
# PROCEEDINGS OF THE NORTHERN BEEF RESEARCH UPDATE CONFERENCE

North Australia Beef Research Council

DARWIN, NT

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## FOREWORD

It is a great pleasure to introduce these proceedings and, on behalf of NABRC, welcome you to the 2023 Northern Beef Research Update Conference (NBRUC).

This is the sixth NBRUC meeting in 22 years. COVID has disrupted the 3-year cycle of NBRUC meetings, and isolation has caused headaches, fever and fatigue among those involved in beef industry research and extension. With few reputable treatments available, passion and purpose have been the key to recovery, and the Organizing Committee is to be congratulated for an innovative program that addresses the other classic COVID symptoms of loss of taste and smell. The spiced-up 'Recipe for Success' menu and the buffet offerings have stimulated our taste buds, and this meeting will surely assist the rapid recovery and reinvigoration of those around the table.

While these proceedings may not match the 2023 Book of the Year (RecipeTin Eats: Dinner), there are many similarities – the focus on food, creativity and cost; over 120 recipes, and the revelation of 'stand out' new talent!

So, this meeting is a great opportunity to listen, reflect and learn, be inspired, rebuild the relationships and expand the social networks, among beef cattle producers, current and emerging researchers and advisors, that underpin innovation and adoption. These are key elements aligned to NABRCs values and its mission to drive a focus on RD&A to support an innovative, proactive, profitable and sustainable northern beef industry.

On behalf of NABRC I thank the organizing committee, under the leadership of Jay Mohr-Bell, and the guidance of Jackie Kyte, the event coordinator, for a stimulating program. Again, thanks to all, and a special thanks to the 'next gen' members of the committee, and the many contributors, for what will undoubtedly be an infectious and memorable event.

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Chair
North Australia Beef Research Council

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These papers have not been refereed by the conference organising committee. The content of each paper is the responsibility of the authors. The papers have been formatted to a common abstract style

# CONTENTS

# KEYNOTE PRESENTATIONS

# Flavour – Advancing the sensory quality of Australian beef

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## Introduction

Flavour is a complex sensation which can be described as a combination of aroma, taste, texture and mouthfeel or trigeminal sensations (Sunarharum, Williams, & Smyth, 2014). Pleasurable flavour experiences are key to delivering high consumer satisfaction, particularly with premium and luxury foods, such as wine, chocolate, oysters, or beef.

For decades it has been well understood that the textural sensation of *tenderness* is a major driver of consumer liking for beef and is the key component of Meat Standards Australia's model of eating quality (Polkinghorne, Thompson, Watson, Gee, & Porter, 2008). With significant improvements in genetics, production systems and particularly through advances in post-mortem handling, *tenderness* of Australian beef has increased across the product category. With the bar lifted *tenderness* has become a baseline expectation among consumers when it comes to beef products.

In a modern market where *tenderness* is a given, the taste and aroma component of *flavour* is moving to centre stage and is receiving new scrutiny for Australian beef. Recent research suggests that like wine and other premium products, beef *flavour* (taste and aroma), has now become the most decisive attribute in eating quality evaluation (Therkildsen, Spleth, Lange, & Hedelund, 2017). But to chase and improve beef *flavour* we first need to understand what it is, where it comes from, and of course, how do we describe it.

## Beef flavour chemistry

Beef flavour originates from inherent characteristics in the fresh meat which are not necessarily developed nor optimised through post-mortem handling other than cooking and beef ageing. In other words, flavour is largely dictated by non-volatile precursors that are already developed in the animal muscle prior to slaughter.

Cooking is an essential step to release the inherent flavour qualities of beef. During cooking the characteristic flavours of beef are released from precursors in the meat which undergo complex thermal transformations involving both the Maillard reaction interlinked with lipid degradation and oxidation. Maillard reactions are similar to caramelisation, but technically not the same. The Maillard reaction is a well-known chemical reaction between amino acids in protein and reducing sugars (e.g. ribose) that deliver flavour and aroma to many protein food products during cooking. With beef, fat plays an important role in these chemical reactions, however, fat on its own is unable to deliver beef flavour. The result of cooking and browning beef is the liberation of a complex mixture of volatile aroma compounds and non-volatile taste components that deliver the mouth-watering organoleptic experience consumers know and love.

Of the five basic tastes detected by the tongue, *umami* is one of the most important to beef flavour followed closely by *sweetness*, *saltiness*, *sourness*, and in unusual circumstances *bitterness* (Therkildsen, Spleth, Lange, & Hedelund, 2017). *Umami* taste has a distinctly savoury property and is associated with the presence of glutamic acid, monosodium glutamate (MSG), some peptides and purine nucleotides which are also known for their flavour enhancing qualities. *Sweetness* in beef has been associated with several amino acids including glycine, alanine, cysteine and methionine (among others) and to a lesser extent sugars glucose, fructose and ribose. Natural *saltiness* in beef comes from inorganic salts including sodium glutamate and sodium aspartate. Organic acids are responsible for *sourness* such as aspartic, glutamic, lactic, succinic, among others. *Bitterness* in beef may arise from certain peptides and amino acids.

In terms or aroma, there are as many as 880+ volatile compounds that have been detected in cooked beef making it comparably complex as wine (Macleod, 1998). However, compared to wine, we know relatively little about the importance and role of individual beef flavour volatiles. The Maillard reaction produces many different chemical classes of important aroma volatile compounds in

beef including furans, pyrazines, pyrroles, oxazoles, thiophenes, thiazoles, and other heterocyclic compounds (Kerth & Miller, 2015). Which of these are most critical to beef flavour quality, or distinguishes one cut from another, is not well defined. Aroma volatiles are detected by the sense of olfaction or smell, which involves sensory organs and chemoreceptors present in our nasal cavity. Unlike our sense of taste, which detects just 5 basic taste stimuli, our sense of olfaction can detect and distinguish literally thousands of different aroma stimuli. It is largely the aroma component of beef that characterises the different flavour types we experience from different muscles (cuts), marbling, genetics, diets and brands.

## Factors that affect beef flavour

Beef flavour is a function of inherent qualities in fresh meat. Other than method of cooking, which is essential in generating and liberating flavour, there are several factors that influence the quality and intensity of flavours that are expressed. These include breed, fat, sex, diet, age, stress, and ageing of meat (Therkildsen, Spleth, Lange, & Hedelund, 2017). Defining the specific flavour impacts of these different factors is challenging, largely because of the strong interplay between the factors themselves. In addition, the sensory methods applied for comparing meat quality historically, has often stopped short at consumer acceptability scores of *overall flavour*, rather than using trained panel assessments to measure specific flavour quality differences (*roasted* vs *gamey* vs *umami* etc) or compositional analysis of key volatile aroma compounds. Many studies report similar levels of *acceptability* between treatments, but don't consider the possibility that different flavour qualities may be expressed which are distinctive but equally acceptable.

Fat is a key deciding factor of beef flavour, particularly intramuscular fat (IMF). Several studies report that with increasing IMF, flavour and acceptability scores also increase, to a point (Kerth & Miller, 2015). Older animals tend to have higher flavour scores, which is linked to fattiness and maturity. Interestingly, increased IMF may also accentuate flavour differences due to breed (genetics), whereas leaner muscles from the same animals are not discernible (Sinclair, et al., 2001).

Diets of beef cattle vary around the world and diet is an important factor impacting beef quality and flavour. This is not surprising given that different diets impact fat content, fatty acid composition and the amount of reducing sugars in the meat (important for the Maillard reaction). There are mixed findings from diet studies comparing grain-based to silage and fresh pasture. Generally speaking, it is the diet prior to slaughter that has the biggest impact on beef flavour.

## A lexicon of beef flavours

A major hinderance to defining flavour differences between beef steaks from different diets, genetics, or even cuts of meat and brands is the lack of clear, concise, and consistent sensory terminology to describe beef flavour qualities. Flavour lexicons provide an objective word bank to describe food products, and are useful tools applied particularly in the premium and luxury food space. Despite the beef industry's recognition of the importance of beef flavour to quality, there have been few attempts to develop and expand a more sophisticated lexicon for beef flavour (Adhikari, et al., 2011) (Maughan, Tansawat, Cornforth, Ward, & Martini, 2012). In Australia, premium beef brands are turning to sensory scientists to develop more tangible descriptions of their product qualities and points of difference, the first of these being the Westholme Wagyu Flavour Wheel.

## The future of beef flavour

Brand differentiation of premium products relies on communicating a point of difference which is validated by perceivable quality advantages. Beef is no exception. However, the industry needs to look beyond *tenderness* and develop a much more sophisticated understanding of the many different flavour qualities that provide hedonic experiences. Not only are more sophisticated language tools needed to describe the sensory experiences of beef, but also a deeper understanding and characterisation of the chemical compounds responsible for beef aroma and flavour. Such research will support the identification of a palate of key beef flavour and aroma traits to draw from and assist with optimisation of those desirable traits through genetics, diet and management. In doing so,

Australian beef will further advance its position as the most sensorily desirable premium beef product in the world.

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# Lecciones del rancho: Applications of western US beef cattle research to northern Australia

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## Introduction

Rangeland beef cattle production in northern Australia and the western United States are similar in several aspects. Both systems contain extensive areas of semi-arid rangelands where vegetative production is limited. Cattle typically graze large paddocks (> 250 ha) to obtain sufficient forage. Drinking water for cattle is also limited, and development of new water sources is expensive. Cattle often need to travel long distances from water (> 1.5 km) to find forage. Grazing distribution is often uneven because of the distance cattle must walk from water and soil or ecological site differences (Holechek 1988). Grazing distribution is a major concern because cattle defoliate forage in preferred areas excessively, and uneven use reduces sustainable stocking levels. Stocking levels can often be sustainably increased by over 30% if cattle grazing patterns can be manipulated.

Drought is also a major management concern in both systems. Managers must monitor forage quality and quantity during drought and develop plans to respond to declining feed availability (Hunt *et al.* 2014). Conservative stocking levels are often used in both locations as a strategy to deal with drought. In the western US, ranches often develop plans to destock as forage availability declines.

Cattle in northern Australia and the western US must deal with high summer temperatures (> 35˚ C), which have the potential to affect grazing behavior, reduce productivity and induce heat stress. Another commonality is the difficulty to monitor cattle well-being grazing extensive rangeland paddocks. Cattle may not be observed for weeks or even months. Managers may not know if cattle become ill or face some other welfare issue.

The objectives of this paper are to describe research conducted in western US ranches and international collaborators that may help beef cattle producers in norther Australia deal with uneven grazing distribution, drought, hot temperatures and livestock welfare concerns.

## Grazing distribution

Strategic placement of self-fed protein supplements is an effective tool to manipulate cattle grazing patterns when forage is dormant and lower in quality (e.g, dry season or autumn/winter after frost). Forage utilization increased by 14 percentage points within 600 to 800 m of low moisture block protein supplements compared to other areas of the pasture during 2-week periods (Bailey *et al.* 2001). These protein supplements attracted cattle into areas with rugged terrain. Research in New Mexico showed that cattle could be attracted to areas located over 3 km from water using low moisture block protein supplements. Although not as persuasive as protein supplements, salt and mineral supplements can be used to attract cattle to areas receiving little grazing. Salt and mineral mixes are most effective as attractants during the summer or wet season when the forage is lush. Mineral mixes attracted cattle to very steep terrain in a study conducted in the Italian Alps (Pittarello *et al.* 2016). In northern Australia, mineral supplements containing phosphorus may be useful for attracting cattle to underused areas.

