrots:

- reasonable energy and protein
- most of the energy is sugar-based so ensure adequate roughage to minimise acidosis risk and scouring
- rich source of vitamin C (an antioxidant) and carotene (vitamin A precursor). Has caused milk and carcass taint issues
- highly palatable and readily consumed.

Citrus pulp:

- reasonable energy (~10MJ) and fibre but lowish in CP (7-8%)
- stock need to become accustomed to its smell and taste
- can be dumped or included in a ration
- good calcium source
- moisture content may be an issue.

Grape marc:

- stems, seeds and pulps remaining after wine grape processing
- low ME (6 to 9MJ), reasonable CP (12-13% but much is unavailable due to tannins)
- most energy is in the seeds (oil ~9%) – may be indigestible unless crushed (crimped marc)
- concerns regarding chemical residues (for example copper), oil impacts, rancidity issues and tannins and possible contaminents such as staples, wire and metal fragments.

Potatoes and pumpkins:

- high moisture, low fibre feeds so costly to transport
- reasonable metabolizable energy (10-12MJ), CP (10-15%) and digestibility's (65-70%)
- concerns regarding possible chemical residues, choking hazard, constipation/prolapse.

Hulls and husks

Hulls and husks are predominantly used as a fibre source.

Table 3: Nutritional information for common hull and husk products.

Hulls and husks	Dry matter %	Crude protein %	Acid detergent fibre %	Digestible dry matter %	Metabolisable energy MJ/kg DM
Almond hulls	90	5	24	66	10
Barley husks	94	6	41	53	8
Cottonseed hulls	93	8	63	36	5
Oat hulls	93	4	39	53	8
Pea husks	89	12	44	52	8
Peanut hulls	91	5	78	21	3
Rice hulls	93	2	74	23	4
Sunflower hulls	92	6	63	34	5

Almond hulls:

- outer covering of the almond (not the shell)
- contaminants (sticks, dirt, hard shells and other foreign materials) may reduce feed value/ acceptability
- reasonable ME (10MJ) and digestibility (60-70%) but low CP (4-5%)
- principally used as fibre source
- concerns regarding possible chemical residues.

Rice hulls:

- limited feed value
- low in energy and protein, high in fibre and silica
- highly indigestible but can be used as (limited) roughage source in total mixed rations.

Processed meals

Processed meals include those made following oil processing from crops including canola, coconut/copra, cotton, linseed, safflower, soybean and sunflowers. Most used in Australia have had the oil extracted by solvent/chemical procedures. Those that have had oil removed through pressure are known as 'extruded' meals.

These tend to have higher oil contents than solvent or chemically processed meal.

Availability or meals will be dependent on seasonality and in some cases importation. The quality may change as a result of process methods. Table 4 describes the nutritional breakdown of products.

Table 4: Nutritional information for common types of processed meal products.

Processed meal	Dry matter %	Crude protein %	Acid detergent fibre %	Digestible dry matter %	Metabolisable energy MJ/kg DM
Copra meal	92	25	30	65	12
Cottonseed meal	90	40	15	80	13
Canola meal	89	39	21	75	12
Safflower meal	92	25	40	65	12
Sunflower meal	90	32	32	62	9
Soybean meal	88	49	9	90	13
Palm kernel expeller	90	17	45	72	11.7

Coconut/copra meal:

- reasonable in energy, contains less protein than most meals
- rancidity can be a problem during storage if the meal is high in fat
- palatability and digestibility can be issues.

Cottonseed meal:

- a by-product of the production of cotton lint and cottonseed oil
- contains reasonable protein and has good palatability.

Safflower meal:

- reasonable in energy, contains less protein than most meals
- palatability can be an issue and should be limited to <20% in a total diet.

Soybean meal:

- high in energy and protein, palatable to livestock
- needs to be fed more regularly than other meals (at least 3 times per week).

Sunflower meal:

- mid-range with respect to protein compared to other meals.

Canola meal:

- a by-product of the oil extraction of canola
- very palatable and easily accepted by livestock
- high in both energy and protein.

Palm kernel expeller (PKE):

- a by-product of the oil extraction from palm fruit
- contains reasonable levels of energy and protein
- can have some palatability issues.

Other alternatives

Saltbush:

- as salt in the feed increases, appetite is suppressed, intake declines and digestion is disrupted
- saltbush can provide high intakes of protein (as non-protein nitrogen) but stock need to have a highly digestible energy supplement for 'production'
- if grazing saltbush alone livestock won't get sufficient nutrients for maintenance
- stock must have access to quality water.

Sawdust:

- little to no feed value
- high in lignin, low palatability and digestibility but can be used as a roughage source (5-15%).

Brewers/spent grain:

- a highly variable by-product of the brewing industry
- composition and nutritional value vary greatly depending on the grain used, the processing methods and the time since processing
- wet brewers/spent grain will spoil quickly and has a dry matter less than 30% on average
- it is a valuable feed source but because of high moisture content transportation and storage can be an issue
- are high in protein and fibre.

Sprouted grain/fodder:

- is a highly nutritious feed that through the sprouting process has converted the starch into sugars and fibre making it safer to feed. Sprouting changes the form but does not increase energy content.
- high energy and protein
- high moisture content, dry matter generally ranges from 6-15%
- has major limitations for practical and profitable use in livestock feeding operations. These are
  - high cost of production–(cost of capital, depreciation, labour, running costs)
  - scale of operation
  - handling of very high moisture feed
  - risk and issues of mould.
- evaluation of the costs and benefits of these systems needs to be conducted prior to investing in sprouted grain/fodder systems.

Cows eating palm kernel expeller (PKE). It is a feed that is safe and can be fed infrequently. Sometimes palatability can be an issue and must be fed with a roughage.
Photo Credit: Brett Littler.

Key points

- By-product stock feeds include any plant material not produced primarily for livestock consumption.
- Alternate feeds includes grain by-products, cottonseed, oilseed meals, tallow or molasses.
- Alternate and by-product feeds may be used as energy, protein and/or roughage feed sources.

Confinement feeding -feed: fibre requirements

Early weaned calves eating a total mixed ration with cereal hay used as the roughage. This ensures good performance and aides in rumen development. Photo Credit: Brett Littler.

Feeding fibre

Sheep and cattle are ruminants. Contrary to popular belief they do not have four stomachs–they have one stomach with four compartments consisting of the:

Rumen

The rumen acts as a fermentation vat where bacteria, protozoa and fungi ferment and break down plant cell walls into their carbohydrate fractions. Rumen bugs digest cellulose and starch, synthesise protein from nonprotein nitrogen, synthesise B vitamins and vitamin K and produce volatile fatty acids (acetate, butyrate, propionate). The rumen walls are lined with papillae (small nodules) for nutrient absorption.

Reticulum

The reticulum's lining has a honeycomb appearance. Its main function is to collect smaller digesta particles and move them into the omasum, while the larger particles remain in the rumen for further digestion.

Omasum

The omasum has many folds or 'leaves' that absorb nutrients from feed and water.

Abomasum

The abomasum is the "true stomach" of a ruminant. It produces hydrochloric acid and digestive enzymes allowing proteins and fats to be processed or broken down and absorbed.

Ruminants eat rapidly, swallowing much of their feedstuffs without chewing it sufficiently. Sheep for example, may only initially chew 30% of grain swallowed.

Feed components such as grain and fibre then undergo a process known as rumination or 'cud chewing' where they move back and forth between the mouth and the rumen, undergoing fermentation and mastication (chewing). In the process, provided adequate fibre is in the diet, a dense floating mat should form in the rumen. Newly ingested food such as starch rich grains initially fall onto this mat and digestion rates are slowed. Below the 'mat' previous feed ingested is slowly mixed and broken down/ digested, slowing digestion of high starch grains and maintaining a good rumen microbe balance.

The rumen is adapted for the digestion of fibre. Fibre reduces the rate of gut flow, contains enzymes needed for the breakdown of fat and starch, is involved in recycling of nitrogen to the rumen. It stimulates cud chewing or rumen contractions and cleans the rumen walls.

There are two measures of dietary fibre - **neutral detergent fibre** (NDF) and **acid detergent fibre** (ADF).

Neutral detergent fibre measures most of the structural, low to poorly digestible components in plant cells (for example lignin, hemicellulose and cellulose). As NDF increases digestibility and intake decline.

Hay is an import component in feeding but sometimes the delivery can be challenging. Photo Credit: Geoff Duddy.

Acid detergent fibre makes up a proportion of NDF levels and is a measure of the least digestible parts of a plant such as cellulose and lignin. As a rule, when ADF increases the digestibility of a feedstuff will decrease.

NDF was developed to specifically measure the fraction of fibre that stimulates chewing and contributes to the floating mat in the rumen. It is used to predict voluntary feed intake and the availability of net energy.

Low NDF values (< 20%) indicates the feed is high in energy, highly digestible and has a potentially high voluntary intake rate.

Physically effective NDF (peNDF) defines the physical, as well as the chemical characteristics of fibre. peNDF can be estimated through measuring the proportion of feed retained in sieves of varying hole sizes or through animal response (productivity, manure). It essentially measures a fibres effectiveness in terms of its ability to stimulate rumination, and hence saliva production, clean rumen walls and stimulate the release of digestive juices.

Aim for a minimum of 10% 'effective' fibre for sheep and cattle.

Hay over the head of animals is not ideal, as dust etc from the hay falls into eyes and face. Also using cattle feed out systems for sheep can be challenging. Photo Credit: Geoff Duddy.

Minimum fibre requirements and quality recommendations for all physiological states in sheep and cattle are outlined in Table 1.

Table 1. Minimum fibre quality and quantity recommendations for sheep and cattle within confinement systems.

Livestock sheep and cattle	Minimum fibre requirements (% of diet)	Minimum fibre quality
Dry	10	Low
Weaners	20	Med-high
Early pregnancy	10	Low
Late pregnancy	20	Med-high
Lactating	20	Med-high

A primary driver of effective fibre is particle size. For roughage sources such as hay or straw, particle lengths of 50–100 mm stimulate chewing and salivation. Increased particle lengths can lead to sorting when total mixed rations are fed. In these situations, chopping or processing roughage is generally required. Target lengths of 25 mm for sheep and between 25-50 mm for cattle.

Note: that ground or fine fibre found in pellets and most cereal grains is not effective fibre.

Increasing the amount of fibre in the ration/diet is recommended during cold and wet conditions.

Maintaining adequate fibre levels will:

- stimulate chewing/saliva production. Under normal grazing conditions sheep and cattle will produce between 6-16 litres and 100-190 litres of saliva daily.
- improve sodium and potassium bicarbonate production, buffering against acid production
- divert phosphorous away from the urine into the manure improving the calcium to phosphorus (Ca:P) balance within the urinary tract, reducing the risk and incidence of urolithiasis (water belly/ bladder stone)
- increases vitamin B12 absorption (needed for energy)
- provides additional vitamin D
- improves magnesium availability and absorption
- increases milk fat.

Inadequate fibre will lead to a reduction in rumen motility and possibly rumen stasis and ultimately acidosis.

As a general rule, if 40% plus of animals are 'cud chewing' fibre levels are adequate.

Monitoring manure can help determine the suitability of the feed on offer, general rumen health and whether the ration contains adequate fibre/roughage.

Sorting can be an issue with most feeders. Even better designed ones and sometimes you get the odd animal caught. Photo Credit: Brett Littler.

Lambs eating out of a hay feeder. We see selection and some waste, but it is less than if the bale is not fed in a feeder. Photo Credit: Sue Street.

A cheap and easy hayfeeder for these calves. These early weaned calves are being supplied with a palatable good quality legume hay which will assist in their performance. Care must when feeding poor quality overhead to stock. Photo Credit: Jill Kelly.

Manure monitoring consists of 3 “C’s” – colour, consistency and content!

Sheep

Commonly seen when a poor-quality diet low in protein and carbohydrates, high in low quality fibre.

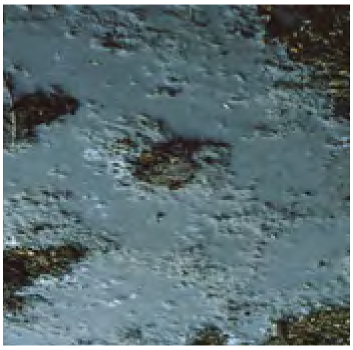
Stacked ‘pat’, solid, intact and ‘weetbix’ consistency. Ideal target consistency when on a grain and roughage diet.

