Intensive Beef Operations in a Tropical Environment

Adapting the feedlot industry to the challenges of operating a feedlot in the climate and conditions of Northern Australia

A report for

By Stewart Borg

2018 Nuffield Scholar

May 2021

Nuffield Australia Project No 1806

Supported by:

Scholar Contact Details
Stewart Borg

Leichhardt Holdings

Address: “Marklands” Station 133 North Inneston Rd,

Sarina 4737

Mobile: 0408 585 161

Email: stewart@leichhardtholdings.com.au

NUFFIELD AUSTRALIA Contact Details

Nuffield Australia

Telephone: 0402 453 299

Email: enquiries@nuffield.com.au

Address: PO Box 495, KYOGLE NSW 2474

Executive Summary

With an Australian cattle herd of 24.7 million head, (Meat and Livestock Australia, 2020) Australia is one of the leading red meat exporters of the world. The industry can not only expand on the volume of red meat produced but also ensure that what is produced is of the highest possible standard.

The purpose of this report is to highlight the areas of adaption required to take the already highly successful Australian feedlot industry out of its traditional areas and into areas further north. Heat, humidity and rain are all issues within the feedlot sector but can be overcome with good prior planning and solid investment. The information within this report has been compiled from talking to experts from countries across the globe, who willingly shared their knowledge and experiences towards an end goal of a better industry. The research gathered is combined with the author's own experiences as a property owner and aspiring feedlot owner, as the business constructs one of the first feedlots in a tropical environment in northern Queensland.

The emerging tropical Australian feedlot industry will not take place overnight but will take decades to reach maturity and show how much potential it has. At present, the northern breeder operations of Australia are reliant on either sending feeder cattle to southern feedlots or the live export trade of south-east Asia. The author is supportive of the live export industry but believes that alternatives should be in place in the event of another live export collapse, as seen in 2011.

The northern feedlot industry is only one part of developing northern Australia and will also require other industries to expand with it. From large-scale water schemes, cotton and cropping, logistics and handling facilities, these developments will ensure processing and supporting businesses will follow. This will stimulate the economy and see agriculture in northern Australia boom and return on money invested by the Australian government return in the form of tax dollars many times over.

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Foreword

Together with my wife Sarah we own and operate Marklands Station, a 2,400 hectare (ha) mixed cropping and beef operation, situated 45kms south of Mackay on the tropical north Queensland coast. We operate a range of enterprises from breeding to selling bulls, producing feeder steers, sugarcane and several pulse bean and fodder crops.

I am the second generation at Marklands and third generation in my family on beef properties in the Mackay region. We have been heavily involved in numerous environmental impact studies and take the role of custodians of the land seriously. We have implemented control measures to reverse the degradation of the soil to ensure that future generations remain sustainable and profitable.

Historically the Mackay area has a history of monocultural systems with very little crop rotation or business integration. I believe that to be successful you must diversify and have a multifaceted business, in this instance rotations between fodder production, pulses and sugar cane on the farming country integrated with feedlot and beef production.

This study is about learning strategies and techniques to adapt the already successful and efficient Australian feedlot industry to northern Australia. Traditionally the feedlot sector has been bound to the southern drier climates, which provide more predictable and less severe weather. As the industry grows and evolves, we must find new ways to overcome the harsh conditions of the north, such as periods of high rainfall, heat and humidity. Northern Australia has advantages with proximity to new and existing markets, reliable seasonal rainfall making huge irrigation projects possible, and its proximity of feeder weight cattle.

We are currently endeavouring to bring some strategies learned from this study into our own business as we construct one of the first feedlots in tropical Queensland. Australia is a land of extremes, and this is even more so in the north, with the distinct seasonal changes of the wet and dry seasons. With this comes feed gaps as pastures deteriorates – or disappears – in drought. I believe that the northern feedlot industry has not only the potential to bridge feed gaps to achieve a steady supply of good marketable cattle all year round, but to also go a long way towards drought-proofing the country.

Acknowledgments

This Nuffield journey would not have been possible without the efforts and support to allow me the opportunity of Nuffield.

Firstly, to Nuffield Australia for making this opportunity possible, and also to my investor Meat and Livestock Australia (MLA) for having faith in me.

To my wife Sarah for holding everything together at home while I travelled the globe looking for answers. To my four girls for understanding that dad needed to be away and being brave until I returned. To our team at home for keeping the wheels turning while I was away.

To the nine other Nuffield Scholars that endured me around the globe on our Global Focus Program, I am sure it was not always easy! Your intellect and frame of mind to challenge what we encountered made the journey all the more memorable.

To Scholars Joe Muscat (2013) and Michael Lyons (2014) for the encouragement and support and ensured I did proceed with applying. And to Ray Vella (2012) for accompanying me on part of my journey.

To Chontell Giannini and her team at ITravel in Griffith for such a great job changing flights with little notice and ensuring that I always reached the destination.

To those that hosted me around the globe and shared hospitality and knowledge I thank you, and hope that in the future I can return the favour.

Finally, to my late father for instilling in me the drive to improve, giving me the mentality that just enough is not good enough. *Not all ideas are good but sitting idle is worse*.

Abbreviations

ADG – Average Daily (weight) Gains

ALFA – Australian Lot Feeders Association

CP – Crude Protein

DDG – Dried Distillers Grain

DM – Dry matter

EHL – Excessive Heat Load

Ha – Hectare

MLA – Meat and Livestock Australia

NT – Northern Territory

NQ – North Queensland

PVR – Plant Variety Rights

QLD – Queensland

USA – United States of America

WDG - Wet Distillers Grain

Objectives

The objectives are to highlight differences between the current successful and efficient Australian feedlot industry based in temperate climates, with adaptions that could be made for the industry to expand north into the tropical climates.

This report focuses on the two main areas of contrast to the existing industry:

- **Alternative feed sources:**
    - Grain corn
    - Corn silage
    - Soybean
    - Cottonseed
    - Cassava
    - Tropical pastures
    - Palm kernel
    - Dry Distillers Grain
    - Molasses
- **Housing**
    - Stock density
    - Rainfall
    - Water security
    - Heat stress
    - Housing designs

This report is not written in contradiction to recommendations given by either MLA or the Australian Lot Feeders Association (ALFA), but an adaption to systems already in place.