Grazing patterns vary greatly among individual cows. Cows in New Mexico varied by over 40% in the distance they travel from water. For example, a cow at the New Mexico State University (NMSU) Chihuahuan Desert Rangeland Research Center on average was 1502 m from water while another cow in the same pasture averaged 1027 m from water. Similarly, at the NMSU Corona Range and Livestock Research Center, one cow averaged 2570 m from water while another averaged 1417 m from water. Our research suggests that selection for cows that are more willing to travel from water or use rugged terrain can improve grazing distribution patterns (Bailey *et al.* 2006). Cows that travel long distances from water should continue to use these distant areas even after cows that remain closer to water are

removed from the herd (culled). Pierce *et al.* (2020) showed that grazing distribution and distance traveled by cows from water are polygenic traits that can be inherited. Two studies, one in the western US and another in New Zealand, found a genetic marker (GMR5, glutamate metabotropic receptor 5) was associated with beef cattle grazing patterns (Bailey *et al.* 2015; Moreno García *et al.* 2022). Although individual animal selection has great potential to improve grazing distribution, more research is needed. Currently, we do not have sufficient data to develop genome-enhanced breeding values for grazing distribution traits. Variability among ranches and pastures currently introduces noise and limits the extent of variation explained by identified genetic markers. However, ongoing research holds promise to develop genomic breeding values for grazing distribution traits. In addition, development and cost reductions in cattle tracking equipment can help development of genetic selection programs for distance traveled from water by measuring the phenotype as to incorporate into genome-enhanced breeding values.

## Hot weather impacts on grazing cattle

Heat stress is a concern for cattle during hot weather, especially if humidity is also high. Cattle in feedlots are particularly susceptible to heat stress because of their high feed intake levels. Changing feeding time, reducing intake, providing shade and sprinkling water can be useful for improving the well being of cattle in feedlots (Davis *et al.* 2003). However, such strategies are not practical for grazing cattle. Our research suggests that cattle remain closer to water and travel less each day during hot weather. Such strategies should reduce energy expenditure and help rangeland cattle cope with high temperatures. However, these behavior changes also affect grazing distribution patterns and decrease use far from water. We hypothesized that cattle might increase grazing at night during hot weather to avoid high midday temperatures, especially during the full moon. We found that during the summer cattle did graze more as illumination from the moon increased (full moon), but there was no increase in grazing during the full moon in the winter. However, increased grazing during the full moon likely does not fully compensate for the reduction in total grazing time when it is hot. During the hot summer months, cattle would benefit from grazing in pastures with greater water and shade availability so that they would not need to travel as far from water.

## Remote cattle monitoring

Technological advancements have made real-time and near real-time monitoring of cattle grazing more feasible and less costly. Some commercially available systems can provide locations in real time using long range wide area network (LoRaWAN) systems. Systems such as Smart Paddock and Moovement have tags with GPS receivers that transmit positions via LoRaWAN to gateways for several kilometers. Other systems such as 701x and Ceres Tag, transmit positions using cellular and satellite transmission, respectively. These systems record positions at intervals from minutes to hours. Several of these tracking tags also have accelerometers which provide indexes of cattle activity. Although costs are declining, the systems are still expensive for most commercial cattle producers. The systems must provide information that is easy to understand and valuable for making decisions to justify the cost. Remote tracking and monitoring systems would be less expensive if only some of the cattle in the herd are monitored, which is often termed a “sentinel animal” approach. Tradeoffs between whole herd monitoring and sentinel animal monitoring needs to be evaluated.

Real-time tracking and sensors, such as accelerometers, have the potential to remotely monitor cattle welfare. Tobin *et al.* (2020) found that accelerometers showed a distinct change in activity when heifers became ill with bovine ephemeral fever. Subsequent research using machine learning shows that bovine ephemeral fever can be detected by comparing current activity levels to recent diurnal activity patterns. Algorithms developed to detect bovine ephemeral fever in one herd were validated in a separate herd. Tracking systems can also detect calving (Williams *et al.* 2022). With the addition of accelerometers remote detection of calving would likely be more accurate. Tracking systems also can be used to detect water system failures (Tobin *et al.* 2021). If water is not available, cattle will remain at the tank rather than leave and rest nearby, which facilitates detection of water system

failures. Unlike detection of illness or calving where all the cows need to be monitored to be successful, a sentinel animal tracking strategy likely could be used to detect water system failures.

Real-time tracking also has the potential to remotely monitor rangeland sustainability by monitoring cattle grazing patterns. However, cattle spatial movements do not necessarily reflect forage defoliation patterns (Jansen *et al.* 2021). There is a sampling problem if all the cattle in a paddock are not tracked. Also, cattle may or may not be grazing while they are stationary or moving. Differential preferences for forage species during diet selection may also affect our ability to monitor vegetation defoliation from tracking data. We had difficulty detecting relationships with forage utilization levels at specific sites and the density of nearby cattle locations monitored by GPS collars when overall distribution patterns were relatively even. If there were clear differences in cattle use across a paddock, forage utilization levels were related to tracking data. Forage utilization was higher in "hot spots" than "cold spots" identified from geographical information software. Although more research is needed, real-time tracking has potential to monitor not only cattle health, but also health and sustainability of the forage resource in the paddock.

## Drought

Conservative stocking levels are essential to maintain rangeland health if set stocking is used, or if it is difficult to reduce stocking levels within a grazing season. In the western US, many ranchers plan when they will sell cattle if the drought continues, and no rain comes. For example, one collaborating rancher said he would sell half of his herd if it did not rain by August 1 (normal monsoon precipitation occurs during early July through mid-September). Such a variable stocking rate drought strategy requires a plan identifying which cattle will be sold and when. Selling older cows is often the first step followed by selling less productive cows. Identifying less productive cows can be problematic unless there is a good record-keeping system. Real-time tracking and sensor monitoring may be useful for identifying less productive cows that could be culled and sold to conserve forage resources.

## Implications

Tracking cattle with "store on board" GPS collars allowed researchers to remotely monitor livestock on extensive rangeland pastures and document the efficacy of practices such as strategic supplement placement to manipulate cattle grazing patterns. This research identified the potential improvement in sustainable stocking levels by increasing the uniformity of grazing. In the western US, stocking levels can be sustainably increased by over 30% by attracting cattle to underutilized areas with supplements or by some other practice such as selection for more adapted cattle. The recent supply chain crisis has facilitated development of real time tracking equipment that can now be used by cattle producers. Currently, commercial equipment is available to track and/or monitor cattle on rangelands, but the equipment is relatively expensive. Further innovations may reduce costs and improve reliability. Ongoing research shows the potential of remote cattle monitoring, including detection of disease and other welfare concerns and for remote monitoring forage use patterns and rangeland sustainability. Technological advancements have great promise to help cattle producers in the western US and northern Australia.

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# Fewer, bigger, bolder for northern Australia – research, development, adoption and sacred cows

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## Introduction

MLA works in partnership with industry and government to deliver products and services to Australia's cattle, sheep and goat industries, and other entities along the supply chain. MLA is primarily funded by transaction levies paid on livestock sales by red meat producers, with the Australian Government also contributing a dollar for each levy dollar MLA invests in research and development. Other funding streams come from specific unmatched grants from the Australian Government and cooperative funding contributions from other research and development corporations, individual processors, wholesalers, foodservice operators, and retailers.

MLA makes investment decisions in collaboration with producers, the government, peak industry councils and other industry organisations. A regional consultation framework enables producers to have direct input into MLA's research and development priorities.

This presentation at NABRUC 2023 will discuss key issues related to MLA investment, with a focus on research innovation, sustainability, and red meat positioning.

## CN30

The Australian red meat industry has set a target to be carbon neutral 2030 (CN30). This means that by 2030 the industry aims to generate net zero greenhouse gas (GHG) emissions from red meat production and processing. This target was first announced in 2017 and is based on CSIRO modelling that confirmed that carbon neutrality by 2030 is a significant, but achievable, challenge. The target was set to ensure continued community and consumer trust in red meat, maintain market and capital access, minimise the need for taxes and subsidies to bring about change, and build resilience to future market and environmental changes.

Achieving CN30 is an indicator of success in the broader industry's Red Meat 2030 strategic plan, which has been developed and led by the Red Meat Advisory Council (RMAC). CN30 supports the industry vision of doubling the value of red meat sales and being acknowledged as a trusted source of the highest quality protein.

Under CN30, the industry has demonstrated a reduction of almost 65% in net emissions between 2005 and 2020. This is mainly attributed to improvements in the way red meat producers manage and care for their land, with reductions in land clearing and increased growth of vegetation along with improved production efficiencies having resulted in fewer emissions per kilogram of red meat.

Efficient and productive grazing systems are vital for future food security, particularly in Australia where less than 3 percent of Australia's land is suitable for producing crops. Grazing land that is not suitable for cropping ensures that this land is managed sustainably while also feeding the world and being part of the overall climate solution.

Livestock have the unique ability to convert plants with low nutrient value into high quality protein. Grazing these plants stimulates more plant growth, which accelerates the absorption of $CO_2$ from the air into plants and soils as carbon. That means that the industry can store carbon in the landscape in order to balance our industry's emissions, while also improving water holding capacity, better managing weeds and feral animals, enhancing biodiversity and, most importantly, improving productivity.

Since 2017, MLA has invested more than $140 million to reach the CN30 goal. MLA will make significant further investment over the next few years with a focus on the development and subsequent adoption of new technology. For investors wanting to contribute to this important goal, there are opportunities to partner with the red meat industry so that we can bring some of these technologies to market even faster.

## Red meat positioning

Australian red meat has an incredibly positive story to tell, and this positive story is being increasingly backed by solid scientific evidence that highlights the immense value of red meat for society. This scientific analysis was recently published in the journal, *Animal Frontiers*, looking at the positive contribution of red meat and livestock production to broader society. The papers in the journal look at various components of the livestock production system and the contributions of the sector including ecological management, human nutrition, and climate. In addition to the publication of this journal, more than 1000 international scientists have signed the Dublin Declaration, which endorses the positive role of red meat for our society. This is a show of faith in our industry and a major step forward in tackling the simplistic anti-meat agenda that is often portrayed in the media.

In a broader sense, MLA also invests in a range of other activities to help tell the positive success story of Australian red meat. These include:

*Social media influencers*

MLA's Australian Good Meat platform partners with respected social media influencers to engage Australians with information on red meat production and its environmental, nutritional and ethical credentials. As the initiative gains momentum, a diverse range of influencers active across channels including TikTok and YouTube are being engaged, with influencers content focused on sustainability and animal welfare in the industry.