Grey, runny manure and evidence of gas bubbles or undigested starch (white patches) indicates rumen acidosis.

Cattle

Clearly defined segments; very dry. Manure firm, stacked. Commonly seen when a poor-quality diet low in protein and carbohydrates, high in low quality fibre.

Stacked and forming a normal ‘pat’ more than 2.5 cm thick with a slight centre divot. Ideal target consistency when on a grain and roughage diet.



Creamy, soup consistency containing gas bubbles. Indicative of acidosis or a highly digestible ration that contains excess protein, carbohydrates or oil, and low fibre.

Key points

- The rumen is adapted for the digestion of fibre.
- Fibre reduces the rate of gut flow, stimulates cud chewing/rumen contractions, and cleans rumen walls.
- A primary driver of effective fibre is particle size, target 25 mm for sheep and 25-50 mm for cattle.

Confinement feeding - feed: minerals

A 1,000L shuttle converted into supplement minerals in a confinement feeding area. It is covered and protected from the weather. Photo credit: Brett Littler.

Minerals

Sheep and cattle are known to need at least 17 different minerals to maintain good health and production.

Macro minerals are needed in reasonably large amounts and form a significant proportion of the body. These include calcium (Ca), phosphorus (P), chlorine (Cl), magnesium (Mg), potassium (K), sodium (Na) and sulfur (S).

Minerals needed in much smaller amounts are known as micro minerals or trace elements. These generally help or increase the rate of chemical reactions within the animal's body.

There are major, ongoing interactions between minerals and vitamins within the animal's body. Unfortunately, mineral levels and bioavailability are not constant within any feed type. It is therefore difficult to clearly define recommendations for supplementation.

The percentage of a mineral that is absorbed or metabolised can vary with the animal's age, physiological state, the minerals chemical form and the presence and interaction(s) of other minerals in the feed or supplements.

Producers may:

- use commercially available 'broad' mineral supplements (usually in the form of a pelleted or dry mix)
- undertake a thorough mineral analysis of rations and seek professional nutritional advice to formulate a specific mineral for the ration in question
- make their own loose lick or dry mixes on-farm (based on 'average' mineral content and availability within feeds used).

The benefit: cost of the options above should be considered when feeding stock within confinement systems.

A mineral mix in a cut down plastic container. The mix of salt, lime and magnesium oxide together.
Photo Credit: Geoff Duddy.

Sheep eating from the mineral mix in a plastic drum.
Photo Credit: Geoff Duddy.

Macro minerals

Table 1 states the macro mineral requirements for sheep and cattle for both maintenance and production. Macro mineral values are measured in grams per kilogram of feed on a dry matter basis (g/kg DM). Of the major minerals, calcium, sodium, phosphorus and magnesium are the most important.

Table 1. Macro mineral requirements for sheep and cattle (maintenance and production).

	Sheep		Cattle	
Macromineral (g/kg DM)	Maintenance	Production*	Maintenance	Production*
Calcium	1.4	7.0	2.0	11.0
Sodium	0.7	1.0	0.8	1.2
Phosphorous	0.9	3.0	1.0	3.8
Sulphur	2.0	2.0	1.5	1.5
Magnesium	0.9	1.2	1.3	2.2
Potassium	5.0	5.0	5.0	5.0
Chlorine	0.3	1.0	0.7	2.4

* Production refers to growing, pregnant and/or lactating animal requirements.

Calcium (Ca)

Important for nerve function, muscle contraction, blood clotting, activation of a number of enzymes and bone formation.

Requirements increase if feeding energy-dense rations; in late pregnancy and early lactation or if there is a high potassium intake.

Deficiency symptoms include muscle weakness, paralysis and/or muscle tremors, "proppy" or staggering gait with head held high, an inability to stand or if the animal is prostrate on its brisket with head to flank.

Cereals, pulses and some meals are low in calcium. Legumes have more calcium than grasses.

An animal's ability to absorb and use calcium depends on its vitamin D3 status.

Control and prevention Finely ground limestone (calcium carbonate) is commonly included (1–1.5% weight/weight) when feeding grains. Acid salts (ammonium sulphate, magnesium sulphate etc) included at 0.5% (weight/weight) may increase calcium absorption from within the small intestine, improving overall calcium availability.

Treatment Affected animals generally respond quickly to an injection of commercial calcium solution at the recommended dose rate if treated quickly.

Magnesium (Mg)

Important for the metabolism of carbohydrates, lipids and protein, nerve conduction, muscle contraction and protection against milk fever. Approximately 70% of cattle and sheep body's magnesium is stored in the skeleton but it is poorly mobilised by adult stock. Young growing animals may use this store when consuming a magnesium deficient diet but all stock need a daily intake of magnesium to ensure optimal growth and production.

Requirements increase if stock are exposed to cold, wet and windy conditions with little or no shelter resulting in short periods of fasting, if animals are either fat and losing condition, or very thin. If roughage used within the ration was produced from pasture heavily fertilised with nitrogen and/or potash fertiliser and/or if calcium intake is excessive in comparison to magnesium intake.

Deficiency symptoms may include restlessness and/or an over-alert appearance, staggers or excitability or (occasionally) aggressiveness.

Control and prevention feeds that are prone to causing hypomagnesaemia are generally deficient in magnesium and sodium and have an excess of potassium. There are several magnesium supplements available including Causmag (magnesium oxide), magnesium chloride, magnesium sulphate (Epsom salts) and grass tetany blocks.

Hypomagnesaemia risk can be reduced through providing adequate salt, adequate fibre and a high energy diet as well as minimising stress (physiological and environmental).

Treatment must be prompt to be effective. It is best to subcutaneously inject a combined calcium and magnesium solution.

Phosphorus

Phosphorus works in conjunction with calcium in the formation of bone and is a component of DNA. Phosphorus is also involved in the chemical reactions of energy metabolism.

Approximately 80% of phosphorous in the body is found in bones and teeth.

Due to their mutual role in bone metabolism, calcium and phosphorus supplementation are usually considered simultaneously. The recommended calcium-to-phosphorus ratio is generally between 1.5 and 2 to 1.

Deficiency symptoms may include depressed appetites, poor growth rates, softening of the bones, lameness and an increased susceptibility to bone fractures, defective teeth and reproductive problems.

Acute phosphorus deficiency is unusual in intensive feeding systems as cereal grains typically have sufficient levels of phosphorus. Calcium phosphates (Dicalcium phosphate, Kynofhos and BioPhos) can be used to correct deficiencies. Phosphorus fertilisers should not be used to correct deficiencies as they may contain fluorine or other heavy metals.

Potassium

Potassium is essential for some enzyme functions, contraction of muscle, nerve impulse transmission and other functions of the nervous system. Potassium is also important to renal function, acid-base balance as well as electrolyte and water balance.

Deficiency symptoms may show as poor appetite, reduced performance and stiffness. High levels of potassium may also interfere with magnesium absorption and may lead to a magnesium deficiency.

Grain often contains less than 0.5% potassium and supplementation may be necessary in high-concentrate rations containing limited quality fibre. Hays, haylage or silage generally contain adequate levels of potassium.

Protein dry lick supplement based on urea and a protein meal. This supplement is being fed to cattle and has a number of minerals added. Phosphorus is one of the components added to fix an imbalance. Photo credit Brett Littler.

Macro mineral interactions

The availability of, and interactions between calcium, phosphorous, magnesium, sodium and potassium are further discussed below.

Calcium to phosphorous ratio (Ca:P)

Livestock seem to be able to tolerate wide calcium to phosphorus ratios if their diets contain more calcium than phosphorus. An excess of phosphorus however can lead to a number of health issues such as urinary calculi or hypocalcaemia (see ***Confinement feeding – health and welfare*** chapter of this guide).

All cereal grains, pulses and processed meals have lower calcium to phosphorous ratios, well below the recommended 1.5 or 2 to 1.

Pastures, and therefore hays and silages, tend to have more calcium than phosphorous. Be mindful however of moisture contents within the grass/crop-based pastures and the stocks ability to consume adequate levels of dry matter to guarantee adequate calcium intakes.

Legumes have greater calcium than grass/cereal crop pastures.

Most references recommend a minimum calcium to phosphorous ratio of 1.5 calcium to every 1 phosphorous (1.5 to 1) or 2:1.

Potassium relative to calcium and magnesium {K/(Ca + Mg)}

Known as 'Grass Tetany Index', low magnesium or calcium in forages can affect animals by producing low blood serum magnesium or calcium. High plant potassium can also have an antagonistic effect on magnesium concentrations and absorption. These singularly and/or combined can predispose stock to hypomagnesaemia and/or grass tetany (see ***Confinement feeding – health and welfare*** chapter of this guide).

A measure of a diet's 'grass tetany risk' can be calculated by calculating the ratio of potassium to total calcium and magnesium {K/(Ca + Mg)}. If the ratio is greater than 2.2, then the risk of grass tetany and/or hypomagnesaemia is high.

All cereal grains, pulses, processed meals and crops/pastures are deficient in sodium relative to potassium. This may exacerbate the impact of potassium on magnesium absorption.

High potassium intakes will reduce sodium absorption. This can impact on muscle and nerve function, growth rates and production.

K/(Ca + Mg)

Cereal grains, most pulses (other than Lupins), copra meal and grass/crop-based pastures have values in excess of the recommended ratio.

Brassica, canola and legume pastures generally fall below the Grass Tetany Index risk value.

Potassium relative to Sodium (K:Na)

Both sodium and chlorine function to maintain the volume, pH and osmosis of body fluids. Sodium is involved in muscle and nerve function and in transporting magnesium into cells.

Increases in sodium intake or a high Na:K ratio in the rumen contents have been shown to improve the absorption of magnesium within the rumen.

Low sodium intakes may exacerbate the impact of potassium on magnesium absorption. A potassium to sodium ratio of less than 7:1 is recommended. At or below this level the impact of potassium on magnesium absorption is reduced.

Implications

If we look at the average levels and relative values of calcium, magnesium, potassium and sodium in our common feed grains, processed meals and pastures (and therefore hays/silages) we can start to understand why some mineral supplements are necessary within confinement feeding systems.

Table 2: Average mineral content (g/kg DM) and mineral ratio's found in common feedstuffs. The shaded numbers below highlight where the ratios are outside the recommended ratio targets.

	Feed type	Ca	P	Mg	K	Na	Ca/P	K/(Ca+Mg)	K/Na
Grains	Barley	0.8	3.9	1.3	5.7	0.1	0.2	2.7	57
	Corn	0.7	3.4	1.4	4.3	0.1	0.2	2.0	43
	Oats	1.1	3.6	1	4.9	0.1	0.3	2.3	49
	Sorghum	0.3	3.8	1.7	4.6	0.2	0.1	2.3	23
	Triticale	0.7	3.9	1.2	5.8	0.1	0.2	3.1	58
	Wheat	0.7	3.6	1.2	4.6	0.1	0.2	2.4	46
	Brewers grain	3.0	5.8	2.3	1.6	0.3	0.5	0.3	5
	DDG	2.1	9.1	3.7	10.9	4.9	0.2	1.9	2
	Cotton seed	1.5	5.9	3.6	12	0.1	0.3	2.4	120
Pulses	Chickpea	1.7	3.9	2.1	11.9	0.2	0.4	3.1	60
	Cowpeas	1.2	4	2.3	15	0.1	0.3	4.3	150
	Faba beans	1.5	5.5	1.8	11.5	0.1	0.3	3.5	115
	Lupin (Narrow)	2.7	3.5	2	9.3	0.5	0.8	2.0	19
	Lupin (Albus)	2.9	9.2	2	9.5	0.5	0.3	1.9	19
	Copra meal	0.7	6.5	3.3	22.8	0.6	0.1	5.7	38
	Cotton seed meal	2.0	12.4	6.3	16.6	0.3	0.2	2.0	55
	Canola meal	7.4	11.6	5.7	13.7	0.5	0.6	1.0	27
	Sunflower meal	4.4	11.6	5.6	16.9	0.1	0.4	1.7	169
	Soybean meal	4.6	7.2	3.2	21	0.2	0.6	2.7	105
	Barley pasture	4.9	1.7	2.4	14.0	0.9	2.9	1.9	16
	Oaten pasture	3.8	2.2	1.3	22.2	1.2	1.7	4.4	19
	Wheat pasture	3.8	2.6	1.2	20.0	0.1	1.5	4.0	200
	Brassica	3.0	0.5	0.2	4.5	0.5	6.0	1.4	9
	Canola	2.7	0.4	0.3	3.0	0.2	6.8	1.0	15
	Lucerne	1.3	0.3	0.3	2.5	0.1	4.3	1.6	25
					Ratio targets		**>1.5 to 1**	**<2.2 to 1**	**<7 to 1**

Source: Feedipedia website

Micro minerals

Micro minerals or trace elements (chromium, cobalt, copper, iodine, iron, manganese, molybdenum, nickel, selenium and zinc) generally help with, or increase, the rate of chemical reactions within the animal's body. Many are components of enzymes (a substance which acts as a catalyst to bring about a specific biochemical reaction).