Chapter 1: Introduction

The northern beef industry has enjoyed and endured some of the most rewarding and challenging conditions over the years. With tighter margins and rising cost of production, its more critical than ever for producers to be as efficient as possible. The fabled “Toyota Index” – to buy a new Toyota Landcruiser – has risen from 19 bullocks in the 1970’s to over 60 bullocks today. The live export industry has been the saviour of the north in recent years with a million plus feeder cattle leaving Australia with good returns for producers. The sudden closure of the live export trade in 2011 has been the exception in recent years, as well as recent drought.

Diversification is essential in businesses and the northern beef industry is no different. Live export is a great market for northern producers with Indonesia, Vietnam and other south-east Asian destinations being great trade partners. Yet it is critical that there is a push from Australian producers to safeguard against market trends and seasonal conditions. With dry years and below average rainfall comes feed gaps, resulting in deteriorating cattle body conditions and lower of carcase values.

Through irrigation projects and more infrastructure in the north, the sector could treble its national herd and have a guaranteed supply of saleable cattle regardless of seasonal conditions to finish increased numbers of slaughter cattle in Australia.

Adapting the feedlot industry to northern conditions require feedlots to operate under severe heat and humidity in summer and periods of intense rain during cyclones and monsoons, which can be overcome. The main benefits of lot feeding are greater control and flexibility in the production and marketing of livestock. Specific benefits as highlighted by MLA include:

- Ability to finish animals when pasture feed is deficient in quality and/or quantity.
- Ability to meet a wider range of markets.
- Turnoff of a more even 'line'.
- Reduction of stocking pressure on-farm during dry conditions without having to sell animals in poor condition.
- Option to increase breeder numbers on-farm in proportion to the number of turnoff animals placed in a feedlot (MLA, 2016).

Profitability is essential and the best way to ensure profitability is to mitigate risk.

Chapter 2: Why Beef?

Animal proteins are essential for the healthy development of growing humans. It is not an argument of straight proteins and calories as it is far more complicated with it being the main source of nutrients, amino acid and iron, as explained by Associate Professor Tyron Wickersham at Texas A&M University (Abby Bauer, 2018). It takes approximately 600kg of corn to finish a steer.

Professor Wickersham explained that there is a subset of people who favour the adoption of a plant-based diet, believing it is a better option for optimising food supply and human health, protecting the environment and maintaining social justice. Yet, humans generally still prefer and demand livestock protein sources when they have money to purchase it. He looked at three numbers when doing his research:

1. **Human-edible protein** —the amount of protein in a feedstuff that can be consumed and utilised by people.
2. **Protein quality ratio** — provides a means of evaluating how the animal production system modified the protein quality.
3. **Net protein contribution** — captures the benefit or harm of a livestock feeding system to the supply of human-edible protein.

It would take a lot of corn, in fact more than possible for a child to consume. "*In general, humans are not deficient in calories. They tend to be more deficient in nutrients*," Wickersham notes. That child would likely become obese before reaching the protein requirement if they ate that much corn. However, if the corn is fed to a steer it converts those nutrients into beef which would meet the annual amino acid requirements of two children. By moving that corn through cattle, it is possible to quadruple the amount of human-edible protein, in a format that is more nutrient efficient (less calories) and more desired by most people.

Wickersham notes that a challenge the beef industry faces is that there is a percentage of people against it. "*There is a large group of our peers that disagree with what the beef industry is trying to do*," he says. The reality, though, is that beef producers do good things by bringing a high-quality protein to consumers by using feed sources that humans cannot, or do not want to eat.

Chapter 3: Alternative Feed Sources

The existing Australian feedlot industry revolves around the supply of cereal grains, generally wheat, barley and sorghum. Unlike the United States of America (USA), corn is not the mainstay of the Australian feed industry, nor is soybean which is used heavily in South America. While travelling to other countries its apparent that there are many non-traditional feed sources available for lot feeding.

2.1 Grain corn

Grain corn has the most relevance to the developing northern industry in multiple forms. Corn is widely used globally for both human and animal consumption and is the third most grown field crop in the world behind rice and wheat. It grows in a wide variety of climatic conditions but relies on heavy nutritional inputs and requires as much as nine megalitres of water per ha to produce. Nutritional requirements vary greatly from one country to another with inputs varying from 150kg – 1000kg of nitrogen. There are many variables when considering crop/soil requirements and fertilising guidelines within countries. It can be used in multiple ways from high moisture corn stacks, dry rolled or cracked corn or steamed flaked corn. Flaked corn is most widely used across the USA and considered to be the grain of choice. Corn is also widely used across South America, but generally in a dry rolled or cracked ration to save on both infrastructure and energy inputs. This keeps the ration price down but does lose efficiency.

Figure 1: An Example of high-quality steam flaked corn at Dimmitt Flaking – Dumas, Texas (Source: Author)

2.2 Corn silage

Corn silage is the most popular source of silage worldwide and was apparent in each of the countries visited. It generates a high-quality product with large yields. Corn is a spring/ summer dominate crop so for Australian conditions would require high water input or suffer much reduced yield. Corn is best grown under low pressure irrigation with multiple regular waters across the crop cycle. The corn plant can be fed whole, either via ensilaging process that allows the crop to remain available all year round without deteriorating in feed value or chopped daily and fed as a fresh product. Both systems have their own merits with fresh chopped product being considerably higher in labour requirements but not needing plastics or inoculants, which are generally used with silage.

Figure 2: Corn chop-chop being harvested by hand and carted for processing and mixed into fresh rations, cut daily. JJAA Feedlot – Lampung, Indonesia (Source: Author)

Research has shown that a range of high-energy silages (ME > 9.5 MJ/kg DM) can sustain cattle liveweight gains in the range of 0.9–1.1 kg/day and can be increased to 1.3kg/day with the addition of grain and protein supplements in the ration, with no adverse effects to carcase quality (MLA, 2016). Crop selection, stage of harvest and effective silage management are three key factors that determine cattle growth rates per tonne of silage. Detailed information is available to producers for maize silage, with further research required to assist in the production of other high quality, high-energy varieties of silage suitable for the feedlot industry.