Red Meat, Green Facts

Red Meat, Green Facts is the industry's pocket guide to sharing positive, fact-based information about the Australian red meat and livestock sector covering topics such as the environment, animal welfare, plant-based proteins, and red meat nutritional information.

*School education*

The Australian Good Meat Schools hub helps to improve teachers' and students' understanding of the Australian red meat and livestock industry by delivering a range of curriculum-linked resources and programs. Working in collaboration with education experts, MLA's school education program is key to bridging the gap for Australian educators and students to learn more about where their red meat comes from and the Australian red meat industry. The resources are free and available on www.goodmeat.com.au/education

Australian Good Meat's teaching resources provide educators with over 170 cross-curricular materials for use across Foundation/Prep to Year 1. Developed in collaboration with the Primary Industries Education Foundation Australia the materials are designed in a 'ready-to-teach' format, and supported with supplementary classroom posters, card games and teacher guidance videos to support teacher adoption.

Australian Good Meat's Smart Farming virtual classroom has been educating Australian primary school students for over twelve years and is one of MLA's most popular and effective school education programs. This free, interactive and curriculum-linked program brings a red meat producer into the classroom for students to engage via a livestream session. Each 30-minute session is facilitated by a qualified teacher and includes student quizzes and farmer Q&A chat time. The sessions are supported with pre and post learning via activity sheets and a Kahoot program, along with vocabulary key word lists. Learn more about Smart Farming Virtual Classrooms at www.mlavirtualexcursions.com.

## More information

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# Genetics of cow temperament at the time of calving

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## Introduction

Since the initial characterization as flight speed (Burrow *et al.*, 1988), various aspects of bovine temperament have been investigated for many years in most breeds of beef and dairy cattle. Of course, cattle with good temperament are desirable from a management and handler safety standpoint. The almost consensus conclusion is that cattle with better temperaments, that is, those that are less reactive or are more docile, have higher levels of performance for critical traits. This is desirable and easily implementable. However, some of the results from over two decades of investigation into the genetic characterization of beef cattle temperament do not conform to this, especially in environments that are challenging for a variety of reasons. The objectives of this work were to characterize the inheritance and other genetic control of *Bos indicus* straightbred and crossbred cattle cow temperament score at the time of parturition, and to assess the correspondence of cattle temperament with performance.

## Methods

A population of full siblings $F_2$ Nellore-Angus was produced by embryo transfer from 2003 to 2007 by 4 $F_1$ bulls and 14 $F_1$ cows. Bulls and cows were kept from those to produce a generation of $F_3$ animals that were born from 2009 to 2013. Bulls and heifers from the $F_3$, $F_4$, and $F_5$ generations were used to produce the $F_4$ (born in 2014 and 2015) and $F_5$ (born in 2018 and 2019) and $F_6$ (born in 2022 and 2023) generations, respectively. Inbreeding was mostly avoided in early generations by maintaining two distinct herds based on the $F_1$ sires of the first generation but has increased in the most recent generations. Another related population of $F_2$ Nellore-Angus cows was born from 2009 to 2015.

Most of the females entered a development program typical of the Southern United States to enter the production herd. All females were exposed annually to bulls beginning at one year of age in 60- to 75-day breeding seasons beginning around May 10. As heifers they were exposed to Angus bulls. Thereafter, most were exposed for several years to bulls from their own generation. After production of the subsequent generation was complete, most were then exposed to Angus or Hereford bulls. Before age 14, cows were removed for two failures to wean a calf. After that they were removed for a single failure to wean a calf. Cows were also removed for health reasons. Some deaths occurred. A small number of cows were removed because their temperament and behavior endangered workers. Each time they gave birth (usually at one day of calf age when calves were weighed and tagged), cows were assigned a subjective score from 1 to 5 in which higher values indicated progressively worse temperament. These were recorded from 2005 through 2022 (n = 4,337 records on 946 cows). The cow's highest (worst) temperament score across her lifetime was evaluated in a single trait animal model. All records were evaluated in repeated records animal models. Correspondence of cow temperament with cow reproduction and productivity traits was assessed with correlation coefficients and evaluation of temperament score as a fixed classification variable using animal models. Genome wide association was conducted modeling covariances among animals with the genomic relationship matrix.

## Results

The estimate of heritability for cows' highest temperament scores was 0.23 ± 0.07. The estimates of additive genetic variance (heritability), permanent environmental variance, and maternal permanent environmental variance as proportions of the phenotypic variance were 0.09 ± 0.03, 0.15± 0.02; and 0.02 ± 0.01, respectively. A population-cow age category interaction was primarily supported by generally lower temperament means for young cows in all populations (Table 1) and lower means for cows in populations 3 through 5, which were descendants of the first generation of $F_2$ animals.

**Table 1. Adjusted means for highest temperament score[1] by cow age category and population[2]**

| | Population |
|---|---|

| Age[3], yr | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 2 | 2.82 ± 0.22$^{A\,Y}$ | 1.86 ± 0.18$^{A\,Y}$ | 1.78 ± 0.15$^{A\,Y}$ | 1.14 ± 0.33$^{A\,X}$ | 0.83 ± 0.25$^{A\,X}$ |
| 3 | 3.14 ± 0.20$^{B\,Y}$ | 3.19 ± 0.22$^{B\,Y}$ | 2.43 ± 0.18$^{B\,Y}$ | 1.92 ± 0.27$^{AB\,X}$ | 1.31 ± 0.32$^{AB\,X}$ |
| 4 | 3.37 ± 0.22$^{B}$ | 3.10 ± 0.16$^{B}$ | 3.02 ± 0.19$^{C}$ | 2.62 ± 0.27$^{BC}$ | 2.33 ± 0.36$^{B}$ |
| 5 to 10 | 3.72 ± 0.17$^{B}$ | 3.74 ± 0.14$^{B}$ | 3.48 ± 0.23$^{D}$ | 3.20 ± 0.21$^{CD}$ | |
| > 10 | 3.67 ± 0.26$^{B}$ | | | | |

$^{A, B, C, D}$Means in the same column that do not share a superscript differ ($P < 0.05$) after correction for multiple comparisons.

$^{X, Y}$When superscripts are present, means in a row that do not share a superscript differ ($P < 0.05$) after correction for multiple comparisons.

[1]Highest temperament scores of each cow at the age of earliest occurrence (some cows had more than one score that was the highest value).

[2]Populations 1 and 2 were $F_2$. Populations 3, 4, and 5 were $F_3$, $F_4$, and $F_5$. All were ½ Nellore ½ Angus.

[3]https://guidelines.beefimprovement.org/index.php/Guidelines_for_Uniform_Beef_Improvement_Programs; accessed February 13, 2023.

Estimates of correlation coefficients of unadjusted values and residuals for cow temperament score (either the highest value or the average of all records) with cow weight and calf birth or weaning weight (not presented) were low in magnitude and ranged from 0.1 to 0.175 ($P < 0.01$). Estimates of correlation coefficients for cow temperament score (either the highest value or the average of all records) with cow reproduction and productivity traits were notably larger and ranged from 0.17 to 0.37 (Table 2).

**Table 2. Estimates of correlation coefficients ($P < 0.05$) of unadjusted temperament scores and cow productivity traits[1]**

| | Calving rate | Weaning rate | WWCE | WW1K |
|---|---|---|---|---|
| Highest temperament score[2] | 0.232 | 0.309 | 0.365 | 0.235 |
| Temperament score average | 0.173 | 0.229 | 0.249 | 0.166 |

[1]WWCE = weaning weight per cow exposed; WW1K = weaning weight per 454 kg (1,000 lb) cow weight.

Evaluation of cow reproduction traits in models including temperament score as a fixed classification variable indicated that those cows with highest temperament score of 1 (most favorable temperament) had lower calving and especially weaning rates than cows that had highest temperament score in the other categories (Table 3).

**Table 3. Means for cow reproduction by highest temperament score[1]**

| Temperament score | Calving rate | Weaning rate |
|---|---|---|
| 1 | 0.78 ± 0.05$^{A}$ | 0.64 ± 0.06$^{A}$ |
| 2 | 0.83 ± 0.04$^{B}$ | 0.80 ± 0.04$^{B}$ |
| 3 | 0.88 ± 0.03$^{B}$ | 0.83 ± 0.04$^{B}$ |
| 4 | 0.89 ± 0.04$^{B}$ | 0.87 ± 0.04$^{B}$ |
| 5 | 0.88 ± 0.03$^{B}$ | 0.83 ± 0.04$^{B}$ |

[1]Higher temperament scores indicate increasing worse temperament. Values represent the highest of each cow across her lifetime scored at one day post calving.

$^{A, B}$Means in a column that do not share a superscript differ ($P < 0.01$)

Two SNP on BTA 4 (3.6 and 5.5 Mb, UCD-ARS1.2 assembly) were associated with highest temperament score and from repeated records of temperament score. The nearest gene to these was cordon-bleu WH2 repeat (*COBL*).

## Discussion and conclusion

Estimates of heritability for cow temperament at parturition were lower than many published estimates including our own work (0.27 to 0.55) in evaluation of a variety of temperament attributes measured close to weaning in the same animals and their half siblings (Riley et al., 2014), Brahman

(Schmidt et al., 2014), and crossbreds with some Brahman (Littlejohn et al., 2018). The strong permanent environmental component suggests retention of life experiences across time; the large component was consistent with that reported in Brahman (Schmidt et al., 2014) and crossbred cattle (Littlejohn et al., 2018). The detection of maternal permanent environmental effects, although not large relative to other components, is novel and suggests that some aspects of behavior may be acquired from maternal exposure, which supports anecdotal observations from our cow herds.

Almost all research conducted reports favorable relationships of temperament with a variety of production and end product metrics; citing all of those would require much more space. The majority of those, however, were measured in younger growing cattle or in cattle being managed in specific situations, such as the time of artificial insemination or milking. It may be easily envisioned how poor temperament (movement or hyperactivity) could detrimentally influence those processes. Our own previous work did not conform to this, as only a few weak relationships between temperament measured at weaning and a complete array of beef production traits including preweaning and postweaning weights, feed efficiency, and growth, or end product characteristics were observed in these project animals and their siblings (Riley et al. 2019a, 2019b; 2020; Baker et al., 2022). Another common observation is the association of heavier weights with favorable temperament. Elzo et al. (2009) reported such a relationship of exit velocity with heavier weights and offered that it could simply be interpreted as heavier animals are slower. Schmidt et al. (2014) noted this effect differently as interacting with age, as heavier calves early in life (4 months of age) had lower (unfavorable) values of exit velocity but later in life (after weaning), the opposite was observed.

The results from the present study are uniquely measured and may indicate that extremely docile females may have lower performance for reproduction and productivity. It is compelling to think that unfavorable temperament as measured by this system of scoring is indicative of superior maternal instinct.

It is possible that temperament scores corresponded to inbreeding. Inbreeding was minimized in the F2 and F3 populations, but unavoidably increased in the F4 and F5 populations. However, regressions of temperament on pedigree or genomic estimates of inbreeding (linear or quadratic) were not significant for temperament traits.