The following table illustrates the micro mineral requirements for sheep and cattle for both maintenance and production. Micro mineral requirements are described in terms of milligrams per kilogram (mg/kg DM) or as parts per million (ppm) on a dry matter basis.

Table 3: Micro mineral requirements for sheep and cattle (maintenance and production).*

	Sheep		Cattle	
Micro mineral (mg/kg DM)	Maintenance	Production*	Maintenance	Production*
Iron	40	40	40	40
Manganese	20	25	20	25
Copper	4	14	4	14
Zinc	9	20	9	20
Iodine	0.5	0.5	0.5	0.5
Cobalt	0.1	0.2	0.1	0.2
Selenium	0.1	0.1	0.0	0.1

*Production refers to growing, pregnant and/or lactating animal requirement.

In general:

- light/sandy soils contain less trace elements than clay soils
- granitic, acidic soils are low in trace elements
- the trace element content of plants can vary widely even in the same soil
- clovers/legumes, herbs and weeds have much higher trace element levels than grasses
- lush, rapidly growing pastures tend to have lower trace element contents
- a diverse diet can often reduce the need to supplement the animal's diet with trace elements.

When confinement feeding most systems will provide a grain and roughage ration, either separately or as part of a total mixed ration. Providing a variety of feed elements will generally ensure that most, if not all, micro minerals/trace elements are adequate. Most micro mineral deficiencies are generally 'induced' through the negative effects of another mineral.

For example:

- high intakes of calcium can induce zinc, copper and cobalt deficiencies
- high intakes of sulfur, zinc, iron, cadmium, and molybdenum can decrease copper availability.

For a more detailed information about micro mineral roles, dietary source and deficiency symptoms please refer to NSW DPI (2009) *Assessing Stock Feed Additives and Mineral Supplements* publication.

Cut down drench container for a mineral supplement for sheep. Photo Credit: Geoff Duddy.

Resources:

Assessing Stock Feed Additives and Mineral Supplements (NSW Department of Primary industries 2009)

Feedipedia - animal feed resources information system www.feedipedia.org

Website: Grass Tetany (Meat & Livestock Australia, More Beef From Pastures website)

A mineral feeder used in a paddock situation that can be as easily used in a confinement situation.
Photo Credit: Geoff Duddy.

44 Gallon drum on a stand for a mineral lick supplement. The drum protects the mix from the weather and having it on a stand stops some of the animals from standing in it.
Photo Credit: Geoff Duddy.

Key points

- Sheep and cattle are known to need at least 17 different minerals to maintain good health and production.
- Mineral levels and bioavailability are not constant within any feed type. It is therefore difficult to clearly define recommendations for supplementation.
- The percentage of a mineral that is absorbed or metabolised can vary with the animals' age, physiological state, the minerals chemical form and interactions of other minerals in the feed.

Confinement feeding - feed: vitamins

Vitamins

Vitamins are needed for normal function, growth and maintenance of body tissues, and to regulate and support chemical reactions in the body. Ruminants are capable of manufacturing most vitamins.

Vitamins can be categorised as being either fat or water-soluble.

Fat-soluble vitamins (vitamins A, D, E and K). They dissolve in fat, are stored in tissue (principally the liver), are available on-demand and, except for vitamin D, cannot be synthesised by ruminants.

Water-soluble vitamins (B vitamins, vitamin C) are easily dissolved, are easily absorbed by the body, are synthesised by ruminants and excess amounts are excreted.

B vitamins

These include thiamine, riboflavin, niacin, biotin, folic acid, B6, pantothenic acid, and B12. All are soluble in water, and all are needed daily. During fermentation, rumen bacteria synthesise, absorb and use these vitamins.

Anything that interferes with normal rumen function (for example acidosis, worms, severe stress or disease) or reduced feed intake can interfere with microbial activity and therefore reduce B-vitamin synthesis. Once the rumen becomes functional, bacterial synthesis should supply adequate levels of all B vitamins.

Rumen bacteria can produce vitamin B12 but require cobalt. Cobalt deficiencies are generally rare but can be found in coastal/sandy soils and during rapidly growing spring grass and or cereal pastures. Lambs and calves with not yet fully functional rumens may also suffer from a B12 deficiency and may benefit from supplementation (greater and extended responses are gained by using intramuscular compared to subcutaneous injection but be careful of injection site inflammation).

Vitamin B12 is needed for cell growth, energy (glucose production) and wool production. Its rate of absorption in the small intestine is **enhanced** by slow gut flow and **inhibited** if the rumen or small intestine is damaged. Deficient animals are unable to metabolise propionic acid into glucose leading to reduced glucose production.

Vitamin C

An antioxidant, vitamin C helps to prevent cell damage caused by free radicals (highly reactive chemicals) and in doing so helps to fight infections, heal wounds, and keep tissues healthy. Ruminants can synthesise vitamin C and it therefore does not need to be provided as an ongoing supplement.

Vitamin A

Produced via conversion of carotene found in green, leafy forages. Green pasture and hay are good sources.
Vitamin A is needed for normal bone growth and development, regulation of cell growth reproduction and light transmission to the brain.

Deficiency symptoms include muscular weakness, night blindness and/or conjunctivitis/blue haze, lack of appetite, poor coordination, lameness, scouring and (possibly) urinary calculi.

Deficiencies can occur in confined animals if grazing drought-stricken pastures or if feeding long-term stored hay. Both vitamin A and E oxidise over time and lose their potency, even if the hay remains green. Stock having grazed green feed for three or more months will have adequate stores of vitamin A in the liver. Young stock may benefit from supplements if they have not had access to green feed for an extended period.

Vitamin D

When ruminants are exposed to ultraviolet light, enzymes in the skin transform cholesterol into cholecalciferol. The blood then transports this compound to the liver and kidneys, where it is ultimately converted to the active form of vitamin D (1,25-dihydroxycholecalciferol). A similar precursor can be found in bleached hay. Access to sunlight and/or sun-cured roughages should therefore ensure adequate vitamin D.

Vitamin D increases the absorption and metabolic use of calcium and phosphorus and helps to regulate blood calcium levels. Deficiency symptoms include ill thrift, laboured breathing, stiffness and/or hunched back, a high incidence of bone fractures or rickets. Young, growing animals have a greater requirement for vitamin D than mature animals.

Vitamin E

An antioxidant important for maintaining cell membranes. Its principal role may be to reduce the destruction of other vitamins and essential fatty acids.

Fat soluble and stored in the liver, vitamin E deficiencies were once considered as rare and only occasionally seen in weaners which have had no green feed for several months. Vitamin E requirements however may be higher than we once believed. This is particularly the case for stock with high growth rates, when stressed, if grazing mature feeds for extended periods or when in confinement feeding systems.

Vitamin E deficiencies can occur if feeding hay or grain over extended periods, feeding high-grain rations with limited or no roughage, if there are high fat levels in the ration or if feeds have been long-term stored (>12 months).

Vitamin K

Common in feeds and able to be synthesised by rumen microbes, animals are seldom deficient in this vitamin.
Vitamin K is essential in the liver to produce prothrombin. Low levels of prothrombin in the blood lengthen blood clotting time and cause internal bleeding. Dicumarol, sometimes found in mouldy sweet clover hay or silages, can interfere with the function of vitamin K and should be used sparingly when confinement feeding.

Key points

- Vitamins are needed for normal function, growth, and maintenance of body tissues, and to regulate and support chemical reactions in the body.
- Ruminants are capable of manufacturing most vitamins.
- Vitamins can be categorised as being either fat or water-soluble.

Confinement feeding -feed: additives

Common supplements and additives

There are several additives that can be included in confinement feeding rations.

Individual additives can be sourced and added to a ration, or alternatively a specific feedlot or drought feeding premix can be used.

As most additives or premixes are included in rations in small amounts, it is extremely important they are evenly mixed throughout the ration. This ensures the additive is effective and in some cases, to minimise the risk of poisoning from the additive.

Generally, cereal grain-based rations require additional calcium and sodium, most often supplied by the inclusion of ground limestone and salt in the ration.

There are a number of other additives that can be incorporated into a ration to either reduce the risk of acidosis, improve efficiency, improve the palatability of the ration, reduce dust/fines in the ration or increase the mineral and/or protein content of the ration.

Listed below are several individual additives with their reason for use and general inclusion rates in a confinement feeding ration.

Acid Buf®

- a calcium and magnesium-based additive
- a natural buffer derived from seaweed
- has a large open structure that allows for the slow release of calcium and magnesium, reducing the risk of acidosis and optimising rumen pH
- buffers at lower pH and for longer than bicarb
- add 1-1.5% of feed weight total.

Acid salts

- acts by mobilising calcium from the small intestine and acidifying urine to prevent bladder stones
- common forms are ammonium chloride, calcium chloride and ammonium sulphate
- bitter and may impact on ration palatability and intake
- add at 0.5-1% of feed weight total.

Bentonite

- a clay that swells to 6-7 times its size when contacting rumen fluid, slowing down the digestion process and gut flow rates
- acts by binding acid 'positive ions' on its surface and removing these from the rumen in the manure
- is not a true buffer
- has a negative effect on protozoa (protozoa consume rumen bugs) increasing protein availability
- some palatability and digestibility concerns
- can help with preventing scours or diarrhea; deactivating some moulds and toxins and reducing the risk of urea poisoning and acidosis
- may reduce feed intake
- add 3-4% of feed weight total when introducing stock to grain and reduce to 1-2% or remove from rations once animals are adapted to grain feeding.

Sodium bicarbonate (bicarb soda)

- an alkali naturally produced by stock when chewing (in saliva)
- buffers against acid production
- buffering ability drops when rumen pH is < 6.0
- a good source of sodium in the diet
- add 1-2% of feed weight total.

Calcium carbonate (limestone)

- a calcium-based supplement
- has some buffering action in the small intestine but may reduce feed intake
- add 1-2% of feed weight total.

Magnesium oxide (for example Causmag®)

- not a true buffer
- it is a slow release neutralising agent (alkaliniser)
- main magnesium supplement
- bitter and may impact on ration palatability and intake.

Dicalcium phosphate

- 22% calcium, 22% phosphate
- used to supplement both minerals.

Ionophores (for example Bovatec®, Rumensin®)

- rumen modifiers that inhibits the growth of specific rumen microorganisms improving feed conversion efficiency
- alters rumen fermentation by:
    - increasing propionate (a glucose precursor)
    - inhibiting protozoa (increasing protein availability)
    - enhancing the absorption of sodium, magnesium, phosphorus and zinc
    - reducing feed intake.
- it is important to be aware that some additives have market implications, so check with possible buyers or markets.
- included at 25-70 g per tonne of feed so is usually included in a mineral premix/supplement.

Molasses and vegetable oils

- both are energy sources but are primarily used to improve palatability and reduce dust levels within rations
- protein levels are low
- both have a laxative effect
- add at 0.5-4% of feed weight total depending on ration moisture.

Sodium chloride (salt)

- a sodium supplement
- increases water and ration intakes and helps protect against water belly
- add 0.5-1% of feed weight total.

Urea

- urea is known as a non-protein nitrogen (NPN) source that is converted to ammonia within the rumen and used to produce microbial protein
- adequate energy in the ration is needed to make full use of the NPN
- may be added at 0.5-1% of feed weight total, providing no other source is used in the ration
- urea is toxic to stock at high levels, so extreme care needs to be taken when mixing and adding to the ration.