Quantity of corn silage fed within a ration varies greatly across the world pending on application, cattle description and target outcome. For instance, many of the USA feedlots on the panhandle of Texas keep silage inclusion low, varying between 8%-20%, but their dairy counterparts in the same area run as high as 50%. Intended outcomes and commodity prices have a huge bearing on ration formulation.

Whilst there is some loss of nutrient content during the ensiling process, there are many advantages of the ensiling technique for a wide variety of high moisture commodities commonly available to feed lotters, including:

- Silage making is an excellent method of preserving high moisture forages at an optimal stage of nutritional composition for protein and energy
- Feed can be stored at low cost, involving minimal investment in storage structures
- Silage will keep indefinitely if correct ensiling methods are implemented, and appropriate storage conditions maintained
- Ensiling can reduce certain toxins in some forages e.g. prussic acid in stressed forage sorghums, and nitrates in other forages. Quality degradation due to mould development can also be curtailed and the feeding risks minimised (provided ensiling occurs prior to fungal toxin release)
- Ensiled product is generally resistant to fire and vermin
- Newer, improved varieties of corn and forage sorghum have been bred to produce silages with high metabolisable energy contents e.g. corn silages with 9.5-11.0 MJ ME/kg DM, and forage sorghum silages with 9.5-10.0 MJ ME/kg DM.
- The use of silage inoculants are important to encourage rapid fermentation and acidification, as well as to encourage subsequent high animal intakes and improved digestibility and performance.
- Effective sealing of storage facilities to exclude air, by means such as:
  - The covering of large silage stacks above the ground surface, or below ground in pits, or in concrete bunkers – with plastic or polythene tarps, often weighed down with car tyres or with soil tossed on top.
  - Plastic wrapped round bale silage.
  - “Sausage” type silos, involving huge plastic bags, often 40m long, containing up to 200 MT of wet silage.
- Management of the open face during feeding out, with rapid re-covering with tarps or plastic to minimise entry of air into the stack.

Figure 3: Precision chopping of silage into 12-20 mm lengths enables effective compaction, air exclusion and fermentation (Source: Author)

Guide to assessing silage quality

- **Colour**. Dark brown or black indicates overheating due to excessive ingress of oxygen. Ideal colour for corn or sorghum silage is light yellow/green.
- **Smell.** Mouldy, sour, rancid, alcohol or sickly-sweet smells are not good. Ideal odour is similar to vinegar.
- **Feel**. Wet and slimy texture is not ideal and suggests excessive moisture during ensiling or caused by excessive exposure to rain.
- **Stem length and thickness**. Too long or thick stems imply a reduced chance of effective compaction, air exclusion and the maintenance of anaerobic conditions. Chop length of forages should not exceed 2cm.
- **Grain content**. Generally, a reliable indicator of energy content. Good corn silages contain up to 35% grain.

2.3 Soybean

Soybean is gaining popularity across the globe and is now the number two crop in Brazil, second only to sugar cane. Not only are soybean exceptionally high in protein, (42%-46%) making it a good addition to cattle rations in Australia, but being a legume is good for soil health and adding nitrogen into soil. Soybean can be one of the main rotational crops grown in northern Australia. Historically it has had little use in the Australian feedlot sector due to high prices of soy and poor availability. Traditionally soybean has been used for human, chicken, pig and other monogastric consumption, as monogastrics cannot digest cottonseed like ruminants can. Generally, cottonseed is a cheaper protein alternative. As soybean production expands, soya may have a place in Australian feedlots as a viable replacement of cottonseed during shortages and for second grade soybean not suited to human consumption. Soybean was one of the main components in feed rations in Brazil, accounting for 40-50% of total ration (Bom Futuro, 2018). This is seen as excessive by many nutritionists within industry but is still considered to have a place in the feed sector of northern Australia at a much lower inclusion rate.

Figure 4: Nelore and Nelore/Angus cattle on a high soybean diet in semi confinement at Bom Futuro, Campo Verde, Mato Grosso (Source: Author, April 2018)

2.4 Cottonseed

Although cottonseed is not new to Australian feedlots, the expansion of the northern feedlot industry goes hand in hand with the expansion of the northern cotton industry. In recent times cottonseed has skyrocketed in price, making it too expensive to source or simply not available. With cotton gins planned to be built across northern Australia, the two industries will complement each other making it both viable and keeping freight to a minimum.

Whole cottonseed is high in fat, protein and fibre and can be fed to cattle, sheep and other ruminants. It can be fed as a supplement to dry standing pasture or as an ingredient in feedlot rations. The digestion of whole cottonseed in the rumen causes a slow release of nutrients. With the slow release of nutrients, a component of protein is bypass protein, which will be available for direct absorption by the animal. As the seed contains little starch and the fat provides the energy, there is no risk of acidosis or grain poisoning.

Figure 5: A cotton crop being grown in northern Australia by the Kimberley Agricultural Investment (KAI) Group – Kununurra, NT (Source: Luke McKay, 2018 Scholar)

Whole cottonseed contains gossypol, and the free form of gossypol is toxic to animals. Cattle, sheep and other ruminants are able to detoxify the free gossypol up to a certain level. Whole cottonseed contains between 0.6% – 1.6% free gossypol. With 21% protein when in whole form and 43% when in cottonseed meal, it is a valuable addition to feedlot rations.

2.5 Cassava

The cassava root is a starchy yam or tuber-type plant that is commonly grown across tropical regions in Africa, Brazil and south-eastern Asia in large quantities for human consumption. It is the third-largest source of food carbohydrates in the tropics after rice and maize and is a major staple food in the developing world, providing a basic diet for over half a billion people. It is one of the most drought-tolerant crops, capable of growing on marginal soils. Nigeria is the world's largest producer of cassava, while Thailand is the largest exporter of dried cassava.

It is exceptionally high in carbohydrates but low in protein. It can be found in many feed rations in Indonesia either as ground cassava or a dried cassava chip "onggok". The widely used onggok product is a waste product of tapioca starch factories, and is referred to in some countries, including Brazil, as cassava "bran" or "bagasse". It is comprised of fibrous cassava root material, but also contains considerable quantities of residual starch that physically could not be extracted as the tapioca starch is separated. It therefore contains a highly significant energy component, which is well utilised by ruminant animals. It also has a large absorption capacity and often contains approximately 75% moisture as it leaves the starch factories.