There was minimal dystocia (n = 16 parturitions) across the years of this project. Seven of those had temperament scores greater than 1. The regression of temperament score on calf birth weight was not significant. It is possible that some temperature or humidity conditions correspond to temperament scores. Annual calving seasons for the animals in this project were in northern hemisphere spring, specifically from February through April, which is always progressively warmer temperatures and increased amounts of green forage. In most years there is some precipitation in April. Regression of temperament score on calving date within year (as an attempt to model those effects) was not significant.

Alternatively, heterosis may be influential in temperament of cattle. Substantial unfavorable heterosis was reported for most temperament traits measured at weaning or in growing heifers or steers of Brahman crosses (Riley et al., 2010; Chase et al., 2017).

The candidate gene COBL encodes a protein that is integral in the structure of neurons (Ahuja et al., 2007), which may be related in some way to reaction and temperament.

## Important observations from this Work:

1. Non genetic components of cow temperament at the time of parturition are large.
2. Favourable cow temperament was associated with lower reproduction and productivity.
3. The maternal environment experience by a female when she is a calf may impact her own temperament as a cow.

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# COOKING WITH CATASTROPHE AS YOUR SOUS CHEFS: DROUGHTS AND FLOODING RAINS

# Likelihood of heat stress in N Australia beef cattle herds

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## Introduction

Heat stress is a condition that arises when livestock are unable to effectively dissipate body heat, leading to an elevation in their body temperature beyond normal levels, having detrimental effects on both the welfare and productivity. Production consequences associated with heat stress have been documented, including a decrease in feed intake, constraining weight gain and milk production, as well as lower conception rates and an elevated risk of mortality. Whilst production losses from heat stress have mostly been documented in intensively managed livestock systems, where animals have limited access to shade and are fed high-energy diets, they're also considered likely to occur in northern beef grazing situations. The Heat Load Index (HLI) provides a measure of the intensity of the heat load. A HLI of 96 indicates a high level of heat stress and is deemed an appropriate threshold for more heat-resilient cattle, such as Bos indicus breeds (Gaughan *et al*., 2009). In this study, data obtained from automated weather stations at ten commercial beef breeding stations collaborating on the Calf Alive project were used to describe the expected heat load experienced by breeding herds during the 2022/23 calving season.

## Methods

Davis Vantage Pro weather stations were installed at each collaborating station in late-Nov or early-Dec-22. The RIMIK DataNode Remote Terminal unit was used to acquire and transmit 15 min environmental sensor data to a server, providing near-real-time access to the data. These data were used to calculate HLI using the equation described by Gaughan *et al*, (2008). Descriptive statistics were performed using R and R Studio.

## Results

Table 1 provides a summary of the percentage of days within each month that exceed an HLI of 96, as well as the percentage of months with three consecutive days exceeding 96.

**Table 1. Percentage of days and 3 consecutive days per month that exceed an HLI of 96.**

| Station | Percentage of days HLI>96 (%) | | | | | Percentage of 3 consecutive days HLI>96 (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dec-22 | Jan-23 | Feb-23 | Mar-23 | Apr-23 | Dec-22 | Jan-23 | Feb-23 | Mar-23 | Apr-23 |
| CAP12 | 100 | 100 | 100 | 100 | 80 | 100 | 100 | 100 | 100 | 67 |
| CAP22 | 100 | 100 | 100 | 100 | -- | 100 | 100 | 100 | 100 | -- |
| CAP26 | 74 | 97 | 68 | 77 | 50 | 52 | 90 | 43 | 55 | 40 |
| CAP32 | 100 | 100 | 89 | 86 | 67 | 100 | 100 | 79 | 64 | 27 |
| CAP34 | 100 | 100 | 100 | 100 | 73 | 100 | 100 | 100 | 100 | 67 |
| CAP42 | 90 | 97 | 79 | 97 | 23 | 76 | 90 | 64 | 90 | 3 |
| CAP49 | 61 | 74 | 68 | 65 | 13 | 29 | 61 | 39 | 35 | 0 |
| CAP62 | 83 | 87 | 79 | 77 | 20 | 60 | 74 | 61 | 58 | 7 |
| CAP63 | 65 | 84 | 82 | 71 | 30 | 35 | 74 | 64 | 45 | 17 |
| CAP66 | 52 | 84 | 82 | 61 | 0 | 16 | 65 | 54 | 29 | 0 |

## Conclusion

data observed in this study suggest that heat stress is likely to be frequently experienced by northern beef breeding cows, as indicated by the percentage of days exceeding a HLI of 96 and the percentage of three consecutive days surpassing this threshold.

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# Climatic indices in practices and what it means for cattle

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## Introduction

Environmental stressors play an integral role in the health, wellbeing and productivity of cattle. Although cold stress has been defined to negatively influence cattle comfort and productivity, heat stress has and will continue to remain a predominant focal research area. This is somewhat associated with the 'greater' impacts hot conditions have on animals, in conjunction with the forecasted changes to the global environment (IPCC, 2021).

## Discussion

Global warming is likely to occur and the current climate change forecast models indicate that climatic conditions may have a greater impact on northern production systems. However, the nature and magnitude of environmental changes, both climatic and non-climatic, are difficult to elucidate at an individual farm level. What most forecast models show is that there will be an increase in extreme weather events, more frequent heat waves, and longer and hotter summers (IPCC, 2021). This emphasizes the need to focus on the impact of hot environments on long term cattle performance is warranted. Heat accumulation and dissipation in an animal's body are influenced by a combination of ambient temperature, relative humidity, wind speed, and solar radiation. However, these climatic variables do not function in isolation. As such there is a need to understand how these variables interact with each other and the impact this has on heat accumulation and dissipation. To do this a number of climatic indices have been developed, specific ones of interest are the temperature humidity index (THI; Thom (1959)), heat load index (HLI; Gaughan *et al*. (2008)) and comprehensive climate index (CCI; Mader *et al*. (2010)). Each respective index then has had a series of "stress" thresholds developed to provide an indication of risk periods. These indices could then be used on farm to gauge the effect productivity in the context of beef production.

## Conclusion

Information from individual or combined climate indices can help anticipate impacts on animals, including decreased feed intake, heightened health risks, reduced reproductive success, diminished milk yield, and reduced growth. Climatic indices provide producers with a useful and proactive tool to support the strategic management of livestock during what are classified as adverse climatic conditions.

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# The temperature humidity index (THI) as a tool for animal management

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## Introduction

The Temperature Humidity Index (THI) is a valuable tool for managing heat stress in livestock. Heat stress can negatively impact various aspects of animal health and performance, and increase the risk of diseases (Sejian *et al*., 2018). The study assessed THI in four Australian regions (Kimberley, Tennant Creek, Orana, and Limestone Coast) over ten years. It aimed to determine the frequency of THI threshold surpassing occurrences, aiding heat stress management planning.

## Methods

The THI is a combined index that considers both air temperature and relative humidity in an equation THI = 0.8 x T + ((RH x 0.01) x (T – 14.4)) + 46 4, where T represents air temperature, and RH denotes relative humidity. Historical weather data from the NASA Power website was used, covering a 10-year period (2011 to 2021) monthly for each Australian region. The average monthly THI over these 10 years was calculated (Table 1) specifically for beef cattle. Heat stress events were determined based on two thresholds: an attention threshold (65-75) and an acute threshold (79).

## Results

When the overall THI obtained during a 10-year period was considered across various Australian regions, differences in the THI were observed. The calculated overall monthly THI for the Kimberly region was evenly split, with 50% falling within the acute threshold and 50% within the attention threshold. The Tennant Creek region results were 17% within the acute threshold and 58% within the attention threshold. For the other regions (Orana and Limestone Coast) no acute threshold was reached. The attention threshold occurred 42% and 33% of the time for those regions, respectively.

**Table 1. The overall temperature humidity index (THI) for different Australian regions.**

| Region | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Kimberly | **80** | **80** | **79** | *76* | *71* | *68* | *68* | *69* | *74* | **79** | **81** | **82** |
| Tennant Creek | **80** | *78* | *77* | *72* | *67* | 63 | 62 | 64 | *69* | *74* | *77* | **79** |
| Orana | *74* | *72* | *69* | 63 | 56 | 51 | 50 | 53 | 59 | 64 | *68* | *71* |
| Limestone Coast | *69* | *68* | *66* | 61 | 55 | 51 | 51 | 52 | 56 | 60 | 64 | *67* |

*Italic* format above or on attention threshold. **Bold** format above or on acute threshold.

## Discussion and conclusion

The THI is a practical tool for enhancing animal management practices, despite some limitations that could lead to overestimation or underestimation of heat load effects and thermal conditions in animals (Gaughan *et al*., 2008). Nonetheless, the THI remains valuable for indicating the thermal status of animals during crucial periods. It also helps in determining the optimal time to administer heat-reducing supplements, like DIT AgTech's uCALM, which can be dosed through the uDOSE water supplement delivery system, which may reduce issues caused by heat stress.

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# Evaluating weather effects on water intake in cattle

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## Introduction

Cattle water intake is crucial for understanding beef cattle production systems. Silva Santos *et al*. (2023) emphasized its impact on feed intake, weight gain, and milk production. The study evaluated water intake data from cattle stations across Australia, correlating it with weather data using the DIT AgTech uHUB platform and uDOSE supplement delivery system. The goal was to examine the effect of weather on animal drinking behaviour.

## Methods

Historical water intake raw data (measured in L/month) was obtained from the DIT AgTech uHUB database for March 2022 to March 2023, along with weather data (temperature in °C and rainfall in mm) from the Australian Bureau of Meteorology. AgroEstat software was used to perform statistical analyses, including descriptive statistics and correlation analysis. A quality control check was conducted on the raw data, but no outliers were found (SEM ≥ 10,938.45).

## Results

The wide range of water intake records (0 to 826,380 L/month) measured at herd level (ranging from 60 to 1,000 head), did not result a correlation with the weather data (p-value ≥ 0.24). The weather, including temperature and rainfall, varied between 14.7º to 39.9ºC and zero to 423 mm, respectively, throughout the months when considering all regions simultaneously.

**Table 1. Correlation analysis of beef cattle water intake and weather (temperature and rainfall).**

| Region | Weather (p-Value*) | |
|---|---|---|
| | Temperature | Rainfall |
| Kimberly | 0.25 NS | 0.28 NS |
| Tennant Creek | 0.37 NS | 0.51 NS |
| Orana | 0.79 NS | 0.24 NS |
| Limestone Coast | 0.95 NS | 0.76 NS |

*Significance at level p-Value<0.05. NS is non-significant.

## Discussion and conclusion

This evaluation attempts to correlate water intake and weather information, but it doesn't yield a definitive conclusion on grazing cattle drinking behaviour, requiring more research. Becciolini *et al*. (2018) highlighted the importance of considering environmental factors and breed specificities when predicting behaviour. The dataset's influence on results is notable, yet it's a significant first step for the industry in exploring animals' preferences for surface water versus trough water. DIT AgTech plans research to improve water consumption measurement in grazing regions, supporting precision nutrition with the uDOSE system.