Virginiamycin (Eskalin®)

- a S4 antibiotic that prevents lactic acid producing bugs from multiplying, reducing acidosis risk and improving energy availability
- require veterinary prescription.

Virginiam yeasts

- claimed to improve dry matter intake and digestibility, increased milk production, better feed conversion efficiency and improved animal health.

Key points

- Cereal grain-based rations generally require additional calcium and sodium, most often supplied by the inclusion of ground limestone and salt.
- There are several other additives that can be incorporated into a ration to improve performance or efficiency.
- As most additives or premixes are included in rations in small amounts, it is extremely important they are evenly mixed throughout the ration.

Confinement feeding - shade and shelter

Shade over the trough is good but means that more animals spend more time in this area and can cause problems. Photo credit: NSW DPI.

Introduction

Sheep and cattle regulate their body temperatures through a process known as thermoregulation. Thermoregulation allows stock to maintain a core internal temperature, allowing body cells and tissues to function optimally and to avoid and/or mitigate cold or heat stress. Their core body temperature is normally about 39 °C.

Sheep and cattle maintain their body temperatures by balancing internal heat production and heat loss to the environment. An animal's thermoneutral zone is the temperature range in which they don't have to expend energy to maintain normal body temperature and optimum production usually occurs.

Sheep are more tolerant of climatic extremes than other farm animals. Their thermoneutral zone ranges between 12-32 °C while cattle range between 15-25 °C.

Options for preventing heat and cold stress within confinement systems are varied. Management practices and infrastructure used or recommended will depend on species (sheep or cattle), breed/cross differences as well as the animal's physiological state.

Sheep under shade in a feeding area. This shade allows for airflow through and about. Will have some areas that will not get the sun and may not dry out. This could be an issue for cattle. Photo Credit: Geoff Duddy.

An animal's ability to withstand heat or cold within a confinement system will vary depending on:

- **animal specific factors** such as breed/cross, coat colour, type or length, adaptation, body condition, health, age and an animal's physiological state (for example dry, pregnant, lactating)
- **environmental factors** such as temperature, humidity, wind, solar radiation
- **infrastructure/physical layout** shelter belts, shade and pen orientation
- **management** including nutrition/ration, stocking density.

Another view of the shade structure.
Photo Credit: Geoff Duddy.

Internal features of the shade structure.
Photo Credit: Geoff Duddy.

Hypothermia (cold stress)

Hypothermia is defined as having an abnormally low or below normal body temperature.

Hypothermia or cold stress may occur when too much body heat is lost, too little body heat is produced or a combination of the two. As a result, body temperature drops, the heart, nervous system and other organs are impacted, leading to a failure of the respiratory system and death. To combat cold stress, the animal must increase its metabolic rate to supply more body heat, increasing daily feed requirements, particularly for energy.

Smaller animals are more susceptible to hypothermia as they have a greater surface area relative to their body weight. Lambs and young calves are more susceptible than adult sheep or cattle.

If windbreaks and adequate nutrition are provided the risk of production losses and death from hypothermia can be reduced. Your confinement system should take in to account the direction of prevailing winds and the impact of rain on the stocks ability to handle declines in temperature.

If considering incorporating windbreaks into a confinement system's design, both natural and artificial windbreaks can be beneficial. Windbreak height, orientation, length and density are also important.

Height – the protected zone of a windbreak may extend out 25-30 times the height of the windbreak with a marked drop in wind-speed.

Orientation – best if perpendicular (90°) to primary prevailing wind direction. L-shaped shelterbelts can provide protection on several sides.

Length – Ideally the ratio of windbreak length and tree/windbreak height is 10:1, which means that to develop a full protected zone a 10 m tall windbreak should be
100 m long.

Porosity/permeability or the percentage of solid space in relation to total space. Windbreaks should be reasonably porous to reduce windspeed and turbulence.

Hyperthermia (heat stress)

Hyperthermia is defined as the condition of having an elevated core body temperature.

When heat stressed stock have to expend energy to get rid of body heat to maintain their core body temperature they do so through a variety of means. These include:

- **Convection** - when air or water is warmed by contact with skin resulting in a loss of body heat
- **Conduction** - when heat is transferred from skin to a cooler surface in contact with the skin
- **Radiation** - movement of heat from the body into the surrounding atmosphere
- **Evaporation** - of water from the body surface (sweating or panting).

For sheep and cattle, evaporative (sweating or panting) and convective cooling (air flow) are the major means of body heat loss.

The methods and efficiency at which sheep and cattle handle heat stress differ between the species.

In cattle, heat is lost from the skin through convection, conduction and evaporation (sweating), as well as through panting. In contrast, panting is the main form of evaporative heat loss for sheep.

Heat stress leads to reduced feed intake and production losses but can, in extreme cases, lead to tissue organ damage and death.

The factors that contribute to body heat load in sheep and cattle include environmental conditions and animal characteristics.

Environmental conditions

A combination of two or more of the following conditions can lead to heat stress:

- high maximum ambient temperature
- high relative humidity (high humidity makes evaporative cooling less efficient)
- high solar radiation level (solar radiation from sunny, clear skies contributes to body temperature)
- minimal to no air movement.

Animal factors

An animal's susceptibility to heat stress will vary depending on:

Breed or cross

- Hair and fat-tailed sheep tolerate heat better than most woolled sheep breeds.
- Bos indicus cattle (Tropical breeds) are more heat tolerant than Bos Taurus (British or European breeds).

Coat colour, type or length

- The insulation properties of wool enable most sheep breeds to handle temperature extremes and is one of the reasons that sheep are generally more tolerant of heat stress than cattle. Freshly shorn sheep must adjust to the loss of insulation by increasing evaporative cooling through panting.
- Cattle with lighter coat colour tend to be more tolerant of heat.
- Cattle with a thick hair coat may be more susceptible to heat stress while those with a thinner hair coat are more likely to be tolerant of higher temperatures in warm regions.

Adaptation

- Long periods of heat exposure have cumulative effects on ruminants.
- If there is a gradual change in temperature over time sheep and cattle can adapt and tolerate high temperatures provided night-time temperatures reduce to a point to allow heat dissipation/loss.
- Bos taurus breeds of cattle will begin to seek shade when the temperature exceeds 20 ˚C, those adapted or adapting to hot conditions may not seek shade until the temperature is around 28 ˚C.

Body condition/fat score:

- High fat score sheep and cattle tend to be more susceptible to heat stress.

Health

- Sheep and cattle with health and/or disease issues are less tolerant of changes in temperature. This especially applies to animals with conditions that compromise lung function and therefore their ability to lose heat through panting.

Age

- Young stock have a greater body surface area relative to their liveweight than older stock and are generally less efficient at regulating body temperature. For these reasons lambs and calves are high risk in terms of the impacts of both cold and heat stress.

Physiological state (dry, pregnant, lactating)

- Higher producing animals are more susceptible to heat stress. This is predominantly due to their increased feed requirements and intakes that result in a higher metabolic heat. Higher metabolic heat is the heat produced in the body when feed is converted by biochemical reactions to supply energy for various functions including maintenance and production needs such as pregnancy, lactation and growth.

Heat stress responses in sheep and cattle

Increases in:

- heart rate (in response to the need for additional blood flow to the lungs)
- panting (increases air flow over the nasal passages, protecting the brain)
- blood cortisol concentration and stress
- nutrient requirements (due to the energy cost associated with heavy panting)
- shade-seeking actions.

Reductions in:

- activity (stock will lie down for prolonged periods)
- digestion and heat generated within the rumen
- appetite/feed intake
- daily weight gains and feed efficiency.

This mob of cows and calves are in a pen with shade to the west. These trees also supply shelter in this environment to the wind. Photo Credit: Sue Street.

Shade

It is always recommended that shade and/or shelter be readily available within any confinement or open grazing situation.

Shade may be provided by existing trees or structures such as sheds within or around confinement pens.

Care must be taken to protect the bark and immediate base of trees from stock. Options include use of barrier fencing, wrapping tree trunks in chicken wire or equivalent and/or use of chemical retardants such as an ammonium sulphate/water mix sprayed on exposed trunk and limbs. Due to high nutrient loads, especially phosphorous, native trees may die in or around confinement pens.

If providing artificial shade structures principles of shade design include:

Size

Provide adequate shade for each animal within the confinement area.

Recommendations for sheep/lambs are a minimum of 0.4 m^2 per animal and 2 m^2/head for cattle.

Location

Ideally shade should be located away from feed and watering points.

If shading water troughs, provide additional shade areas to minimise congregating and bullying around water trough areas that can limit water intake for some animals.

This tree offers great shade and is protected from the livestock. Photo Credit: Geoff Duddy.

Orientation

North-south shade orientation will maximise the amount of shade available throughout the day within each confinement pen and the shade footprint will move across the confinement area allowing the ground surface to dry.

Material type

If using shade cloth, chose one with minimum solar rating of 80%, minimum 300 GSM (gram per square metre) and at least a 10-year warranty against UV degradation.

Shade cloth tension must be adequate to prevent damage during windy conditions.

Galvanised and/or corrugated iron reflects more solar radiation than shade cloth however they may need additional support due to the weight.

Steel posts, set in concrete to prevent corrosion and damage, are recommended.

Height / ventilation

Ensure any shade structure is high enough so as not to interfere with cleaning or drying.

Shades should be constructed to maximise ventilation and afternoon shade.

These native eucalypts were protected from the livestock but the nutrient from the yards and the feeding area outside has caused them to die and no longer offer shade. Photo Credit: Brett Littler.

Resources

Feedlot Shade Structures (Meat & Livestock Australia 2006)

Shelterbelts (Sustainable Farms 2018)

Sheep farmers: Increase your productivity (Goulburn Broken Catchment Authority 2015)

Hypothermia in Sheep (WA Department of Primary Industries and Regional Development website)

Key points

- Thermoregulation allows stock to maintain a core internal temperature of normally about 39 °C.
- Sheep are more tolerant of climatic extremes than other farm animals. Their thermoneutral zone ranges between 12-32 °C while cattle range between 15-25 °C.
- There are various options for preventing heat and cold stress within confinement systems.
- Shade and/or shelter is recommended based on animal welfare, health and care grounds.
- North-south shade orientation will maximise the amount of shade available and allow the ground surface to dry.

Confinement feeding - water

This well thought out confinement feeding area has the trough near the outside of the pen. The conveyor belting allows the water when cleaned to drain outside the pen. Photo credit: Jill Kelly.

Water supply and quantity

Water is the single most essential element. It is critical in terms of meeting all necessary animal care and welfare targets as well as meeting the physiological needs of stock (such as digestion, blood circulation, temperature control and production).

A confinement system needs a reliable supply of good quality water capable of meeting daily stock and operational needs.

While not all stock will drink at once, it is important that water be available on demand. Check that supply line pipe size (diameter) and water pressure can deliver water when needed.

Flow rates of at least 10-15 litres/head/hour are recommended.

It is also recommended that you have a minimum of 2-3 days water supply stored in above ground tanks in case of mechanical failure (for example pump breakdown) or misadventure (leaks).

Troughs are recommended for water supply. Avoid using dams, as these may become boggy and water quality may be compromised due to contaminants. Poor quality water will reduce water intake and undermine animal health, safety and production.

An audit to determine daily water use and availability is recommended. Stock intakes usually account for 90% of daily water use. Losses from trough cleaning, minor leaks, dust suppression and evaporation should also be considered.

Water troughs

Troughs should be drained and cleaned regularly. Frequency of cleaning will depend on temperature, winds, evaporation, contamination and algae growth. Daily cleaning is recommended during summer, while twice weekly cleaning may be sufficient during the cooler months.

Young stock may need to be trained to recognise and use troughs.

Provision of high quality, cool water is essential.

Water trough length will vary according to number of sheep/lambs or cattle per pen, number of water access points, trough design and water pressure.

Water trough space recommendations are:

Sheep

30 cm plus 1.5 cm per sheep

Example: 300 sheep

= 30 cm + (300 1.5 cm)

= 30 + 450 cm

= 4.8 m total lineal access

Cattle

30 mm/head and/or space for 10% of stock to access water simultaneously during normal weather conditions and 75 mm/head during hot conditions.