Indonesian rations tend to be nutritionally better balanced than those in the Philippines and Malaysia, the result of a broader range of commodity options within each of the main feed ingredient types being generally available in feedlotting areas. Ration DM contents are often close to an ideal level of approx 73%. More importantly, Indonesian rations are also generally higher in energy, due to the availability of high starch cassava root products - dried tapioca pulp ("onggok"), and tapioca chips ("gaplek") - which are ideal commodities for finishing cattle in feedlots. This particularly applies to feedlots in the Lampung Province of south Sumatra, and on the island of Java, which have the largest cassava plantation areas of Indonesia (Willis, 2009).

The Indonesian feedlot industry has a big presence in the Lampung Province of south Sumatra and the three main provinces of Java, as it is centrally located to the largest cassava root growing regions of the country. Cassava roots are used to produce tapioca starch. By-products of this manufacturing process, together with raw, dried cassava root chips, have formed the basis of high energy, low priced feedlot rations since the inception of the feedlot industry in the mid 1990's. Over 40 tapioca starch factories are located in Lampung Province. However, the dynamic has now changed with cassava products being increasingly exported and both commodities being targeted by newly established ethanol factories. Similarly, the very commonly used proteins, copra and palm kernel meals, are being exported to many countries. It has been estimated that approximately 80-90% of waste products from the huge Indonesian palm oil industry are now exported.

The issue with cassava is that unless an industry is established in Australia the likelihood of ever seeing cassava in Australian feedlots is slim with little to no chance of imported cassava ever being able to comply with Australian biosecurity measures.

2.6 Tropical pastures

Tropical pastures have developed in recent years through hybridising different species of grasses to produce hybrids that far exceed performance of parent varieties. Several seed stock companies in Australia and overseas have been trialling new varieties and although they are still in early stages, the results are promising that they will surpass any of the current tropical pasture species currently available in Australia. Whilst in Brazil, the author observed a stocking density of 14 dairy cows per ha under full milk production. At present, this is a production rate unheard of in Australian conditions but is achievable under favourable conditions with pivot irrigation and high fertiliser input, in conjunction with these evolved pasture species.

Tropical pastures can influence the feedlot industry in the tropics in two ways – hay production and silage. It is possible that tropical grasses (in some instances) take the place of corn or sorghum silage as cost of production in tropical grasses may be cheaper to produce at superior protein levels but lower yields per hectare. The fact that grasses only need to be established once allows large savings and ongoing costs preparing seed beds and planting costs.

2.6.1 Mulato II

Mulato II is one of the newly released varieties. The registration of the Mulato hybrid brachiaria (*Brachiaria ruziziensis x B. brizantha*) by Grupo Papalotla in 2001 and the granting of Plant Variety Rights (PVR) in 2002 marked a significant breakthrough for tropical perennial grass cultivars. Mulato was the first hybrid brachiaria cultivar released from the hybridization program that begun in 1988 at CIAT (Centro Internacional de Agricultura Tropical). Hybrid Brachiaria varieties are the result of three generations of crosses that result in a three-way hybrid. Being apomictic, the hybrid remains true to type, is genetically stable and does not segregate or divide from one generation to the next. Mulato II is one such three-way hybrid, being the result of three generations of crosses and screening carried out by CIAT's tropical forages project. This variety is the second Brachiaria hybrid developed by CIAT. Hybrid Brachiaria are well suited to tropical, sub-tropical and warm temperate coastal regions. These varieties are commonly grown in the wet and seasonally dry tropics but will extend into the sub-tropics. They are well-suited to a wide range of soil types, performing best on well-drained soils of medium to high fertility but can also grow in less fertile soils, particularly low phosphorus soils and weathered tropical soils characterised by low pH (acid) and high aluminium saturation. Plants regrow after fire and following frost when warmer conditions return (Pizarro, Hare 2014) (Figure 6).

According to Heritage Seeds:

- Suitable for environments considered outside normal adaptation range for Brachiaria
- Strong persistence, even under seasonally dry conditions
- Maintains green leaf of high nutritional value into seasonally dry periods
- Forage yields recorded up to 27mt DM/ha/year and up to 21% crude protein
- Capable of sustaining high stocking rates−high nutritional value for ruminants
- Tropical species that can sustain dairying activities
- Suitable for direct grazing, cut-and-carry methods, baleing and silage (Heritage, 2014)

Figure 6 Cultivar Mulato II with deep roots in Brazil (Source: Pizarro and Hare, 2014)

From 2003-2008, further detailed studies were conducted in Mexico and Thailand on 155 new brachiaria hybrid lines resulting in four lines, BRO2/1718, BRO2/1752, BRO2/1794 and BRO2/0465 being granted PVR. BRO2/1752 produced similar dry matter yields to Mulato II. Yet trials in Mexico demonstrated good water logging tolerance, in contrast to Mulato II which had very low water logging tolerance leading to extensive plant death. BRO2/1752 has since been released as cultivar cayman (CIAT, 2018).

2.6.2 Cayman grass

Cayman grass is predicted to be highly suitable to the wetter tropical regions of northern Australia, providing a high protein, more productive variety of grass than the humidicola variety that is popular under same conditions. Although cayman is yet to be released in Australia, it is highly anticipated when released in the coming years.

Figure 7: Bos indicus cross steers grazing on cayman grass in Costa Rica (Source: Author, August 2014)

2.7 Palm kernel

Palm kernel meal is an important addition to tropical feedlot rations and is the by-product of the oil palm. This palm tree is cultivated for its oils rich in highly saturated vegetable fats. The palm oil, extracted from the fruit flesh and the palm kernel oil, extracted from the fruit kernel.