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# Agreement between interpolated and measured weekly rainfall and temperature humidity index

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## Introduction

The well-being, health, and productivity of cattle are influenced by environmental conditions. However, quantifying the impact of these conditions, including rainfall and heat load, on animal performance is often challenging due difficulty measuring the environment. However, in situations where direct measurement is limited or unavailable, interpolated data is often used. As part of the Calf Alive project, automated weather stations were installed at each of the ten collaborating commercial beef breeding stations, allowing for a comparison between measured and interpolated data. This paper reports the outcome of this analysis.

## Methods

Davis Vantage Pro weather stations were installed at each collaborating station in late-Nov or early-Dec-22. The RIMIK DataNode Remote Terminal unit was used to acquire and transmit 15 min environmental sensor data to a server, providing near-real-time access to the data. Interpolated data was downloaded from https://www.longpaddock.qld.gov.au/silo/point-data/ using the GPS location coordinates of each automated weather station. These data were used to calculate THI according to Hahn *et al* (1999). Data from both sources were compared using linear regression analyses by employing R (version 4.3.0) and R Studio (version 23.03.1).

## Results

Overall, linear relationships existed between measured and interpolated data for both weekly cumulative rainfall (P<0.001) and average daily THI (P<0.001) (Figure 1). The overall mean absolute error for interpolated THI was -1.35 and 9.8 mm for weekly rainfall.

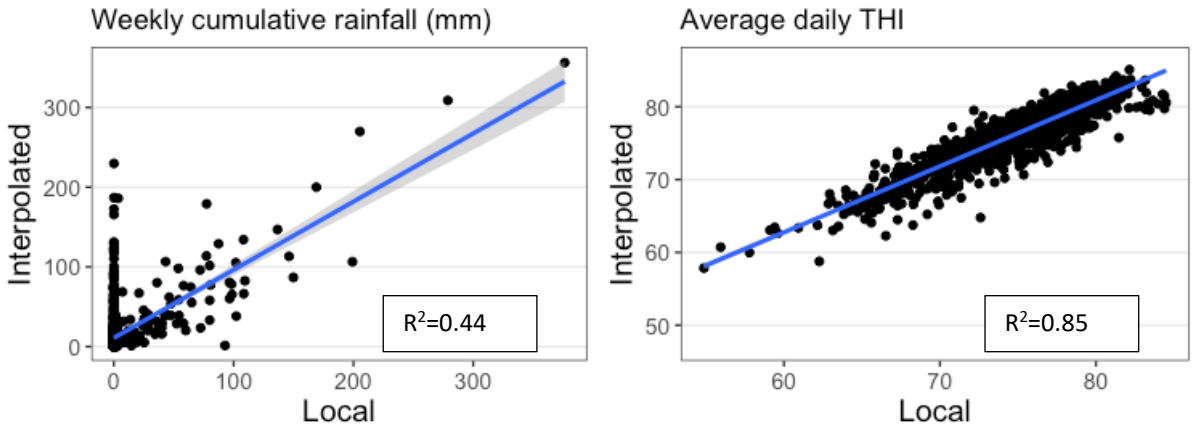


**Figure 1. Relationship between weekly total rainfall and calculated average daily THI.**

## Conclusion

This study found satisfactory agreement between interpolated and measured rainfall and calculated THI, which demonstrates the potential usefulness of the interpolation method in approximating environmental factors associated with livestock production.

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# A data driven heat stress alert system

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## Introduction

The accurate forecasting of cattle heat stress at an individual animal level will inform purchasing, management and infrastructure investment decisions, particularly at feedlot.

## Methods

This study investigated how autonomously recorded cattle behaviour datasets (n=96 cattle) can be leveraged to propose new approaches to cattle heat stress forecasting. Behaviour data were acquired using accelerometer sensors in two experiments using mixed breed feedlot cattle, with duration of the heavy breathing sensor state used to quantify heat stress. Two time-forecasting methods were proposed for predicting the average panting duration of a herd of cattle 24-hours into the future using climate meteorological data, animal characteristics and treatment factors as inputs. The first method utilised a simple deep learning framework based on Long-Short Term Memory networks, while the second applied traditional statistical methods to HLI, AHL and animal characteristic data. An optimisation algorithm was used to select which climate meteorological factors and how much historic data should be considered by the deep learning model.

## Results

Even with a limited dataset (96 cattle), the deep learning approach was able to effectively model the lagged effect of climate weather on cattle heat stress. Consequently, it was found to be more accurate than traditional statistical methods and climate indices at forecasting the cattle heat response (Table 1).

**Table 1. Results of classification experiment. For each method, the sensitivity, false positive rate, and Youden's index and accuracy were calculated at the prediction threshold that optimised the Youden's index. Furthermore, the area under the receiver operator curve was calculated to aggregate the Youden's index across all potential prediction thresholds.**

| Model | Sensitivity | FPR | Youden's Index | Accuracy | AUROC |
|---|---|---|---|---|---|
| Deep Learning (Optimal) | 0.84 | 0.26 | 0.57 | 0.80 | 0.84 |
| Deep Learning (Default) | 0.80 | 0.28 | 0.52 | 0.77 | 0.81 |
| AHL (Optimal) | 0.86 | 0.36 | 0.49 | 0.78 | 0.73 |
| AHL (Default) | 0.89 | 0.42 | 0.46 | 0.78 | 0.75 |
| Logistic Regression | 0.65 | 0.24 | 0.40 | 0.68 | 0.75 |

## Discussion and Conclusion

The automated monitoring of individual cattle promises to overcome many of the limitations of climate-based indices by enabling accurate assessment of heat stress at the individual level. These methods further enabled the continuous assessment of cattle, which was not possible via manual observation. Autonomously derived behaviour datasets and deep learning can improve animal welfare and productivity, with a strategic deployment of sensors recommended (extending on the number of cattle used here) to calibrate a real-time, accurate heat stress alert system for Australian cattle.

## References

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# The Gulf Country floods – comparing extreme events

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## Introduction

In late February and early March 2023, a tropical depression that developed across the northern tropics, delivered record-breaking rainfall and flooding to parts of the Gulf Country. Four years prior, a similar extreme event led to the February 2019 floods, causing the loss of half a million livestock (Cowan *et al*. 2022). This paper explores and compares these two events, including the climate conditions leading into the events and capability of predicting them in weeks in advance.

## Methods

Gridded observations of rainfall and surface temperatures from the 5 km Australian Gridded Climate Dataset are used to analyse the events' weather conditions. The thermal impact on cattle is measured by the Cattle Comfort Index (CCI; Mader *et al*. 2010), which describes a cattle feel-like temperature influenced by solar irradiance, relative humidity and wind speeds. Predictions of the events come from the Bureau of Meteorology's operational multi-week forecast system, ACCESS-S.

## Results

For the 2023 event, the highest daily accumulated rainfall occurred near the QLD/NT border with Century Mine receiving 313 mm on the 8th of March, whereas for the 2019 event the highest inland rainfall amount was at Julia Creek, which received 230 mm (5th February). Comparing the two events, 10-day total rainfall amounts were similar, with some locations exceeding 750 mm. Daytime temperatures were between 8°C and 12°C colder than normal during both events, further exacerbating the impacts on cattle. For example, in the 2019 event, Winton experienced five consecutive days of the CCI below an extreme threshold, with values that would be considered severe for southern Australian sheep in the middle of winter. While the Bureau's ACCESS-S predicted a 20-30% likelihood of extreme conditions for the Gulf two weeks prior to the 2019 event, it struggled to forecast the 2023 event.

## Discussion and conclusions

It is likely that the higher loss of livestock in the 2019 flood event was partly due to the record-breaking heat in the three months (Nov-Jan) prior to the floods and sharp drop in temperature due to evaporative cooling after the rain. Anecdotal reports suggest that cattle were in a weakened state and unable to acclimatise to the cold temperatures over the timeframe of a week. In contrast, much wetter and cooler conditions across the tropical north in early 2023 meant that livestock were able to better cope with the potential exposure to chill. Further research will aim to understand whether monsoon depressions over northern Australia will occur more often in the upcoming decades and how this will affect the risk of livestock exposure to unusually cold weather conditions.

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# Variability of minimum rainfall requirements for pasture response in N Australia

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## Introduction

The northern rainfall onset (NRO) is defined by the Australian Bureau of Meteorology as the date when 50mm of accumulated rainfall has occurred after the 1st September. It is the theoretical minimum rainfall required to stimulate pasture growth for northern Australia. In central and southern Queensland, Green Date (GD) is used and defined as the minimum amount of rainfall required after 1st September over a set period to stimulate pasture growth, dependant on land type. Seasonal forecasts of these events are used by producers to make management decisions. This paper reports a descriptive summary of these metrics for eight properties collaborating in the Calf Alive project.

## Methods

Interpolated daily rainfall records from 1942 to 2022 were downloaded for each of the eight collaborating properties from the SILO website (SILO | LongPaddock | Queensland Government). Using R statistical package, NRO and GD were calculated annually for each location. Accumulation of 50mm of rainfall in five consecutive days after 1st Sept was used to calculate GD. Descriptive statistics were performed on the data.

## Results and discussion

Large variability existed for NRO and GD across years, with GD having a range 113 days larger than NRO and a much lower probability of occurring before mid-Dec (Table 1). All locations experienced NRO each year, however the Charleville region did not receive minimum rainfall to break the season in nine of the 80 years observed, based on the GD definition used.

**Table 1. Variability of NRO and GD over eight locations in northern Australia (1942-2022).**

| | NRO | | | GD | | |
|---|---|---|---|---|---|---|
| Location | % yrs before 15-Dec | % yrs before 15-Jan | Range (d) | % yrs before 15-Dec | % yrs before 15-Jan | Range (d) |
| Georgetown | 78 | 100 | 121 | 44 | 86 | 154 |
| Camooweal | 64 | 96 | 139 | 31 | 60 | 259 |
| Cloncurry | 75 | 96 | 147 | 36 | 74 | 209 |
| Delamere | 96 | 100 | 97 | 46 | 90 | 137 |
| Julia Creek | 70 | 94 | 144 | 29 | 65 | 351 |
| Torrens Creek | 68 | 76 | 150 | 30 | 61 | 232 |
| Clermont | 85 | 98 | 150 | 50 | 71 | 358 |
| Charleville | 85 | 96 | 158 | 38 | 51 | 304 |
| Average | 78 | 95 | 138 | 38 | 70 | 251 |

## Conclusion

Understanding the implications of NRO and GD timing for pasture growth and stocking rates is key in effective decision making, and using the best suited definition based on location, soil/land type and pasture composition will result in more accurate predictions of pasture response. The variability in timing of receiving minimum rainfall requirements leading into the growing season highlights the importance of utilizing accurate seasonal climate forecasts especially with limited pasture availability.

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# Rain ready rangelands paddock challenge: trialling research station strategies on commercial properties

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## Introduction

Can you improve land condition on your property, while still producing quality beef? The Quality Graze project, a long term grazing trial on Old Man Plains Research Station (OMP), located southwest of Alice Springs shows that it is possible, using stocking rates based on long-term carrying capacity (Materne *et al*. 2021). The Paddock Challenge is a component of the Rain Ready Rangelands Project funded by the Australian Government Future Drought Fund. The Paddock Challenge is working with commercial producers to adapt the Quality Graze strategies for their own circumstances, including monitoring to record any gains in herd efficiency and land condition.