Example: 100 cattle

= 30 mm x 100

= 300 mm

= 3 m of linear trough space during normal conditions or 7.5 m during hot conditions

A water trough with access from two pens. This PVC pipe has the float protected from the stock. The long section cut out may lack some structural integrity in the middle. Photo Credit: Sue Street.

Another view of the PVC pipe trough. Note how this trough when cleaned drains out into the paddock and not into the pen. Photo Credit: Sue Street.

Water trough options

Troughing can be made using a wide range of materials. Longevity, durability, heating, fouling and cost must be considered when deciding on the material used.

Rectangular rather than round troughs are recommended. Rectangular troughs can be comfortably sited within pens or along fence lines, are easily cleaned, provide more linear space (as the same volume round ones) and low-volume systems are available. These low-volume troughs effectively waste less water during cleaning.

Common water trough materials include reinforced concrete, polyethylene, fiberglass, steel and low-volume PVC pipes.

Consider using exclusion bars or fence lines along the length of water troughs to minimise damage and soiling from mud or manure.

Ensure float valves, supply and drainage pipes are well protected. Stock will play with, and potentially damage, unprotected float valves and fittings which can lead to water waste, costly repairs and mud/boggy conditions. Wet, boggy areas can impact on water use and increase odours and flies within a confinement area.

Provide a robust apron around all watering points. Concrete or compacted road base (containing coarse and fine materials) aprons between 1.5 m (for sheep) and 3 m (for cattle) wide will prevent the immediate area around water troughs from becoming boggy or prevent holes from developing.

These areas can also be protected using conveyor belt although care must be given to minimise any water splash or leakage as these bases will become slippery.

If possible, consider having multiple watering points or troughs within your confinement area. Placing troughs within fence lines for example have several advantages including:

- multiple access points reducing stress on lower order or timid animals
- backup if one trough is damaged or unavailable
- greater animal/trough contact as stock 'walk' fence lines
- better distribution of manure throughout pens
- traffic or stock pressure spread across several areas.

Try to ensure water is removed from containment areas during trough cleaning. Positioning water troughs so the bung is near the downside fence of the confinement area, so the wastewater quickly drains out of the pen or alternatively run wastewater out of the pens through PVC or similar pipes.

If possible, maximise the distance between feeding areas and water troughs. Doing so will minimise contamination from feed, especially grain, carried on the animal's mouth/muzzle.

Estimating water requirements

To meet average daily water requirements budget on providing a minimum of ~10% of the animals liveweight. For example, mature sheep and cattle will need ~5 and between 30-60 litres/day, respectively.

Alternatively, you can budget on stock drinking between 2.5-3 times what they eat.

Table 1 provides an indication of average water requirements for different classes of sheep and cattle.

Table 1. Average water requirements for sheep and cattle.

Stock type	*Consumption per head per day (L)
Weaner sheep	2-4
Adult dry sheep	2-6
Ewes with lambs	4-10
Young cattle	25-50
Dry cattle (400kg)	35-80
Lactating cows	40-100

* The figures quoted for consumption have a wide range. Actual daily consumption will vary according to water quality, environmental and animal specific factors.

Factors affecting water intake

The suitability of water for stock use is determined by:

- water quality (salinity, acidity, contaminants and algal growth)
- environmental factors (air and water temperature, humidity, feed quality)
- animal factors such as breed differences, age and condition of stock.

Confinement feeding systems may source water from existing surface water supplies (dams or creeks) and/or groundwater bores. This water should then be pumped to storage tanks and reticulated to the confinement feeding area. While more reliable than surface waters, bore waters generally have higher salinity levels which may impact on intakes and performance. Regardless of water source, it is recommended that water be tested regularly and, if possible, any quality issues corrected.

Water quality

Salinity, acidity

Water quality and its suitability for stock use is critical. Water quality is determined by the levels of dissolved minerals, pollutants (such as dust, feed, manure and algal growths), micro-organisms, suspended solids, organic and inorganic compounds, salt and pH levels, toxic substances and algal growths.

In general terms salinity (a measure of dissolved salts) should be < 7,000 ppm and pH between 6.5-8.5. Highly acidic or alkaline water can lead to digestive upsets, reduced intakes and production loss. Please refer to NSW DPI's *Water requirements for sheep and cattle and Water for livestock: interpreting water quality tests* for additional information.

Water is near the outside. Water did dry out of the pen but with time it is now running back into pen when cleaned. Photo Credit: Phil Cranney.

It had been some time since this trough had been cleaned and it was noted that the cattle were only drinking from the flow end, indicating that there was an issue. This issue was temperature and also contamination. Photo Credit: Brett Littler.

Close up view of the dirty trough, showing considerable contamination which meant the cattle only drank from the flow end. Photo Credit: Brett Littler.

Contaminants

Sheep and cattle are sensitive to water taste, odour and contaminants.

Common contaminants include suspended solids, dust films, feed grains and fibre as well as algal growths. Contaminants may affect water intake, productivity or health with some requiring treatment or fixing.

Suspended solids may cause cloudy water, while not a major quality issue, muddy water may block valves and pipes. Use of alum (aluminum sulphate) or gypsum in storage tanks will settle clay particles but be mindful of treatment impacts on water acidity.

Dust films can impact on intakes, particularly among weaner sheep. Suppression of dust in and around confinement pens can help reduce dust films forming. Sprinklers or a higher stocking density may help but be mindful of potential health issues that may arise.

Reticulated (piped), continual flow systems may reduce the incidence and/or impact of dust and feed. The benefit/cost of such systems needs to be considered with additional infrastructure (such as in-line water treatment options) and pumping expenses major costs.

An increasing number of producers are using agitators within open trough systems to 'disturb' surface water and reduce dust film impacts. Most are solar-powered systems used to aerate fishponds and aquariums.

Sprinklers or piping (with holes) plumbed into the primary water line and set above or just below the water surface can also be used. Light chain suspended above the water line has also been used as a means of breaking down a dust film.

Algal growths are common during dry times and/or drought. While regular scrubbing and cleaning of troughs is recommended, if you also choose to treat low-volume systems/storages or troughs with commercial copper sulphate blocks be extremely careful of copper poisoning risk. A safer option is to include a section of rigid copper tubing within the trough. Commonly used for water supply lines in the home, this tubing releases minute amounts of copper, helping to control algae without significantly increasing poisoning risk.

Environmental

Temperature

Body temperature is affected by an animal's condition, diet, immediate surrounds (shade/shelter), coat type and/or thickness, weather factors - particularly rain, wind and humidity.

Air and water temperature can have a major impact on their ability to maintain a thermoneutral state (when heat production and heat loss are balanced) and to perform during periods of cold or heat stress.

In hot weather, sheep and cattle use more water for evaporative cooling (sweating and panting). While shade may provide some relief, water intakes may be between 40-80% higher than during winter months depending on environmental conditions, physiological need and water quality issues.

Sheep tend to be less susceptible to heat stress than cattle. The insulative properties of wool help sheep to regulate body temperature.

Cattle will seek shade when it is available to minimise the effects of high temperatures.

Humidity

High humidity makes evaporative cooling less efficient.

Cool, clean quality water helps with regulating body temperature and the efficiency of evaporative cooling (panting and sweating).

This lamb has it head stuck trying to drink from the clean side of the trough. The side of the trough had been eaten away and lambs were cranking their head over to get a drink. Also, the trough had missed a clean the previous day so this lamb was trying to get clean water. Photo Credit: Brett Littler.

Water temperature

Sheep and cattle generally prefer water at or below body temperature with cool water preferred in hot conditions.

In terms of performance the optimum temperature of drinking water for sheep and cattle is between 16-18 °C. If water temperature is > 25 °C, water intakes rises sharply due to the increased requirement when sweating and panting.

Shaded water troughs are consistently cooler (by 6 °C or more), have lower rates (up to 36%) of evaporative loss and will help with heat loss. Be mindful however of dominant animals using shade around water troughs and preventing others from accessing the troughs.

Non-shaded water troughs may be a preferred option if the confinement pens do not have adequate natural or artificial shade available.

Ensure all water pipes are buried to reduce water temperature within supply lines. Holding tanks will assist with maintaining water below water source temperatures, particularly if supplied from bores.

Feed quality/rations

Water intakes will vary according to feed type and quality. Under normal grazing conditions stock will obtain much of their daily requirements from moisture within the pasture particularly during winter and early Spring.

Within confinement systems however stock either graze dry pasture and/or are fully supplemented with high dry matter cereal grain and straw/hays. Stock need to increase water intakes to improve digestibility and gut-flow of these feeds. Silages or haylages containing from 40-80% moisture may reduce daily water requirements depending on the percentages used within the stocks total diet.

If feeding other types of high fibre/salty feed (such as saltbush) or high rates of salt additives (ad-lib or within a ration), there will be an increase in water demand due to the need for a high-water turnover to maintain the salt balance in the body.

Animal factors

Stock age and condition

Lambs, calves, weaners, late pregnant or lactating females, and aged or weakened stock are less tolerant of poor to low quality water. Growth, feed conversion efficiencies, fertility, milk production and disease resistance may all be negatively affected.

Fat stock tend to be less tolerant of heat stress and more reliant on cool, clean quality water.

Breed type

British breed sheep and crosses need about 20% more water than Merinos in hot weather. Hair and fat-tailed sheep tolerate heat better than most woolled sheep breeds and have shown in overseas trial work to consume approximately 30% less water on an absolute and metabolic weight gain basis.

Bos indicus or Bos indicus-infused cattle are better adapted to hot environments and drink significantly less water under hot conditions than Bos Taurus (British or European breeds).

Black or dark coloured cattle breeds and crosses generally have higher internal body temperatures than light coloured cattle, increasing water intake and requirements for thermoregulation.

Water around this trough making it muddy and a mess. Also note the float is available for the cattle to play with, causing it to overflow regularly. Photo Credit: Geoff Duddy.

Cleaning of a PVC trough. This is on a concrete apron but water is running out into pen. Also note - it is under cover to prevent from heating. Photo Credit: Geoff Duddy.

PVC trough within pen. Sometimes this shade will have the animals resting under it for shade stopping other animals from getting a drink. Photo Credit: Geoff Duddy.

Resources

Beef cattle feedlots: design and construction *Site design Section* (Meat & Livestock Australia 2015)

National procedures and guidelines for intensive sheep and lamb feeding systems (Meat & Livestock Australia 2011)

Water for livestock: interpreting water quality tests (NSW Department of Primary Industries 2014)

Water requirements for sheep and cattle (NSW Department of Primary Industries 2014)

Model Code of Practice for the Welfare of Animals: The Sheep (Australian Government 2006)

Heat Load in Feedlot Cattle (Meat & Livestock Australia undated)

Key points

- Water is critical in meeting the physiological needs of stock (digestion, blood circulation, temperature control and production).
- While not all stock will drink at once, it is important that water be available on demand.
- Troughs are recommended for water supply and should be cleaned regularly.
- Poor quality water will reduce water intake and animal production.
- Water trough length will vary according to number of animals per pen, number of water access points, trough design and water pressure.

Confinement feeding - health and welfare

Scabby mouth in a lamb. Photo Credit: Jill Kelly.

Welfare

The welfare of animals in confinement areas is a paramount priority for all producers. It is their responsibility to take reasonable actions to ensure the welfare of animals under their control.

One of the most practical ways to ensure the welfare of animals is to implement the five freedoms and provisions.

The five freedoms and provisions are:

- **Freedom for thirst, hunger and malnutrition** – by ready access to fresh water and a diet to maintain full health and vigour.
- **Freedom from discomfort** – by providing a suitable environment including shelter and a comfortable resting area.
- **Freedom from pain, injury and disease** – by prevention or through rapid diagnosis and treatment.
- **Freedom to express normal behaviour** – by providing sufficient space, proper facilities and the company of the animal's own kind.
- **Freedom from fear and distress** – by ensuring conditions and treatment which avoid mental suffering.

Through the correct design, construction and management of confinement feeding areas the five freedoms and provisions of animal welfare can be ensured.

Health in confinement feeding areas

There are many diseases that can affect sheep and cattle in confinement feeding systems. This section outlines some of the more common conditions, grouped by common presentations. In all cases, it is important to seek veterinary assistance to diagnose the disease and formulate an appropriate treatment plan.

There are diseases that are exotic to Australia that are beyond the scope of this document (for example, foot and mouth disease). If you are at all concerned about an exotic disease, please phone the Emergency Animal Disease hotline on 1800 675 888.