Palm oil is both a major staple oil (common in south-east Asia and tropical Africa) and an indispensable ingredient for the food industry (Nair, 2010). It has numerous non-food applications including as a feedstock for biodiesel. Palm kernel oil, which is semi-solid at room temperature, is economically less important. The demand for palm oil, fuelled by the growth of the Chinese and Indian economies, has been growing rapidly since the 1990s. Palm oil production doubled between 1996 and 2005 and increased yearly by approximately 10% during the 2000s (Vijay, 2016). Palm oil overtook soybean oil in 2004 to be the world’s leading vegetable oil (45 million tonnes in 2010). The production of palm kernel oil, while less important (5.6 million tonnes in 2010) overtook that of groundnut oil in 2007 (FAO, 2012).

Palm kernel meal is a complete feed and can be fed on its own in a cattle supplementation scenario or portion of a wider ration. Although lower in protein than dried distillers' grain, palm kernel is a cost-effective source of protein with good fibre and energy. As the name suggests, it is a by-product of the palm oil industry, and although it is not produced in Australia it is readily available for import from south-east Asia and deliverable to Australia via ports in Darwin, Townsville or Brisbane. Palm kernel comprises a large portion of the protein component in rations at the Indonesian feedlots of Sumatra and Java.

2.8 Dried Distillers Grain

Dried Distillers Grain (DDG) is a valuable alternative feed source where available. As the north develops, distilleries will have a need for grains and in turn produce the by-product of DDG or Wet Distillers Grain (WDG). DDG has varied feed values and it depends on the grains used and moisture content as to what nutrients are left over from the distillation process. At present there is no DDG available locally in northern Australia and is sourced from southern ethanol plants. Alternatively, it may be imported from overseas in the future.

2.9 Molasses

Molasses is a large part of the existing Australian feedlot industry in varying ration portions. High energy and dry matter levels makes a cost-effective addition to rations and its ability to keep minerals and additives suspended makes an excellent carrier for micronutrients and additives.

Molasses is recognised as a valuable cost-effective and convenient source of metabolisable energy (11.0 MJ/kg DM) and minerals. Conventional ration inclusion rates are in the range of 3-8%. Research and industry experience indicates that molasses can be beneficially incorporated in balanced production rations at rates much higher than generally practised in Australia. When costed, on a cost per unit of metabolisable energy basis, a 15% inclusion rate is feasible and there are indications that rates of 25% or higher are possible and practical (MLA, 2008) but does show the danger that price rises may ruin the economics of feeding molasses to cattle.

Chapter 4: Housing

There are approximately 700 accredited feedlots throughout Australia (MLA, 2012) with most located in areas close to cattle and grain supplies. Much of the industry is based in Queensland and New South Wales, with expanding numbers in Victoria, South Australia and Western Australia. At present there are few permanent structures in the feedlot industry, instead relying on shade cloth as rainfall is not an issue when built in southern drier climates. As feedlots progress further north and enter higher rainfall areas, it is necessary for adaptions to be made to counter the climate conditions in a tropical environment. The three main factors to consider with housing are rainfall, heat and humidity.

4.1 Overview

Animal welfare, environmental and practical management of a feedlot all become greater issues in areas with more extreme conditions. For example, in hot, high rainfall areas, feed gets wet, and animals are heat stressed. In more extreme environments, covered housing is usually adopted to control climate and minimise the effect of adverse weather and improve cleanliness and welfare of cattle. Environmental management issues such as minimising odour and/or effluent runoff are additional secondary advantages of covered housing. A covered housing system will depend upon the level of protection required and the issues being addressed, such as more ventilation against heat. The main disadvantage of covered housing is capital cost of constructing sheds. The higher stocking density could result in an increased accumulation of manure, and this also stays wet due to the shaded environment.

Here are some points for consideration:

Functional housing provides a suitable environment for cattle through shade and protects feed from rain without causing waste management problems. Feed troughs (bunks) must be covered under tropical climatic conditions. Pens can be fully or partially covered (over the feed trough only). Fully covered pens cost more but reduce effluent control requirements as there is no run-off. Partially covered pens cost less but require more complex systems for effluent control. Open-sided feedlot sheds can be orientated east–west to reduce direct sunlight during the day. However, north–south orientation can allow early morning and late afternoon sunlight into the pens to promote drying. Sheds should have high eaves, open sides and open ridge caps to promote natural ventilation. Ridge caps must allow sufficient overhang to prevent wind-driven rain passing through the gap. Sheds must allow easy access for machinery to deliver feed and clean pens. Clear-span structures are preferred. No columns should be placed inside pens other than in line with fences or on the alley side of feed troughs. Steel columns should be encased in concrete to prevent corrosion around their bases. Roof pitches should be steep enough (between 1:2 and 1:3 slope) to promote good natural ventilation. All run off should be collected in gutters and diverted away from effluent management systems.

4.2 Stock density

Type of housing and flooring has a big bearing stocking density. For example, many full enclosed operations worldwide far exceed the stocking densities that are considered normal here in Australia. Stocking density is generally defined as the average feedlot pen area allocated to each beast. It can influence the performance of cattle, as well as their general health and welfare. It is also important for environmental management as it affects moisture content of the pad and its potential to produce odour and dust.

Consider these general principles when selecting a design stocking density minimum stocking density of 9 m2/beast is stipulated in the *'Australian Code of Practice for the Welfare of Cattle in Beef Cattle Feedlots*' (National Guidelines - ARMCANZ, 1997 Department of Agriculture and Fisheries, 2010-2017). The National Guidelines give a guideline of a maximum cattle area per head of 25 m2/head the *'National Feedlot Accreditation Scheme Standards Manual*' stipulates a range of 9 to 25 m2/head of male bovine 600 kg (Standard Cattle Unit or SCU), however exemptions are allowed subject to written approval by the relevant state authority.

Many commercial feedlots in Queensland operate at about 12 to 20 m2/SCU stocking densities. The density should take into account local climate and the size of cattle. Fully covered pens can be stocked more densely (2.5–4 m2 per head) than partially covered pens (5–9 m2 per head). Higher stocking rates require bedding material that adds to ongoing costs. Pen capacity is best matched with the expected numbers of cattle entering or leaving the feedlot in each consignment—for example, a standard truck load.

4.3 Rainfall

Expanding the feedlot industry further north is not easy, and has previously not been recommended, with recommended areas having a lower annual rainfall and low humidity.