## Methods

The Department of Industry, Tourism and Trade will be collaborating with 2 stations: one 400km southwest and the other 300km northwest of Alice Springs. The prevailing grazing management of each station will be compared to a 'challenge paddock' where a strategy adapted from Quality Graze is being applied. Comparisons and benchmarking will be at whole paddock or waterpoint scale, depending on station infrastructure. Pasture dynamics and herd behaviour, performance and health will be monitored over the two year challenge.

## Results

Site data will inform pasture, herd, and economic modelling to extrapolate site results over the longer term, incorporating variations in seasonal conditions that are expected from past records. Results will be documented through case studies and field days to promote peer-to-peer learning.

## Discussion and conclusions

Discussions and conclusions will be available upon the projects completion in 2024.

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# Land reclamation using water harvesting techniques in the Desert Uplands Bioregion

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## Introduction

'Adelong Station' is a 22,000ha property in the Desert Uplands Bioregion of Queensland with a median annual rainfall of 430mm in a summer dominated pattern. Historic preferential grazing has degraded the gidgee country, characterized by *Acacia cambagei* trees and shrubs, and given the relative fertility of this land type, high priority has been given to reclamation activities. Along with investments in fencing, water development and changed grazing management practices, water harvesting techniques have been implemented including shallow water pondage and water spreading structures.

## Methods

In 2021, a claypan in cleared gidgee country was treated using the 'shallow water pondage' technique. The aim is to build ponds which capture and hold rainfall to a low depth so it either soaks in or evaporates, reinstating the shrinking and swelling of clay soils, improving infiltration, and providing a seedbed for pasture recovery. Water spreading banks have also been trialled taking concentrated water flows into a water spreading structure (e.g. Figure 1), an excavated channel which, when full, allows the water to break out across its entire length. A portion of water is harvested from the flood flows of a degraded creek and distributed over the degraded cleared gidgee country through the water spreading structure. To maximise the chances of success in the reclamation sites, the sites with water ponded, or spread, were ripped with a Yeomans plough and sown with a mix of high value pasture species including Mekong Brizantha (*Urochloa brizantha*).


**Figure 1. Level sill on water spreading structure.**

## Discussion

It is theorised that introductions of pasture species from 'higher' rainfall zones (>500mm annual rainfall) to the sites with water spreading or shallow water pondage will both improve the rate of response to reclamation activities and provide high value grazing in previously poor areas. This trial tests the assumption that generic pasture recommendations for rainfall zones do not represent the complexity of water movement and retention in the landscape. Therefore, species requiring a 'higher' rainfall zone can persist and be productive when sown into landtypes and landscape positions that infiltrate and store more moisture than average.

## Conclusion

While we have yet to determine the long-term success of the current trials, reclamation efforts involving water harvesting and water spreading present an opportunity for experimentation in expanding the potential area under sown pastures, including species options typically not thought suitable, and improving the success of landscape recovery.

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# Faecal seeding, drought, and seed survival in dung

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## Introduction

Faecal seeding is a natural process whereby seeds are ingested by animals and dispersed in their dung in a viable state. There is an acknowledged interest in this process as a low-cost method of introducing and establishing pasture legumes in Northern Australia. Faecal seeding has been successful in regions with lighter textured soils, with considerable areas of Stylosanthes established following inclusion in supplements (Rains 2005, Gardener *et al* 1993). However, the semiarid regions of Northern Australia with heavier textured soils are frequently deficient in high-protein sown legumes, with a lack of appropriate species and unsuitable terrain for conventional means of sowing seeds. This study focuses on Desmanthus, a legume species more suited to these regions, and aims to identify whether the germination rates are impacted by long dry periods after faecal seeding.

## Methods

Phase 1: July 2014. Progardes Desmanthus cv JCU 2 hard seed was added to molasses supplements for cows as part of routine management at James Cook University. Their dung was collected from the paddock 48 hours later, sun dried, and stored on trays in an open shed at ambient temperatures for 9 years (simulated drought).

Phase 2: April, 2023. One half of each dung pat was kept intact on the trays for an outdoor germination trial whilst the other half was soaked in water and the seeds recovered for a germination test in a controlled laboratory environment. A fresh sample of Desmanthus cv JCU 2 seed (control and scarified) was also germinated in the lab for comparison.

## Results

There was an average of 288 seeds recovered from each dung pat (range 32-1102) with an average germination of 1.6 seeds (range 0-12) per dung pat in the trays. The germination rates in the laboratory were the highest for the digested seeds from 2014 at 84% compared to the fresh seeds germinated as a control, as seen in Table 1.

**Table 1: Laboratory germination rates of recovered 2014 seeds and fresh seeds for comparison.**

| | 2014 seeds | Fresh control | Fresh scarified |
|---|---|---|---|
| Germination rates | 84% | 10% | 71% |

## Discussion and conclusion

This study demonstrates the viability and longevity of hard seed Desmanthus after passing through the digestive tract of cattle. Improved germination rates were observed with the digested seeds compared to both the fresh control and fresh scarified seeds. The seeds' ability to sit in a dormant state allows them to survive an extended dry period of 9 years and germinate when conditions improve. This confirms the potential of faecal seeding legumes for commercial producers in the appropriate regions of Northern Australia.

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*Agrimix provided seeds, JCU students (J. Bornman, E. Bourke, T. Cook, B. Hayne, N. Isacowitz) for assistance and background research.*

# Long term performance of different stocking strategies in a variable climate

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## Introduction

A number of grazing strategies such as stocking at long term carrying capacity (LTCC) are promoted to manage for climate variability in northern Australia. However, there is a little data on their performance relative to conventional management. In 1997 we established a large, replicated trial to address this issue.

## Methods

The trial is in *Eucalypt* savanna near Charters Towers, Queensland. Strategies being tested are: Heavy stocking (HSR) at 4-5 ha/AE (animal equivalent), moderate stocking (MSR) at LTCC (8-10 ha/AE), moderate stocking with rotational wet season spelling (R/Spell) and Flexible stocking (range: 4 - 20 ha/AE) applied with (Flex+S) or without rotational wet season spelling (Flex), both with stocking rates varied with available forage. Paddocks (100 ha) are stocked with Brahman steers and gross margins (GM) calculated as product value less costs. Pasture composition is monitored bi-annually using the Botanal procedure (O'Reagain *et al*. 2022).

## Results

Rainfall varied markedly (246-1223 mm) over the 24 years. Ongoing drought conditions necessitated destocking all paddocks in May 2022 except the Flex strategies, which remained very lightly stocked (20 ha/AE). Average live weight gain (LWG) per ha was highest in the HSR (data not shown) but this required expensive drought feeding in seven of the 24 years. Consequently, the average GM/ha over 24 years (Figure 1a) in the HSR was only half ($7/ha) that of the other strategies ($13/ha). May 2022 pasture yields were extremely low in all strategies reflecting the extended drought conditions. Nevertheless after 24 years total pasture yield and that of the desired perennial species (3P) was by far the lowest in the HSR and highest in the two Flex strategies (Figure 1b).

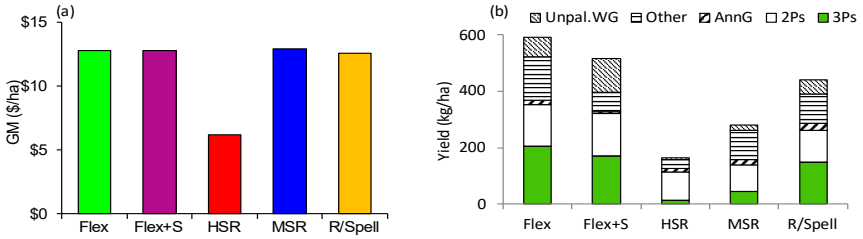


**Figure 1. (a) Average gross margin (GM) per hectare over 24 years and (b) pasture species composition in May 2022 at the Wambiana trial. (3Ps & 2Ps= perennial, productive and/or palatable grasses, AnnG.=annual grasses, 'other' =other species and UnPal.WG= unpalatable wire grasses).**

## Conclusion

The relatively good pasture composition in the two Flex strategies and the fact that these strategies did not have to be destocked in May 2022, highlight the clear advantages of adjusting stocking rates to forage availability. These results, the ongoing pasture recovery with the recent good season and our experience managing the trial, show that risk-averse flexible stocking around LTCC coupled with wet season spelling, is likely to be the most profitable and sustainable strategy for managing climate variability.

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*We thank the Lyons family of 'Wambiana' for their ongoing guidance and support. This project is co-funded by the Queensland Department of Agriculture and Fisheries and Meat and Livestock Australia.*

# GETTING IN THE KITCHEN: HUMAN CAPACITY FOR A PROFITABLE, SUSTAINABLE, AND PRODUCTIVE NORTHERN INDUSTRY

# Have we got our extension/adoption models right?

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## Introduction

The failure to achieve substantial adoption of decades of research and development (despite numerous adoption programs and priorities) is a concern for all extension practitioners in the northern beef industry. Could a human-centred design approach make a difference, and where is the starting point for addressing the needs and experiences of the producer?

## Discussion

This extension/advisor role has typically been intermediary as an agent for information transfer between researchers and producers (Taylor *et al.* 2020), and although the information transfer model is slowly changing, we often offer solutions to producers that have yet identified they have a problem.

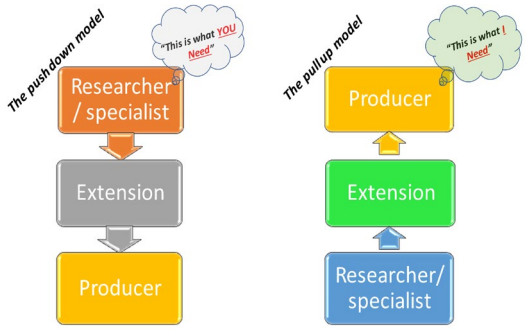


**Fig. 1. The push-pull extension model**

Traditional information transfer is typically 'top down' (this is what you need), often starting with the researcher defining a problem and 'pushing' the solutions onto the producer. An alternate model assists producers discover the issues affecting their business and they pull the information they need from the research sector (often via extension). This 'push/pull' theory (Fig.1.) is well documented, particularly for international projects and the 'pull up' model has had good success in improving adoption rates.

Recently, the farmer centred Queensland Model of Extension, DAF Grazing Practices Framework, and the NB2 Pathway to Practice project, has incorporated a ground up approach, but how can this be applied at an industry level, given the complex nature of the extensive grazing system. People, land, livestock and business are all critical factors, but it is an unrealistic expectation for extension officers/advisors to have the complete suite of skills. Extension officers will need to combine skills from both the public and private specialist sectors to co-design (with producers) the appropriate strategies. The involvement of producer peers can be critical in this change process.