Scours in a calf. When feed is contaminated by faeces, diseases can be easily transmitted between animals. Photo Credit: Brett Littler.

Sudden death

Acidosis

Also known as grain poisoning, or grain engorgement.

Predisposing factors

Acidosis is caused by the ingestion of large amounts rapidly fermentable carbohydrates (particularly starch) contained in feeds, leading to a decrease in ruminal and then systemic pH. Cattle and sheep are susceptible to acidosis.

Cereal grains are the most commonly used feed that contain rapidly fermentable starch. Wheat, triticale, maize/core, sorghum, barley and oats are (in that order) the grains most likely to cause acidosis. Manufactured products like pellets or pelletised dried distiller's grain (DDG) are usually high in rapidly fermentable starches, are highly processed and have been implicated in cases of acidosis. Some products contain buffers or ionophores to reduce the risk of grain poisoning. Pulses (lupins, beans, peas) are generally lower in starch than cereal grains and rarely pose a threat unless finely cracked or ground.

Ingestion of large amounts of rapidly fermentable starch is more likely to occur when animals are:

- offered large amounts of grain or even their normal ration after a period off feed
- offered a sudden increase in amount of feed
- experiencing sudden change to a different grain or even the same grain from a different source
- accustomed to grain that is more finely processed.

Clinical signs

- acidosis may present with a range of severity, ranging from sudden death to sub acute ruminal acidosis which causes low level production losses over the longer term.
- mild distension of the abdomen
- inappetence, depression, isolation, panting and dehydration
- lameness
- reduced cud chewing
- faeces may vary from firm to diarrhoea and may appear foamy, with gas bubbles and/or contain undigested fibre or grain.

Control and prevention

The gradual introduction of cereal grains and grain-based pellets over a two to three week period is the most effective method of prevention

Rumen buffers commonly used to reduce acidosis risk. Some of these include:

- sodium bicarbonate
- magnesium oxide plus sodium bicarbonate,
- Bentonite
- other commercial products are available (speak with a veterinarian or a nutritionist about these products and their role).

Rumen modifiers such as lasacolid, monensin and virginiamycin may be used under veterinary supervision.

Speak to a nutritionist/veterinarian about the inclusion rate for your mix and feeding situation.

This ration is over processed. There are large amounts of fine particles which substantially increases the risk of acidosis. Photo Credit: Jill Kelly.

Acidosis can cause a bubbly scour with whole grain visible. Photo Credit: Jill Kelly.

Feedlot bloat

Predisposing factors

Feedlot bloat is usually caused by livestock consuming large amounts of rapidly fermentable grains and grain by-products. If the grains or by-products are heavily processed and contain large amounts of fines it increases the risk of feedlot bloat.

Generally, it is associated with a sudden increase in intake of feed or if there is limited trough or feeder space available and competition is an issue. Feedlot bloat can also occur when legume hays are used in the diet and particularly if these are included in a total mixed ration.

Aside from high proportions of grain/grain by-products and legume hay, both management and animal factors can contribute to feedlot bloat.

Clinical signs

- abnormal distention of the abdomen, particularly on the left hand side
- labored breathing
- discomfort as indicated by stomping of feet or kicking at the belly.

Control and prevention

The cause of feedlot bloat is often difficult to predict and understand. At times, subtle changes in routine and diet can trigger an increased incidence of feedlot bloat. Reducing the level of grain/grain by-products in the diet can help, but this also tends to reduce livestock performance. Limiting the use of legume hay in total mixed ration and taking care not to over process it reduces the risk. The following can also assist:

- attention to the processing method to reduce the amount of over processing and fines/smaller particle size
- particular care when using a hammer mill as over processing can be an issue
- wetting the grain can sometimes can assist in reducing shattering and fine particle size
- make sure chop length of roughage is not too small in total mixed ration (2.5 cm or larger)
- ensuring adequate trough and feeder allocation to reduce bullying and competition
- the use of feed additives such as ionophores and bloat preventives
- Minimise changes to routine when feeding and time held off feed particularly on grain diets 70% or higher.
- if using a highly digestible hay or silage in confinement feeding situations, limit the total grain used in the diet to less than 45%.

Urea/ammonia/protein toxicity

Nitrogen is an important part of the ruminant diet. It is an essential building block of animal protein. It may be supplied in the ruminant diet as non-protein nitrogen or true protein. Urea is used in ruminant (particularly cattle) diets as a source of non-protein nitrogen. It is also used as a fertiliser.

In the rumen, the ingested nitrogen (in the form of protein or urea) is rapidly converted to ammonia, which is then converted into microbial protein and other forms of nitrogen. The ingestion of excessive quantities of nitrogen can result in a build-up of ammonia gas in the rumen.

Predisposing factors

- Rations high in rumen-degradable protein (such as legume-based silage, some protein meal and pellets) or urea.

Clinical signs

- bloating
- abdominal pain
- muscle tremors or convulsions
- weakness
- sensitivity to sound and movement
- death.

Control and prevention

- ensure stock do not have access to fertiliser stores
- sheep are more susceptible and require lower inclusion rates and more caution
- introduce urea into diets over a period of 1-2 weeks and any changes should be gradual
- include a readily available carbohydrate in the diet if feeding urea.

Nitrate/nitrite poisoning

Many plants can accumulate nitrate under ideal conditions. After ingestion by sheep or cattle, nitrate is broken down to nitrite and then ammonia and absorbed through the rumen wall. If the nitrate intake is too high or if the animal is unaccustomed to nitrate in the diet, nitrite can accumulate in the rumen and then get absorbed into the bloodstream. This can interfere with the ability of blood cells to transport oxygen around the body.

Predisposing factors

Plants commonly associated with nitrate/nitirite toxicity include sorghum, millet, cereal crops, brassicas, ryegrass and the weeds capeweed, pigweed, variegated thistle and mint weed. Hay and silage made from plants containing high levels of nitrate/nitrite will also contain high levels and must be fed with caution.

Factors that lead to a build-up of nitrate in the plant include:

- continuous cloudy conditions
- high temperatures
- low moisture
- frost
- high, recent applications of nitrogen fertiliser.

Factors that contribute to nitrate/nitrite toxicity in the animal include:

- hungry stock / limited alternative feed
- stock that are not accustomed to feeds containing nitrate.

Clinical signs

- sudden death (can take as little as one hour)
- brown "chocolate" coloured blood – transient – dissipates within 20 minutes of death
- diarrhoea, abdominal pain
- respiratory distress – extreme when in terminal stages
- profuse salivation
- muscular tremors, weakness.

Control and prevention

High risk feeds should not be fed or fed as a small part of a ration. Hay and silage can be tested at feed labs to determine whether the sample contains toxic levels of nitrate/nitrites.

Hungry stock should never be given access to feeds that may contain high levels of nitrate/nitrite.

Nitrite toxicity in calves. Introducing cattle to high nitrate crops while they are hungry poses the greatest risk. Photo Credit: Jane Bennetts.

Enterotoxaemia

Also known as pulpy kidney.

Rapidly growing lambs and weaners are most at risk, although enterotoxaemia can affect all ages. Enterotoxaemia is uncommon in cattle.

Enterotoxaemia is caused by toxins produced by the bacteria Clostridium perfringens type D. This bacterium is a normal inhabitant of the small intestine. Under the right conditions, it can multiply rapidly and cause death quickly.

Predisposing factors

Rapid multiplication of Clostridium perfringens can be initiated by highly nutritious diets such as grain feeding or sudden release from confinement lots onto lush pasture. Sudden changes in diet are often implicated in outbreaks.

Often, it is the best animals (those with the highest dietary intakes) that are affected.

Clinical signs

Often, sudden death is the first sign of the disease.

If animals are seen alive, the following may be seen:

- frothing at the mouth
- diarrhoea
- staggering progressing to recumbency
- convulsions.

Control and prevention

Vaccination is a useful tool for the prevention of enterotoxaemia. 3-in-1, 5-in-1 and 6-in-1 vaccines all cover enterotoxaemia. Vaccination programs should be developed in consultation with a veterinarian. Duration of immunity, and risk factors for the individual production system should be taken into account. Annual booster vaccinations for adult sheep may not provide adequate immunity. In high challenge situations, 6-12 weekly booster vaccination is recommended.

Avoid sudden changes in diet, particularly to lush pasture or grain. In the face of an outbreak, changing to a higher roughage diet is recommended.

Digestive system

Coccidiosis

Coccidia (Eimeria species) are microscopic protozoan parasites. They are found in the gut of healthy animals, and cause disease when environmental conditions allow build-up of the organism on the ground. Young stock are generally affected, particularly calves 3-8 months of age and lambs 1-6 months of age.

Predisposing factors

- stress, poor nutrition and early weaning
- faecal contamination of feed or water
- high stocking rates of weaned lambs and calves
- moist environmental conditions.

Clinical signs

- diarrhoea, sometimes containing blood
- lack of appetite
- dehydration
- abdominal pain
- weakness
- recumbency and death
- mild cases may have poor growth rates.

Control and prevention

- minimise stress
- control concurrent disease problems
- ensure optimal nutrition
- avoid faecal contamination of feed and water by feeding from troughs
- feed additives (Monensin, Lasalocid) in total or partial mixed rations can aid in prevention.

Rectal prolapse (sheep)

Rectal prolapse can be a common issue in lamb feedlots but tend to be less of an issue in adult sheep in confinement feeding. Rectal prolapse can also occur in cattle. Rectal prolapse is a complex disease condition in sheep and there are many predisposing issues associated with this problem. The following may contribute to or be associated with the incidence of rectal prolapse.

Predisposing factors

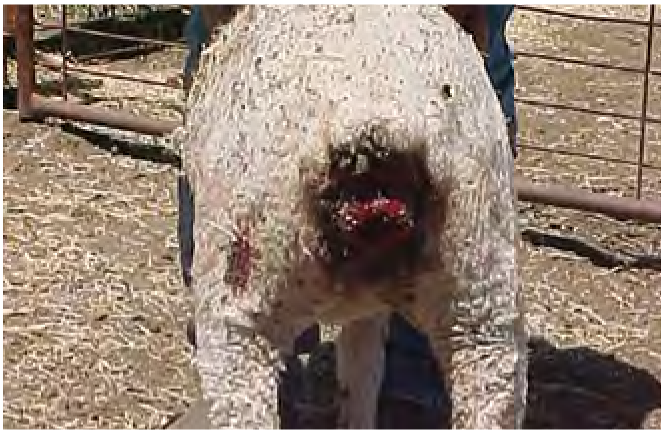
- females
- overly fat animals
- weaners
- coughing due to respiratory disease or dust
- diarrhoea (any cause)
- genetic predisposition
- tails docked too short.

Clinical signs

The rectal prolapse can be observed as a red mass of tissue protruding from the anus. Initially it may be intermittent, visible when the animal coughs or lies down. It will often progress to permanent prolapse, with progressively more of the rectum outside the body.

Control and prevention

- minimise dust to reduce coughing
- minimise risk factors for pneumonia and coccidiosis
- use correct technique for tail docking
- dietary management to reduce diarrhoea
    - fibre
    - Bentonite.



Prolapsed rectum. Photo taken from rear. Photo Credit: Geoff Duddy.

Prolapsed rectum close up. Photo Credit: Geoff Duddy.

Skin and eye disease

Pink eye (sheep)

Also known as contagious ophthalmia or ovine infectious keratoconjunctivitis.

Clinical signs

The eye of infected animals can appear white, blue or pink, and may affect one or both eyes. Animals severely affected in both eyes may be blind and stand away from the mob.

Control and prevention

- reduce dust by careful site selection (aspect and prevailing winds, soil types), construction and placement of windbreaks
- screen animals on entry to confinement pens for grass seeds or signs of pinkeye
- remove affected animals and manage in a hospital pen with easy access to feed and water
- do not feed dusty, fiberous or weed contaminated hay
- keep ration fines to a minimum.

Mild case of pink eye in a lamb. Photo Credit: Nigel Gillan.

Pink eye (cattle)

Predisposing factors

Pinkeye in cattle is generally associated with infection by the bacteria Moraxella bovis, although infection with other bacteria and viruses may exacerbate the condition. Damage to the cornea, by UV light, dust and grass seeds predispose cattle to infection. Flies spread the bacteria between cattle.