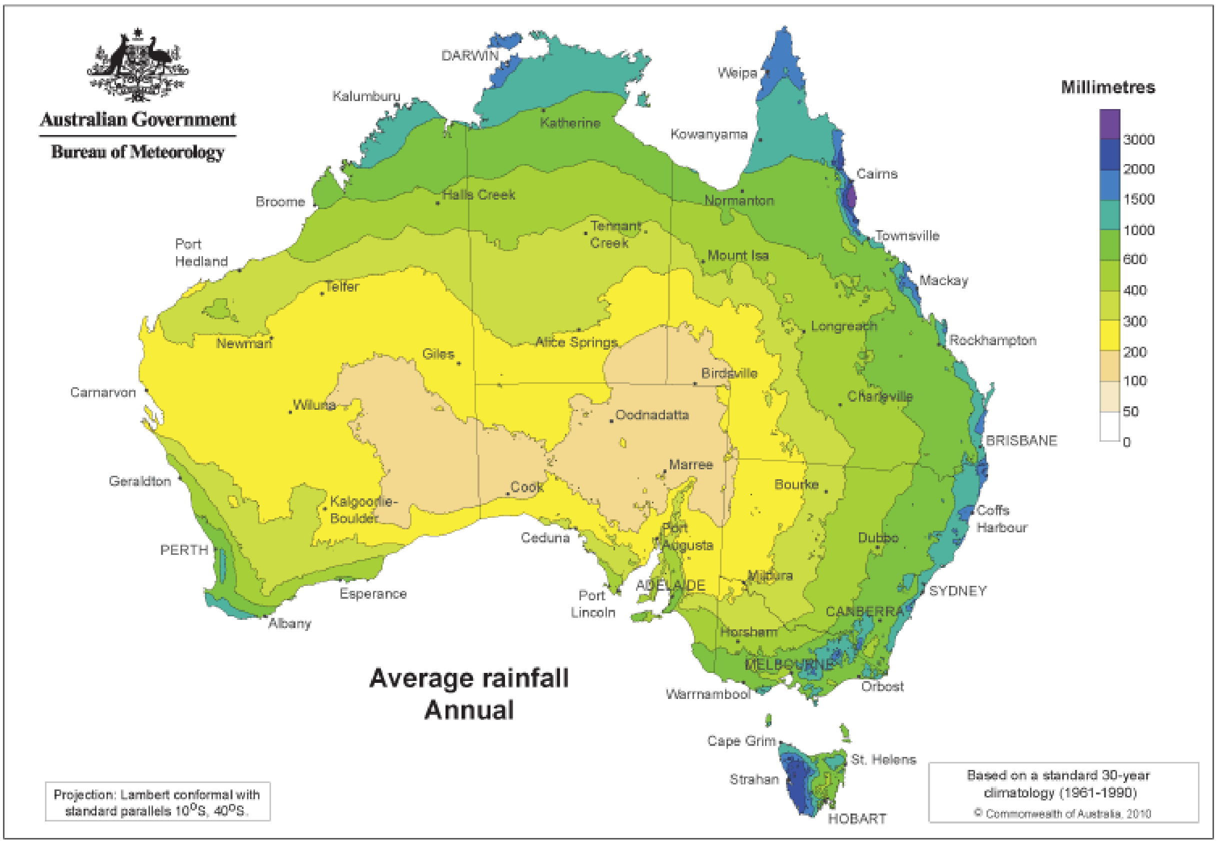

Figure 8: Annual rainfall chart of Australia – Bureau of Meteorology, Australia

Any feedlot operation built in the tropics must be built with adequate shelter and effluent catchment to handle heavy rainfall. Implementing covered sections will reduce effluent solids in run-off water and quantity of run-off as rain falling onto shed structures is turned away from catchment zones. The nature of cattle is to seek shelter in rain resulting in them leaving open pens to seek shelter in housing structures. This leaves the rain falling onto the pen areas less disturbed with less solid matter being removed in run-off. By having less solids in runoff, the weirs and effluent dams will require less frequent cleaning and will be much more functional in operation. Any water falling onto the housing structures should be either directed away or directed towards a clean water supply, keeping it separated from effluent storage areas.

4.4 Water Security

Without large, nation-building irrigation schemes across the north, the beef industry will remain stagnant with little growth. For large-scale projects and a tropical feedlot industry to emerge it is critical for irrigation systems to be built and available water to be utilised in the production of sustainable agricultural products. Australia currently sits as one of the least developed countries in the world in harvesting water, which results in potential opportunity. There is an unharnessed potential to store water across the northern regions and to turn the northern regions of Australia into the fabled Asian food bowl. Some of the most productive areas visited as part of this research are situated in deserts such as California and the Panhandle. There are arguments regarding developing the north and water security in northern Australia, with those in opposition arguing against developing northern Australia which implies they are in turn against feeding the growing world population.

Figure 9: The Itaipu Dam, the largest hydroelectric power supply in the world and one of the seven man-made wonders of the world, Foz do Iguazu, Brazil (Source: Author, 2018)

A recent Future Directions International (FDI) Strategic Analysis Paper outlined how climate and water availability presents significant challenges for any future development of northern Australia, as was advocated by the 2015 Government White Paper on developing northern Australia. While there are significant groundwater resources in northern Australia this water can be tens or hundreds of thousands of years old. Aquifer recharge events can be millennia apart and are certainly unlikely to occur within lifetimes. In addition to these aquifers, surface water and more transient groundwater are also significant. These can be emptied and recharged within one year. Rainfall therefore is a critical component of the northern Australia water supply, but inconsistent patterns of rainfall require rainwater to be captured and stored. Given the potential dependence on water sources, an understanding of the climatic patterns that bring drought and flood to northern Australia will help in planning for potential development.

4.5 Heat stress

Humidity and heat are two serious factors to consider when designing a housing system and must give shelter but let heat load escape at the same time. Excessive heat load (EHL), or heat stress, describes the situation where lot-fed livestock, primarily cattle, are not able to dissipate body heat effectively and their body temperature rises above normal. EHL initially 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 cattle are complex and include environmental conditions and animal characteristics.