**Fig. 2. Qld (DAF) model of extension**

Assisting beef producers to understand their current business situation will identify if there is a problem somewhere in their business. This is the basis of the NB2 'Pathway to Practice' diagnostic process positioning producers to determine their pasture and live weight production (kg), costs to produce it ($/kg) and the subsequent returns ($/kg). Using their business specific information, a strategic, diagnostic process allows them to identify if they have a problem and where to make changes. Working with their peers and advisor support is the final step in determining the best solution to implement, changes. This farmer centred approach should yield higher adoption rates.

## Reference

Taylor et al. (2022) The Rangeland Journal 42(5) 277-292

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# Recognising the people in grazing businesses

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## Introduction

The Queensland Department of Agriculture and Fisheries (DAF) beef extension team deliver workshops across the Burdekin catchment, as a means to engage with producers, provide information to support grazing businesses and increase the adoption of management practices. Workshop topics are generally targeted towards regional production challenges. An indicator of workshop topic relevance to producers, can be seen through the number of producers in attendance. This paper focuses on producer attendance of different workshop topics, and what this could mean in relation to the adoption of management practices in the region.

## Results

From March 2021 to November 2022, the beef extension team ran 15 workshops on various topics across the Burdekin catchment. The average producer attendance of these workshops was 16. Four workshops were on topics related to business management (Fig. 1 grey bars) and all had above average producer attendance. Two of these workshops were on succession planning, and they had the highest producer attendee numbers over the two years. With 29 producers from 17 businesses attending the 2021 workshop, 42 producers from 17 businesses attending the 2022 workshop, and 7 businesses and 12 producers attending both succession workshops.

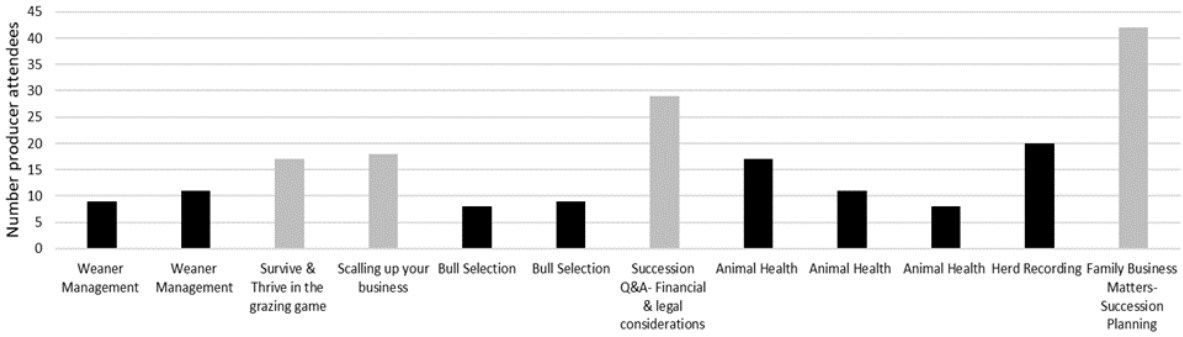


**Figure 1. Producer attendance at DAF workshops held in the Burdekin Catchment for 2021 to 2022.**

## Discussion

The regional production challenges which often influence workshop topics tend to be more widely observed and discussed topics, and production based in nature. In contrast, the business and people management challenges beef producers face tend to be more sensitive in nature, and not as commonly discussed. Ultimately, it's the people working in the business that underpin the performance of the land, the animal production and the bottom line. Whilst succession planning is not as widely observed or discussed compared to topics such as grazing management or herd performance, the 2 succession planning workshops run by DAF had the highest number of producer attendees and were clearly the most popular. If a primary challenge for a business is around succession planning and people management, this needs to be addressed before other management practices are likely to be adopted. This leads to the question, is a barrier to adoption of recommended management practices due to the inherent structure of family beef businesses and the dynamic of the people within them? There needs to be more recognition of the role people play in the grazing businesses, as this is one of the primary challenges family beef businesses face.

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# Staff retention on northern cattle stations — a survey of station staff

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## Introduction

The topic of staff retention on northern cattle stations was raised as a priority for research, development and extension at a 2022 MLA BeefUp forum in the Northern Territory (NT). There are a number of articles on staff retention on the Beef Central website (Beef Central, 2023); however; the most informative resource would be open conversations with employees. To help start these conversations, a small survey of station staff was designed.

## Method

The survey was emailed to station employees and employers across the NT, Western Australia and Queensland. There were 3 multiple choice questions (up to 5 answers could be selected including 'other'), 4 open-ended questions, and 6 questions regarding the participant's demographic. Responses were collected anonymously via email between October 2022 and April 2023.

## Results and discussion

The survey included 15 station hands, 3 managers, 1 headstockperson, and 5 'others'. Survey respondents had worked on stations for: <2 years = 4, 2–5 years = 10, 5-10 years = 5, and 4 did not specify. 70% had worked for more than one manager.

Top responses to multiple choice questions on why staff stay/leave stations are shown in Fig. 1 and 2. Expanding on what might make staff stay longer (e.g. 4+ years), the most common themes were: career progression/professional development (12); responsibility/respect/recognition of work (6); pay rise (5); and good working environment/culture (5). Common themes in answers to "what makes a good manager?" were; good communication (7) and takes the time to teach (5). The top themes for "what makes a good station culture" were good people/attitudes (7) and fun (4).

This survey may help station managers understand why staff leave and identify ways to improve staff retention. It may also help start conversations on the issue. Giving employees a chance to share their thoughts, and listening to their responses could be the first step in improving staff retention on cattle stations and across the livestock industry.

## References

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# Effectiveness of the Department of Agriculture and Fisheries Animal Science staff informal induction and mentoring program

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## Introduction

The induction, training and development of new staff is essential for any business or work group to provide high quality and consistent services and deliverables. Department of Agriculture and Fisheries Animal Science (DAF Animal Science) have recognised the need for a formal induction and mentoring program due to the inconsistency in value from informal mentoring. The broader Department has a formal graduate program however, this is only offered to those who have graduated from university within two years.

## Methodology

The Extension Officers, Scientists and Technical Officers were divided into two groups, mentors, and mentees based on their period of continuous employment at DAF (~5 years of continuous employment). Separate surveys were created for mentors and mentees to gather information from Extension Officers, Scientists and Technical Officers working for DAF Animal Science across Queensland to identify their perceived value in the mentoring process for new staff. People were asked to rate their experiences from a scale of 1 to 10 (1 = poor and 10 being excellent).

## Results and discussion

Participants rated the informal mentoring received as of 6.5 out of 10. On average, confidence of new staff improved from 4.5 to 7.2 out of 10. Overall, 95% of mentees had a positive change in confidence level. This improvement was not correlated to either the period of continuous employment at DAF Animal Science, or the rating of mentoring received. Eighty-one per cent of the surveyed mentors would be interested in participating in a structured mentoring program, but only 10% were willing to commit a week block to mentoring staff. The most common areas new staff indicated a proficiency included, grazing land management, genetic selection, and animal nutrition. The most common areas new staff indicated a need for development included, grazing land management, genetic selection, animal nutrition, trial site development and project development and management. Pasture agronomy and beef economics were two areas where few staff feel proficient and most new staff would like further development in.

## Conclusion

In conclusion 95% of staff had a positive change in confidence regardless of rating of informal mentoring or period of continuous employment. Whilst there is mentor interest in a formal induction process, few experienced staff will commit the time needed to mentor. Instead, there is a reliance on a few people to mentor numerous new staff. This can be difficult due to time constraints and the practicalities of distance between regional offices. A structured induction process could ensure mentoring occurs in conjunction with project work and overcome time constraints and practical challenges. Informal mentoring appears to have caused new staff to focus on technical areas the experienced staff are proficient in, despite staff identifying that they have reasonable proficiency in these areas. A structured induction and mentoring process may be able to train new staff in technical areas experienced staff are not experienced at or interested in.

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# Teamwork makes the enviro-dream work

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## Introduction

With the commitment of the Australian red meat industry to be carbon neutral by 2030 (CN30), Meat and Livestock Australia (MLA) have focused on investing into reducing emissions whilst maintaining production gains and demonstrating environmental stewardship. Achieving carbon neutrality seeks to increase market opportunities for Australian livestock producers by rewarding their environmental stewardship through a range of mechanisms including future biodiversity markets and/or certification schemes. The Australian Biodiversity Stewardship Package was initially released in May 2021. The framework supports improved biodiversity, improved on-farm management and rewards livestock producers for demonstrating stewardship. Graziers are important caretakers of the Australian landscape since they manage over 50% of Australia's land mass.

## Methods

The "From Method to Markets" project team have been collaborating with family-owned livestock businesses across the Brigalow belt of Central Queensland (McMillan 2021) and the Morven region in South West Queensland, to assist in identifying methods to reduce on-farm carbon emissions and demonstrate stewardship. BioCondition monitoring sites across the Brigalow, and Mulga regional ecosystems have been established with flora and fauna assessments collected in alignment with the BioCondition manual (Queensland Government 2021). Involving the producers and service providers such as Department of Agriculture and Department of Environmental Science in collecting data for the BioCondition tool has been beneficial for all parties.

## Discussion

The mutually beneficial relationship of sharing knowledge, skills and experience across livestock production and environmental systems, whilst undertaking BioCondition site selections and measurements, has demonstrated the importance of these partnerships. An appreciation of the whole system approach to livestock production including biodiversity for both service providers and producers has been achieved. The use of BioCondition has made researchers realise that producers are already doing this. Techniques that producers are already demonstrating to provide biodiversity conservation on property include retaining shade lines and removing grazing from bird nesting sites in the breeding season. It is crucial that service providers and producers unite to support biodiversity and maintain profitable livestock production systems.

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# The Next Generation Land Managers project – promoting sustainable beef production through Rangeland Management Courses

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## Introduction

The Northern Territory Department of Industry, Tourism and Trade (DITT) have been offering the free, on-station, Rangeland Management Course (RMC) targeting first and second year station hands for over 20 years. The aim is to educate young people working in the pastoral industry about the fundamentals of land and pasture management at the beginning of their career, creating stepping stones to more advanced courses such as Meat and Livestock Australia's EDGE Network workshops. The course teaches the importance of rangelands in northern cattle production and also builds a relationship between station and DITT Livestock Industries staff which is important for increasing industry interaction with government.

The RMC covers land and pasture condition, species identification, ruminant nutrition, fire as a management tool, weeds & poisonous plants, and carrying capacity. Different learning styles are stimulated through theory, demonstrations and practical sessions in the paddock.

## Methods

Feedback collected from 63 participants over five courses in 2022 and 2023 was used to evaluate participant's satisfaction, attitudes, learning outcomes and suggestions.

## Results and discussion

The feedback shows a positive response to the course. Table 1 indicates that many participants did not feel they had good prior knowledge, but found the course very valuable; with the accessibility attracting participants who would not normally attend on their own accord.