Clinical signs

Often the first signs are increased tear production and a reluctance to open the affected eye. The surface of the eye may appear pink, blue or white. If both eyes are affected, cattle may be blind. In severe cases the eyeball can rupture, leading to permanent loss of vision in that eye.

Control and prevention

- control flies
- control dust
- avoid grazing young cattle on long pasture, or overhead hay racks
- remove affected cattle from the mob if possible
- a vaccine is available. Discuss use with your veterinarian.

Scabby mouth

Scabby mouth is also called Orf or Contagious Pustular Dermatitis and is caused by an orf virus.

Scabby mouth is a zoonotic disease (it can affect people). Use personal protective equipment if handling infected sheep and seek medical advice if you are concerned about human infection.

Predisposing factors

scabs from affected animals can contaminate the environment for at least a year.

damage to the skin facilitates infection. Coarse fibrous feeds and the presence of thistles or other spikey weeds contributes to outbreaks.

Clinical signs

- pustules and scabs around the nose and lips is the classical presentation
- pustules and scabs can also appear on the lower legs, udder, scrotum, ears, anus and vulva.
- affected animals may be reluctant to eat or suckle. Lameness occurs if the limbs are affected
- flystike on affected areas
- lesions usually resolve over a period of about three weeks.

Control and prevention

Vaccination is an effective way of preventing Scabby mouth. It is administered as a scratch vaccine on the hairless area under the front leg. Vaccination should only be performed on properties on which Scabby mouth has been diagnosed. It is a live vaccine and can produce infectious scabs from the vaccination site.

Avoid feeding coarse feeds and grazing areas with prickly plants where possible.

Scabby mouth in a lamb. Photo Credit: Jill Kelly.

Respiratory disease

Pneumonia

Pneumonia refers to an infection of the lower respiratory tract (lungs) and can affect both sheep and cattle. It can be caused by a variety of bacteria, viruses and sometimes fungi, which are often normal inhabitants of the upper respiratory tract. It can cause widespread economic losses from death, reduced liveweight gain, and treatment costs. Pneumonia can occur in all breeds and crosses and at any age, although it is more common in young animals.

Predisposing factors

Risk and incidence are increased during periods of:

- high humidity and/or excessive heat
- dust or damp bedding
- following stressors such as transport, weaning, mixing with unfamiliar cattle/sheep.

Clinical signs

The first sign of pneumonia may be sudden death. Affected animals may show the following signs:

- temperature of 40-42 °C
- laboured breathing
- coughing
- nasal discharge
- lowered head and droopy ears
- reduced feed intake
- weight loss or reduced weight gain.

Control and prevention

Management of pneumonia requires reducing environmental stressors where possible. Vaccinations are available for some of the bacteria and viruses involved in pneumonia. Vaccination against pestivirus may be of benefit in cattle. Affected cattle should be moved to a hospital pen for management and treatment.

Chest cavity of a lamb diagnosed with Pneumonia. Photo Credit: Jess Bourke.

Neurological and lameness diseases

Polioencephalomacia

Polioencephalomalacia (PEM) has also been called Vitamin B1 deficiency, cerebrocortical necrosis or Star Gazing Disease. It can affect both sheep and cattle.

Vitamin B1 is normally produced by the rumen microbes. PEM is usually caused by compounds that break down or block uptake of vitamin B1 rather than a dietary deficiency.

Predisposing factors

- diets or water sources high in sulphur
- diets with high levels of starch and inadequate effective roughage
- ingestion of some types of ferns can induce PEM.

Clinical signs

- blindness
- walking aimlessly
- head pressing
- “star gazing” posture.

Control and prevention

- ensure diets contain adequate roughage
- have water sources or byproduct feed sources tested for sulphur levels
- minimise stress and time off feed, particularly during processing (vaccinating, drenching, etc).

Laminitis

Laminitis is the inflammation of the attachment of the bone in the foot to the horn of the hoof. Acute laminitis can be a result of acidosis or other severe systemic illness. Subclinical laminitis causes a deterioration in the quality of the hoof horn leading to sole ulcers. Chronic lamintis causes visible deformity of the hoof horn. Laminitis can affect sheep and cattle.

Predisposing factors

- acute lamititis: as for acidosis
- subclinical laminitis: Sub acute ruminal acidosis, or a long term, moderate reduction of ruminal pH caused by diets high in rapidly fermentable starch (mostly in dairy cattle).

Clinical signs

- lameness and reluctance to stand or walk.
- “sawhorse” stance with front and back legs further away from the centre of the body.
- stiff gait with an arched back.
- hoof may feel warm.

Control and prevention

As for acidosis.

Urinary tract diseases

Urolithiasis

Also known as, urinary calculi, bladder stones, or water belly if the urinary tract ruptures.

Urolithaisis is a common disease of male sheep and cattle caused by the formation of small stones (calculi) in the bladder. These stones can lodge in the urethra and inhibit urine flow. It may lead to the rupture of the bladder or urethra. Females can develop urinary calculi but obstruction of the urinary tract is less likely.

Predisposing factors

There are several types of urinary calculi. Different conditions favour the development of different types of calculi.

- rations high in phosphorus without calcium supplementation (cereal grains)
- the presence of silicates in the ration, (cereal hay, cereal grain and many grasses)
- reduced water intake (for example cold weather, inadequate supply, inadequate trough space, pH).

Clinical signs

Signs can vary from mild to severe depending on whether the urinary tract is completely or partially obstructed.

- straining to urinate, with reduced or absent urine flow
- standing with an arched back
- kicking at the belly
- reluctant to eat or drink
- tail twitching.

Control and prevention

Chemical analysis of the urinary calculi can provide useful information to determine the cause of the outbreak. Analysis of the ration and water can also aid in identifying potential causes.

General preventative measures include:

- provision of good quality water and adequate trough space
- inclusion of 1.5-2.0% (w/w) feed grade limestone in the ration
- addition of between 0.5-1.0% of sodium chloride (salt) to the ration to increase water intake.
- the addition of 0.5-1% (w/w) of ammonium chloride to the ration can aid in the prevention of some types of calculi
- attempt to achieve a Ca:P ratio of 2:1
- include a minimum 10% roughage in the ration.

A sheep bladder with stones present. This led to a blockage and subsequent rupture of the urethra, commonly known as waterbelly. Photo Credit: Nigel Gillan.

Reproductive diseases

Pestivirus (cattle)

Also known as Bovine Viral Diarrhoea, caused by Bovine Viral Diarrhoea Virus (BVDV)

Pestivirus is common in Australia, with up to 90% of cattle herds showing exposure. The immune suppression caused by infection with pestivirus can contribute to disease on entry to confinement areas.

There is a sheep strain of pestivirus, and some strains are able to infect sheep and cattle. In sheep, pestivirus causes Border disease or hairy shaker disease. It appears to be an increasingly important disease in sheep.

Predisposing factors

The virus is spread via nose-to-nose contact between a naïve (not previously exposed) animal and either a persistently infected or transiently infected animal.

Mixing cattle from different sources.

Clinical signs

Infection of non-pregnant adult animals (transient infection) will usually cause mild immunosuppression and diarrhea. In a confinement lot situation, this may make animals much more susceptible to pneumonia.

Infection of a pregnant cow can result in early embryonic death, congenital abnormalities, or a persistently infected (PI) calf that will shed virus throughout its life.

Infection of a PI animal with a different strain of BVDV can develop mucosal disease. Elevated temperature, watery diarrhoea, lesions in the mouth and between the claws and death may be seen.

Control and prevention

Several control methods are commonly used:

- a vaccine is available to aid in the prevention of Pestivirus.
- identification of PI animals and exposure of heifers to the virus prior to joining or entry to a confinement lot
- eradication and maintaining a closed herd. This can be difficult as over-the-fence contact with neighbouring cattle can transmit the virus.

Campylobacteriosis (sheep)

The bacteria, Campylobacter fetus sub species fetus is an emerging cause of abortions among confinement area or supplementary fed ewes.

Predisposing factors

Ewes that are exposed to the bacteria for the first time during pregnancy are most at risk. High stocking density, as found in confinement pens, can facilitate transmission.

Clinical signs

Abortion in the third to fifth month of pregnancy. Ewes may have retained foetal membranes. A large proportion of the ewes may abort. Laboratory isolation of the bacteria is necessary to differentiate campylobacter abortions from other causes of abortion that my present in a very similar way.

Control and prevention

To control an outbreak of abortions:

- foetuses and foetal membranes should be removed from the confinement lot as soon as possible
- aborting ewes should be separated from those that have not aborted
- those that have not aborted should be run at a lower stocking density.

To prevent abortions:

- Ewes that have been exposed (Campylobacter fetus ss fetus) develop strong immunity and are unlikely to abort. A vaccine is available to protect ewes that have not been exposed. Discuss appropriate usage with your veterinarian.

Miscellaneous conditions

Mouldy feed and mycotoxins

Mycotoxins are toxins originating from fungi. They can cause many types of disease, ranging from abortion to stagger syndromes to photosensitisation.

In addition mycotoxins, mouldy feeds may

- reduce dry matter intake and growth rates
- have reduced digestibility and energy content.

Some feed toxins can be identified through laboratory analysis. Where a toxin is suspected the feed should be tested and a veterinarian consulted for specific treatments.

Clinical signs

Wide variety of clinical signs depending on the specific toxin. If mouldy feed has been offered to stock, laboratory testing and consultation with a veterinarian is essential.

Control and prevention

- ensure grain moisture content is 12% or less
- visually inspect feed for visible mould and avoid feeding grossly contaminated feed if possible
- laboratory testing for specific mycotoxins is available. There are thousands of possible toxins, which makes routine screening of feeds cost prohibitive and difficult. Samples may not be representative of the rest of the feed source.

A thick layer of wasted feed with a pen for scale. Note the wetness of the waste feed. Photo Credit: Brett Littler.

Feeding stock on the ground wastes feed and makes it difficult to calculate quantities consumed. When stock are repeatedly fed in the same area, faecal contamination can lead to health problems. Photo Credit: Brett Littler.

Resources

Australian Animal Welfare Standards and Guidelines: Sheep and Cattle www.animalwelfarestandards.net.au

Website: Animals and Livestock - see Beef cattle and Sheep health and disease pages (NSW Department of Primary Industries) www.dpi.nsw.gov.au/animals-and-livestock

Grain poisoning of cattle and sheep (NSW Department of Primary Industries 2006)

Website: Coccidiosis (Meat & Livestock Australia)

Nitrate and nitrite poisoning in livestock (NSW Department of Primary Industries 2018)

Website: Pinkeye (Meat & Livestock Australia)

Pneumonia/Pleurisy (Animal Health Australia undated)

Sheep health - scabby mouth (NSW Department of Primary Industries 2016)

Key points

- Through the correct design, construction and management of confinement feeding areas the five freedoms and provisions of animal welfare can be ensured.
- It is important that producers are aware of potential issues and clinical signs.
- Animals should be checked and monitored regularly, ideally on at least a daily basis, to ensure no health issues are developing in the confinement area.

Confinement feeding - budget tools and calculators

Cows and calves being fed on the ground with a total mixed ration. Photo Credit: Brett Littler.

There are several applications available to assist with calculating feed requirements and costings for sheep and cattle in confinement feeding areas.

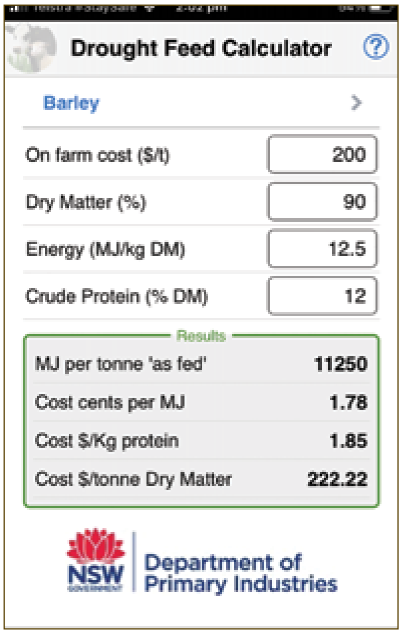
NSW DPI Drought Feed Calculator

NSW DPI Drought Feed Calculator phone app allows the user to develop a drought feed ration for sheep and cattle. It calculates the daily feed requirement of dry, pregnant, lactating, and growing animals using a database containing 71 different feeds. The app calculates the total amount and cost of feed required for a mob over a selected period.