4.5.1 Environmental conditions

A combination of two or more of the following can lead to EHL in Australian lot-fed cattle:

- Recent rainfall
- A high ongoing minimum and maximum ambient temperature
- A high ongoing relative humidity
- An absence of cloud cover with a high solar radiation level
- Minimal air movement over an extended period (4-5 days)
- A sudden change to adverse climatic conditions

Animal characteristics

Some cattle are more susceptible to EHL than other cattle:

- **Breed**. Bos indicus cattle are more heat tolerant than Bos Taurus
- **Coat colour and type**. Cattle with lighter coat colour tend to be more tolerant of heat
- **Body condition**. Heavier cattle tend to be more susceptible to EHL
- **Adaptation**. Cattle will adapt to heat provided the temperature change is gradual
- **Health**. Cattle with a prevailing health condition are less able to cope with changes in temperature.

4.5.2 Managing EHL

Feedlot operators can minimise the heat load burden placed on animals during hot conditions by implementing management strategies. These must be planned and implemented in unison as activities undertaken in isolation and not as part of a broader approach are rarely effective.

These are main components to an effective EHL management plan:

- Examining the feedlot environment including site characteristics, infrastructure and condition. Upgrades to key elements such as shade and water can be implemented
- Management review of the feedlot preparedness for an EHL event
- Preparation of a summer nutrition program that considers EHL risk
- Preparation of an EHL event strategy
- Development of a summer management program to reduce the risk of an EHL event and allow early detection
- Preparation and implementation of an EHL event strategy when an EHL event is forecast or occurs

A proactive approach to the management of EHL is more effective than a reactive response once an EHL event has occurred.

4.6 Housing designs

There were a variety of housing systems found in cattle operations across the world in this study. Not all structures are suitable to tropical conditions but the merits of each and their application is covered.

Figure 10: An open ridge cap shed in a housed beef operation in Wicklow, Ireland (Source: Author, March 2018)

4.6.1 Open ridge cap

This design (Figure 10) is seen commonly throughout the northern hemisphere, particularly in dairies and smaller feedlot holdings. Being a standard apex roof with a gap at the apex to allow heat load to escape to atmosphere. This type of structure is designed for the tough winters and driving winds that cold countries endure, and although cheaper to construct will not have the desired effect as too much rain will pass onto the feed alleys below. Due to the cold conditions in these climates the sides of the sheds are dropped to halt winds and blizzards blowing through the sheds.

4.6.2 Raised ridge capping

This design is the recommended design by MLA at present (Figure 11 and 12), and is seen throughout Indonesia and south-east Asia, either in full or partially enclosed systems. The peaked roof allows for heat load to rise to the centre before escaping to atmosphere above via openings on each side of the raised ridge caps. After talking to multiple users of the design it was agreed that a rise of 700mm is the desired gap height with the raised section extending past to overlap the lower section of roof.

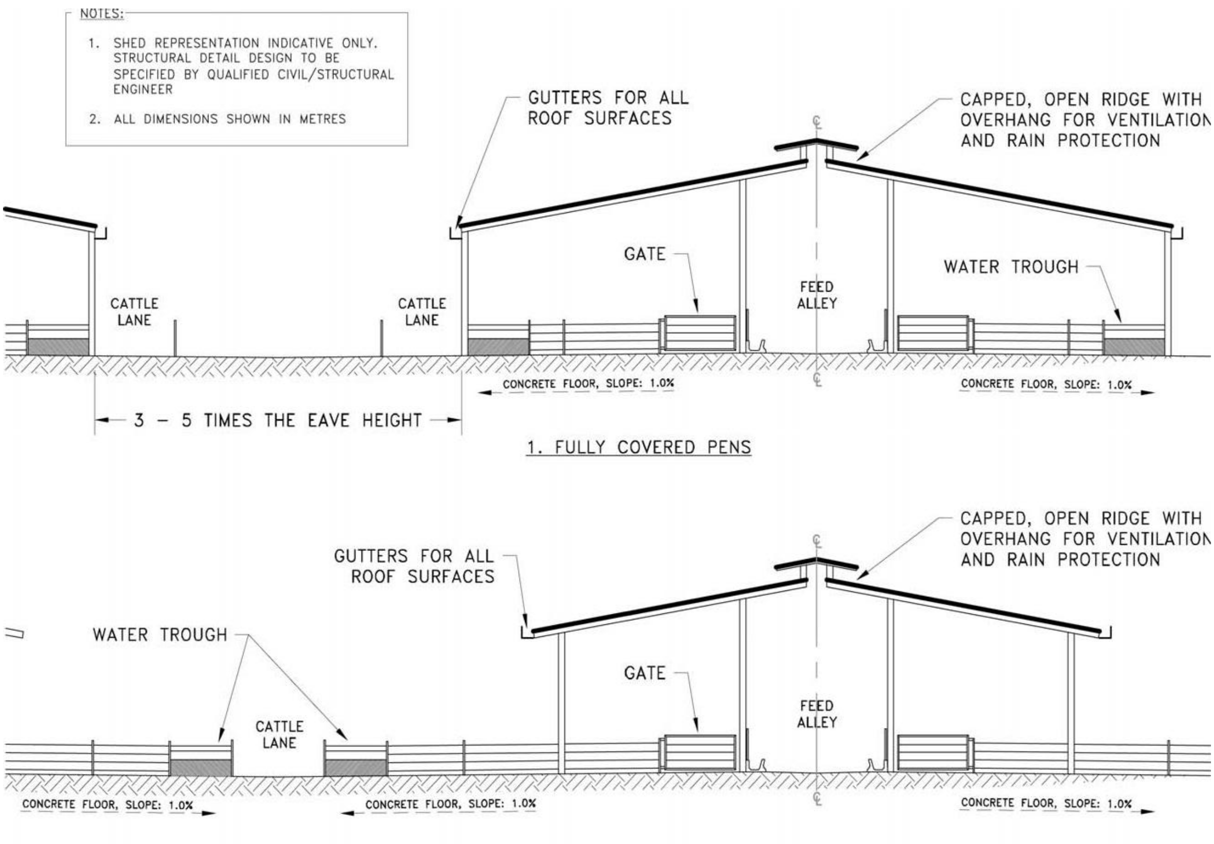

Figure 11: Image from MLA. Manual for south-east Asian cattle feedlots

Location and wind direction is also critical for this design to work sufficiently as good ventilation is critical.