It is designed for use in the paddock or at the silos, no mobile phone coverage needed.

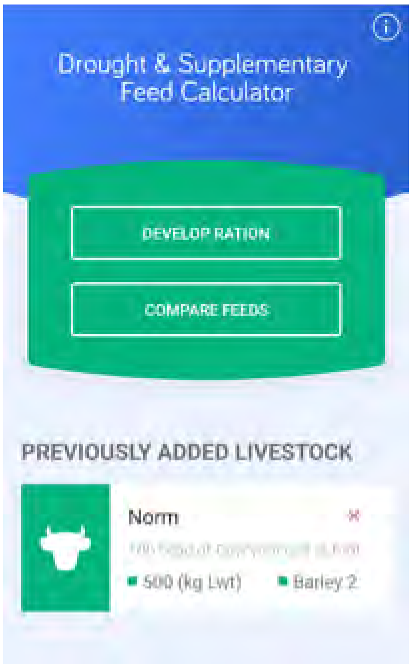
There are 71 different feeds to select from each with its own estimated energy, protein, and dry matter values. Values can be over written when feed test results are available (recommended). The user can easily assess the value of different feeds by simply comparing the results for up to three feeds as well a mixed ration.

The phone app is free and can be downloaded from the App Store or Google Play or just search 'Drought Feed Calculator'.



The Drought feed calculator app (screen shot).

NSW DPI NSW Drought and Supplementary Feed Calculator



The Drought and supplementary feed calculator app (screen shot).

The Drought and Supplementary Feed Calculator is an essential tool for sheep and cattle producers to develop drought feed rations as well as rations for dry periods when supplementary feeding is required.

Featuring a comprehensive feeds database listing average nutritional values of 71 different feeds you can compare and develop a mixed ration containing up to five feeds. Feed additives can be incorporated to calculate overall ration cost, however their nutritional benefits (other than energy and protein) cannot be included.

The supplementary feed outputs rely on the user's ability to accurately assess pastures. The calculator displays a range of outcomes to inform the user to the potential impacts of their pasture assessments.

The tool calculates the individual feed quantities and auger timings needed when making single and mixed rations and when feeding out. It is designed to calculate the requirements of different sized mobs and feeding frequencies. It also contains a handy summary page and outputs can be saved to a home computer or sent directly to a printer.

The DPI Drought and Supplementary Feed Calculator app is free to assist sheep and cattle producers to develop feed rations during drought and dry seasons.

Download from the Apple App Store.

A desktop version is also available on the NSW DPI website (www.dpi.nsw.gov.au/animals-and-livestock/nutrition/feeding-practices/drought-and-supplementary-feed-calculator).

GrazFeed

GrazFeed helps farmers save supplement costs and reach livestock production targets by calculating the daily nutritional requirements of sheep and cattle. It is an up-to-date and user-friendly computer version of the Australian Ruminant Feeding Standards that can be applied to any breed or class of sheep and cattle and takes into account the effects of selection and substitution by grazing stock.

GrazFeed can be applied to any temperate or tropical grazing system where sheep or cattle graze pasture, rather than browse shrubs. It can also accommodate management systems which restrict pasture intake, such as strip grazing, cut-and-carry systems and feedlotting.

Grazfeed can be used to determine feed requirements and the value of feed supplements.

GrazFeed® is available from:

Horizon Technology Pty Ltd

PO Box 598 Roseville NSW 2069

Phone: 02 9440 8088

Email: horizonag@hzn.com.au

Sheep CRC Feedlot Calculator

A web based gross margin calculator that enables the user to enter different real time production, economic and feeding scenarios to estimate likely total feed requirements, costs and returns for a sheep/lamb confinement or finishing program.

Can be downloaded from www.dpi.nsw.gov.au/animals-and-livestock/nutrition/feeding-practices/feedlot-calculator

Lifetime Wool / Lifetime Ewe

Lifetime Wool was a national research, development and extension project that delivered profitable and practical guidelines for managing Merino ewes in the Australian wool industry.

The project was conducted on farms at plot and paddock scale and then through on-farm demonstration sites, in the temperate wool growing areas in five states across southern Australia.

Feed budgeting tools can be found at www.lifetimewool.com.au/toolsmgt.aspx.

The guidelines and practical recommendations from the project have been developed into a nationally accredited training program 'Lifetime Ewe Management'.

You can download the Lifetime Ewe Management app from the App store or Google Play.

Confinement feeding -resources

A range of publications have been recommended in the individual chapters of this Guide. This chapter provides a summary of these resources. Whilst all care has been taken to provide the correct links to the online resources, over time these links may change. Go to the individual websites and search the publication title to find any updated links.

Introduction

Beef cattle feedlots: design and construction

(Meat & Livestock Australia 2015)

- https: www.mla.com.au/globalassets/mla-corporate/research-and-development/documents/beef-cattle-feedlots---design-and-construction---web2.pdf

National procedures and guidelines for intensive sheep and lamb feeding systems

(Meat & Livestock Australia 2011)

- https://www.mla.com.au/globalassets/mla-corporate/extensions-training-and-tools/documents/nationalproceduresandguidelineslambfinishing.pdf

What is confinement feeding

No recommended resources.

Confinement feeding - regulations and requirements

Temporary arrangements for droughts and other emergency events – factsheet (NSW Department of Planning and Environment 2019)

- www.planning.nsw.gov.au/-/media/DF56F171900B43FFB18FA79F78837542.ashx

State Environmental Planning Policy (Primary Production and Rural Development) 2019

(NSW Government 2019)

- https://legislation.nsw.gov.au/view/html/inforce/current/epi-2019-0137

Planning Guidelines Intensive Livestock Agriculture Development (NSW DPI 2019)

- https://www.dpi.nsw.gov.au/agriculture/lup/development-assessment2/dev-app-intensive

Confinement feeding - site selection

Beef cattle feedlots: design and construction

Site selection Section (Meat & Livestock Australia 2015)

- https:www.mla.com.au/globalassets/mla-corporate/research-and-development/documents/beef-cattle-feedlots---design-and-construction---web2.pdf

Managing Biosecurity in NSW (NSW DPI) - webpage

- www.dpi.nsw.gov.au/biosecurity/managing-biosecurity

National procedures and guidelines for intensive sheep and lamb feeding systems

(Meat & Livestock Australia 2011)

- https://www.mla.com.au/globalassets/mla-corporate/extensions-training-and-tools/documents/nationalproceduresandguidelineslambfinishing.pdf

Planning Guidelines Intensive Livestock Agriculture Development (NSW DPI 2019)

- https://www.dpi.nsw.gov.au/agriculture/lup/development-assessment2/dev-app-intensive

Confinement feeding - stocking densities and mob sizes

No recommended resources.

Confinement feeding - pen design

No recommended resources.

Confinement feeding - infrastructure

Beef cattle feedlots: design and construction Site design Section (Meat & Livestock Australia 2015)

- https: www.mla.com.au/globalassets/mla-corporate/research-and-development/documents/beef-cattle-feedlots---design-and-construction---web2.pdf

Confinement feeding - feed requirements

NSW Managing Drought Guide

(NSW Department of Primary industries 2019)

- https://www.dpi.nsw.gov.au/emergencies/droughthub_old/information-and-resources/managing-drought

Confinement feeding - Feed: grains

No recommended resources.

Confinement feeding - Feed: pellets

No recommended resources.

Confinement feeding - Feed: alternate and by-products

No recommended resources.

Confinement feeding - Feed: fibre requirements

No recommended resources.

Confinement feeding - Feed: minerals

Assessing Stock Feed Additives and Mineral Supplements

(NSW Department of Primary industries 2009)

- https://www.dpi.nsw.gov.au/animals-and-livestock/nutrition/feed/assessing-additives-supplements

Feedipedia - animal feed resources information system

- www.feedipedia.org

Website: **Grass Tetany** (Meat & Livestock Australia, More Beef From Pastures website)

- https://mbfp.mla.com.au/herd-health-and-welfare/tool-6.07cattle-disease-guide/grass-tetany/#

Confinement feeding - Feed: vitamins

No recommended resources.

Confinement feeding - Feed: additives

No recommended resources.

Confinement feeding - shade and shelter

Feedlot Shade Structures

(Meat & Livestock Australia 2006)

- http://lshs.tamu.edu/docs/lshs/end-notes/tipstoolsfeedlotshadestructuresoct2006-3661603100/tipstoolsfeedlotshadestructuresoct2006.pdf

Shelterbelts (Sustainable Farms 2018)

- https://www.sustainablefarms.org.au/resources/shelterbelts-brochure/

Sheep farmers: Increase your productivity

(Goulburn Broken Catchment Authority 2015)

- www.gbcma.vic.gov.au/downloads/Shelter_Belts/2015_-_Shelterbelt_information_sheet_for_sheep_and_shelterbelt_designs.pdf

Hypothermia in Sheep (WA Department of Primary Industries and Regional Development website)

- www.agric.wa.gov.au/animal-welfare/hypothermia-sheep

Confinement feeding - water

Beef cattle feedlots: design and construction

Site design Section (Meat & Livestock Australia 2015)

- https:www.mla.com.au/globalassets/mla-corporate/research-and-development/documents/beef-cattle-feedlots---design-and-construction---web2.pdf

National procedures and guidelines for intensive sheep and lamb feeding systems

(Meat & Livestock Australia 2011)

- https://www.mla.com.au/globalassets/mla-corporate/extensions-training-and-tools/documents/nationalproceduresandguidelineslambfinishing.pdf

Water for livestock: interpreting water quality tests

(NSW Department of Primary Industries 2014)

- https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0018/111348/water-for-livestock-interpreting-water-quality-tests.pdf

Water requirements for sheep and cattle

(NSW Department of Primary Industries 2014)

- https://www.dpi.nsw.gov.au/emergencies/droughthub_old/information-and-resources/water-requirements-sheep-cattle

Model Code of Practice for the Welfare of Animals: The Sheep (Australian Government 2006)

- https://books.google.com.au/books/about/Model_Code_of_Practice_for_the_Welfare_o.html?id=n_hDeD_6yQoC&printsec=frontcover&source=kp_read_button&redir_esc=y#v=onepage&q&f=false

Heat Load in Feedlot Cattle

(Meat & Livestock Australia undated)

- https://futurebeef.com.au/wp-content/uploads/Heat-load-in-feedlot-cattle.pdf

Confinement feeding - health and welfare

Australian Animal Welfare Standards and Guidelines: Sheep and Cattle

- www.animalwelfarestandards.net.au

Website: **Animals and Livestock** - see Beef cattle and Sheep health and disease pages (NSW Department of Primary Industries)

- www.dpi.nsw.gov.au/animals-and-livestock

Grain poisoning of cattle and sheep

(NSW Department of Primary Industries 2006)

- www.dpi.nsw.gov.au/__data/assets/pdf_file/0016/101338/grain-poisoning-of-cattle-and-sheep.pdf

Website: **Coccidiosis** (Meat & Livestock Australia)

- https://www.mla.com.au/research-and-development/animal-health-welfare-and-biosecurity/parasites/identification/coccidiosis/

Nitrate and nitrite poisoning in livestock

(NSW Department of Primary Industries 2018)

- https://www.dpi.nsw.gov.au/animals-and-livestock/sheep/health/other/nitrate-nitrite-poisoning

Website: **Pinkeye** (Meat & Livestock Australia)

- https://www.mla.com.au/research-and-development/animal-health-welfare-and-biosecurity/diseases/infectious/pinkeye/

Pneumonia/Pleurisy (Animal Health Australia undated)

- https://animalhealthaustralia.com.au/wp-content/uploads/NSHMP-Pneumonia-Pleurisy.pdf

Sheep health - scabby mouth

(NSW Department of Primary Industries 2016)

- www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/179835/sheep-health-scabby-mouth.pdf

Confinement feeding - budget tools and calculators

No additional resources.

Local Land Services

NSW GOVERNMENT

Australian Government
Department of Agriculture, Fisheries and Forestry

Future Drought Fund

SOUTHERN NSW Innovation Hub
SUSTAINABLE AGRICULTURE, LANDSCAPES AND COMMUNITIES

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