Figure 12: A good example of raised ridge cap housing at JJAA Feedlot, Lampung Indonesia (Source: Author, July 2018)

4.6.3 Ridgeback (Curved Design):

The Ridgeback design is the latest innovation developed by Entegra, Signature Structures at Swan Hill, Australia. It provides a cooler, drier area and greater comfort. The Ridgeback™ showcases the ultimate in Entegra innovation, with its concave curved roof and self-ventilating structure, allowing at least 20% more air flow in comparison to Standard straight apexed roof designs. This design has been patented in Australia, New Zealand and USA.

Figure 13: Berrimah Export Facilities, Darwin, NT (Source: Beef Central, 2018)

A good example of this is the newly constructed Berrimah export facilities in Darwin, NT (Figure 13). This state of the art five million-dollar facilities was opened early 2018 with the help of NT Government funding. With a one-time capacity of 4,000 head of cattle, it is expected to have an annual throughput of 40,000 animals. With 20% increased airflow produced by the self-ventilating curved roof design, it helps with the comfort of animals in tropical conditions and keeps animal welfare and animal weight gains at an optimal level (Nason, 2018).

Conclusion

The Australian Feedlot industry is in a positive position. As the industry expands north and investment in infrastructure and irrigation development occurs, the national herd can increase past its current 24.7 million head. As a comparison the Australian herd was 33.4 million head in 1976 (MLA, 2015) and the national herd could surpass 70 million head in the years to come. It is however important that Australian beef does not become just another commodity on the world stage, competing with countries such as Brazil and India as just a major beef exporter. Australian beef must be recognised as a premium product and is rewarded for its quality. Producers are obliged to ensure that the quality of carcasses supplied to processors are presented as high-quality as possible.

Adapting the feedlot industry to northern Australia is necessary for the industry to continue to expand. The main benefits of lot feeding are:

- Greater control and flexibility in the production and marketing of livestock
- Ability to finish animals when pasture feed is deficient in quality and/or quantity
- Ability to meet a wider range of markets
- Turnoff of a more even 'line'
- Reduction of stocking pressure during dry conditions without having to sell stock in poor condition
- Option to increase breeders in proportion to the number of turnoff animals in a feedlot

Major factors influencing the profitability of lot feeding are:

- Price and availability of feed.
- Value of store animal.
- Price of finished animal.
- Costs of labour and establishment.
- Need for and costs of obtaining approval and accreditation

Finally, biosecurity is a key factor to ensure that Australia retains its disease-free status. South America could be a much larger competitor to Australia if they were not hindered by diseases that prevent them from entering world markets that have high quality specifications. A major disease outbreak would be difficult to contain and destroy market access in the long-term.

Recommendations

The recommendations listed below are one path forward on what needs to be done for the beef industry to thrive and survive. With a growing world population, and many of the biggest beef exporters struggling to keep ahead of demand, it is critical for the supply of good -quality, sustainably-produced beef to lift supply in expectation for increased future demand.

- Large-scale irrigation projects are critical for expansion of the feedlot industry away from traditional cropping areas. Without a reliable water source, it is not possible to adequately produce the feed required to satisfy large-scale intensive systems.
- Further research the potential of currently underutilised farming areas in northern Australia to justify future irrigation schemes. It is futile to invest in water if there is not the means to use it.
- Genetic gains on feed and conversion rates within cattle should continue to be researched. There has been significant focus on straight ADG (or weight) but the industry also needs research on cost of grain and feed conversion.
- Biosecurity measures in Australia are world-leading, but continual improvement is vital. Ongoing improvements will safeguard Australia's clean, green products.
- All levels of government should be more proactive in ensuring adequate support for farmers who wish to expand or intensify their operations. Many producers are reluctant to expand as going through an extensive approvals process is deemed too difficult.
- *'It is hard to stay green while farmers books are in the red'*. When businesses are financially stressed, corners are cut. Producers should be rewarded with a fair price for their produce, as well as proactive environmental programs, so they can afford to reinvest in their operations and expand for future for generations.

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Plain English Compendium Summary

Project Title:	Intensive Beef Operations in a Tropical Environment. Adapting the feedlot industry to the challenges of operating a feedlot in the climate and conditions of Northern Australia
Nuffield Australia Project No.:	1806
Scholar:	Stewart Borg
Organisation:	Leichhardt Holdings “Marklands” 133 North Inneston Road Sarina QLD
Phone:	0408585161
Email:	stewart@leichhardtholdings.com.au
Objectives	The objectives are to highlight differences between the current successful and efficient Australian feedlot industry based in temperate climates, with adaptions that could be made for the industry to expand north into the tropical climates. In particular: • Research methods to adapt the Australian feedlot industry into tropical environment. • Explore non-traditional feed sources that are used in tropical feedlots across the globe. • Make comparison between housing designs and the benefits of providing housing.
Background	The purpose of this report is to highlight the areas of adaption required to take the already highly successful Australian feedlot industry out of its traditional areas and into areas further north. Heat, humidity and rain are all issues within the feedlot sector but can be overcome with good prior planning and solid investment. The information within this report has been compiled from talking to experts from countries across the globe, who willingly shared their knowledge and experiences towards an end goal of a better industry. The research gathered is combined with the author’s own experiences as a property owner and aspiring feedlot owner, as the business constructs one of the first feedlots in a tropical environment in northern Queensland.
Research	Intensive Tropical and Sub-Tropical beef cattle operations. Research was conducted in Indonesia, Brazil, Europe, USA and Australia using a combination of interviews, farm visits, conferences and personal study.
Outcomes	The emerging tropical Australian feedlot industry will not take place overnight but will take decades to reach maturity and show how much potential it has. The northern feedlot industry is only one part of developing northern Australia and will also require other industries to expand with it. From large-scale water schemes, cotton and cropping, logistics and handling facilities, these developments will ensure processing and supporting businesses will follow.
Implications	Highlighting the ability for Australian producers to further intensify their operations with the purpose of lifting both the quantity and the quality of beef produced while also safeguarding against seasonal conditions
Publications	Nuffield Australia National Conference, Brisbane, QLD. September 2019.