**Table 1. Average scores out of five for feedback questions (1=strong no/never/not valuable; 5=strong yes/highly likely/very valuable)**

| | |
|---|---|
| "Prior to the course, would you say you had good knowledge of the topics covered?" | 2.5 / 5 |
| "Is this course something you usually would have attended off your own back" | 3.3 / 5 |
| "How likely are you to use the things you have learned today?" | 4.6 / 5 |
| "Overall, how valuable did you find this course?" | 4.6 / 5 |

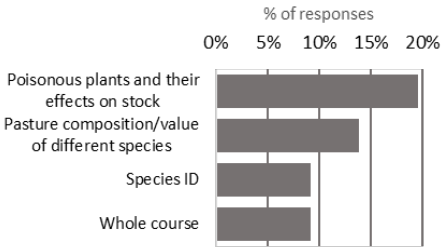


**Fig. 3. The top themes of answers to "any standout things that were useful, interesting or surprising?"**

Fig. 1 lists the most popular parts of the course, as per the themes of comments from participants. When ideas for improvement of the course were requested, an overwhelming 45% of responses revolved around making the course more interactive with more activities and more time outside, highlighting the importance of tailoring training material to the audience.

Content updates, modernisation and expansion of the Katherine and Barkly region RMC, and the development of an Alice Springs region course will be delivered as part of the DITT & Northern Hub Next Generation Land Managers project.

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# Pasture development using the Action Learning Cycle: A case study

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## Introduction

Large areas of sown pastures in the Brigalow Belt Bioregion of Queensland suffer from pasture rundown where the gradual reduction of plant-available nitrogen limits pasture and beef production. The most profitable long-term remediation is to establish perennial legumes, and in some cases, to also include new sown grasses if undesirable species are present (Peck *et al.* 2022). Adoption of perennial legume plantings has increased across this region, however there is still potential to significantly increase the area sown. In this case study, the Action Learning Cycle was used to guide pasture development on a commercial beef property in central Queensland.

## Methods

The case study site is on a commercial beef property located South East of Moura, Queensland, suffering from pasture rundown. The development of a new pasture on this site was guided using two rounds of the Action Learning Cycle (Fell 2005). Cycle one was completed as follows. ***Plan.*** The producer offered to host a pasture research trial site with DAF and in 2020 planning for pasture establishment was conducted by DAF and the producer. ***Act.*** The producer and DAF conducted the site preparation and planting together (2020/21 summer) which included the best management pasture establishment steps detailed by Peck *et al*. (2022). ***Reflect***. Four site visits were conducted in 2021-22 including establishment and pasture yield assessments to determine outcomes. ***Learn*****.** Discussions between the producer and DAF staff included what were the key practices and other factors that lead to establishment success. The plan and act part of the action learning cycle was then repeated by the producer without DAF input, to plant a new pasture in a nearby paddock.

## Results

The producer paddock had very good establishment of most species planted. Rhodes grass (*Chloris gayana)* was dominating with small amounts of shrubby stylo (*Stylosanthes scabra)* and caatinga stylo (*Stylosanthes seabrana)* but no Buffel grass (*Cenchrus ciliaris)* despite being included in the seed mix.

## Discussion and conclusion

After reflection with the producer, it was determined that a seed germination test for each species was not provided before seed purchase. It was possible that the quality of buffel grass seed was low and germination unlikely, and the proportion of stylo seed in the mix was low, allowing the Rhodes grass to outcompete the establishing legume seedlings. The learning was that the producer had followed most steps for successful pasture establishment but needed to pay more attention to sourcing higher quality seed and a blend with a higher proportion of legumes. The Action Learning Cycle has guided the successful establishment of new legume-grass pastures on paddocks suffering from pasture rundown. The *plan – act – reflect – learn* process was used two times and a third round is currently underway with the producer planning to incorporate the learnings from the most recent cycle.

## References

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# Integrated approach to extension delivery in the Reef Catchments to build capacity.

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## Introduction

The Department of Agriculture and Fisheries (DAF) Grazing Extension Support project for the period of July 2017 to June 2022 provided grazing industry extension services under the Queensland Government Reef Water Quality Activities Program to meet Reef Plan targets and those within the Reef 2050 Plan. Over the five-year project period the project team have worked with and geographically recorded the impact of 1470 unique beef properties representing 19.2 million hectares of extensive rangelands across the Burdekin, Fitzroy, and Mackay Whitsundays regions.

From July 2017 to June 2022, DAF beef extension officers delivered and coordinated 2419 activities: 254 workshops, 128 field days, 1646 one-to-one engagements, 167 extension capacity activities, and 224 other activities (e.g. forums, communication products, webinars, industry event planning, and media) across the three reef catchments. There were 11,003 producer engagements and a total of 16,157 participant engagements. Average activity attendance from individual properties was two activities over the five-year period with 1 to 7 interactions per property

## Method

The project's extension effort takes a whole of systems approach that encompasses grazing land management, animal production, and business and economic considerations, with the aim of reducing sediment loss from grazing lands and improving reef water quality. The project has provided effective extension support through integration with related projects and collaboration to achieve improved working relationships, develop flexible and integrated access to technical knowledge and skills and facilitate practice change.

## Discussion

Many of the one-to-one interactions have multi-faceted themes rather than a focus on one topic as animal production, animal health and grazing land management are often interdependent within the management of a business. About twenty-nine percent of the field days held over the five years had a whole of business theme. This included field days that that were organised by DAF extension and where DAF participated as a collaborator or a presenter. Thirty percent of workshops delivered had a whole of business theme and co-reported toward the achievements of other projects. The project consistently achieved improved capacity in the knowledge and skills of participants. Participants also indicated a high level of intention to change a practice based on new information received.

**Table 1. Project target vs actual achieved – improved capacity.**

| | 2017-2018 | 2018-2019 | 2019-2020 | 2020-2021 | 2021-2022 |
|---|---|---|---|---|---|
| Improved capacity of producers. annual target = 80% of producers had improved their knowledge and/or skills | 83% | 78% | 94% | 79% | 79% |
| Intention to change practices annual target = 50% | 62% | 48% | 53% | 81% | 69% |

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# Advancing Beef Leaders: leadership, impact and influence

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## Introduction

The north Australian beef industry faces significant challenges in environmental stewardship, economic sustainability, and human resilience. The next generation of industry leaders must understand, advocate for and implement solutions to these. To support developing leaders in the beef industry, Advancing Beef Leaders (ABL) was launched in 2020. A joint initiative led by the Department of Agriculture and Fisheries (DAF) and supported by private sector collaborators, ABL has proved to be a program that opens pathways to leadership, enhances industry impact and develops influence for graduates.

## Methods

A regional location was set for each yearly ABL cohort and the participants filled eleven positions from all parts of the beef industry. The application contained no restrictions on age or gender and consisted of a written application for shortlisting. Shortlisted applicants participated in an interview with a panel for final selection. The program was designed with a foundation of peer-to-peer adult learning that included six modules (self and others, spheres of influence, technical foundations, economics and finance, governance, communication), a group action learning project and a mentoring partnership. Each cohort of participants were facilitated and coordinated by an outside industry professional and a local DAF extension officer.

## Results

In 2020-21 ABL was delivered to one cohort in the Charters Towers district and in 2021-22 and 2022-23, there were two concurrent cohorts each year (Central Qld, North West Qld, Maranoa and Far North Qld), resulting in a total of 53 ABL graduates. In 2022-23 participant feedback for Maranoa and Far North Qld groups averaged 6.3 out of 7 for overall usefulness of the program. Graduates have reported applying ABL learnings to their beef businesses including adoption of on-property improved practices, better financial literacy, focus on drought resilience and business planning, earlier attention to family succession, and improved communications. Increased industry representation and advocacy has been achieved, with eleven graduates appointed to community and industry positions including AgForce committees, Regional Beef Research Committees, Natural Resource Management group boards and Local Council. A number of graduates have received industry awards and several have been invited guest speakers at industry events.

## Discussion and conclusion

ABL has positioned itself as a critical change agent, increasing the capacity of individuals for meaningful contribution to personal, business, community and industry outcomes. The successful delivery model of topical modules, mentoring partnerships and group action learning projects under the facilitation of trained extension and adult learning practitioners has proven ABL to be a leadership development program unique to others offered in the beef industry. In June 2023, two new cohorts began ABL, bringing the total program participation to 75 people. The ABL Foundation was established in 2022 to support alumni activities and ensure ongoing interaction and networking with program participants. Sponsoring partnership opportunities were offered in 2023, with Rabobank's Rabo Client Councils being the first private sector partner signed.

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# Working with graziers within a practice framework.

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## Background

Department of Agriculture and Fisheries (DAF) beef and sheep extension officers work with graziers to implement recommended industry practices in landscapes that influence water quality entering the Great Barrier Reef. The grazing extension team have developed a practice framework, specifically for beef extension services to enhance adoption of best practice. The foundation for DAF's Grazing Extension Practice (the framework) is the Queensland Extension Model of Practice (EMoP). This model is producer centred and provides a practice framework with 3 core practice elements, key personal practice enablers and 6 practical steps that underpin every interaction with producers; enabling a collaborative partnership with producers to support decision making and adoption. The core practice elements are relational practice – relationships between extension officers and graziers are central to the change process; change practice – change is both a process and an outcome of the collaboration between extension officers and graziers; and technical knowledge practice – the extension officer provides technical knowledge and access to expertise and acknowledges, utilises, and builds on the grazier's existing expertise and knowledge.

Grounded theory research using a longitudinal survey conducted with graziers in the Burdekin Catchment applies the graziers' perspective to this farmer centred practice as six service delivery principles. These are:

1. Support as follow-up to implement/trial changes in their system.
2. Conduct activities that are known to be locally relevant and held locally
3. Other graziers using the practice now
4. Evidence of the advantage of the change over current practice
5. Access to specialist information/services
6. Remember that graziers know their property/business situation well.

While there is a lack of evidence that individual and social factors are causally linked to adoption (Hobman & Taylor 2018) it is theorised that the six principles could increase the rate of adoption among their cohorts.

## Discussion

The framework aims to increase and measure the frequency and reliability of producers investing in change through a ground-up process by viewing producers and extension officers as equal contributors in extension activities; providing a consistent structure, professional standards, skills, and approaches for extension officers; and improving clarity of purpose through extension practice, methods, and processes that enable and facilitate greater change.

Extension officers are using the framework to determine the most appropriate extension method dependent upon where the producer or producer group is at in the implementation steps. It is also being used to guide the development of project plans and research project adoption strategies. It can be used as a diagnostic tool to determine why desired outcomes are not being achieved or how outcomes could be improved. Finally, staff development programs including mentoring and induction development use the core elements to identify consistent training requirements.

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# MLA P.PSH.1278 – NB2 Indigenous Group

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## Introduction

This project, the indigenous component of the Northern Breeding Business project is a joint venture initiative with support from Meat and Livestock Australia (MLA) Indigenous Land and Sea Corporation (ILSC), Animal Health Australia (AHA) and Tropical North Queensland Drought Hub (TNQ) under the Northern Breeding Business (NB2) project framework. The first phase of the project was supported by an MLA/ILSC/AHA partnership and operated throughout 2021 and 2022.

As a continuing part of the NB2 initiative, this phase of the project will maintain and expand the existing indigenous producer group and will work with that group to:

1. Establish baseline data and production records to understand current breeder herd productivity and to monitor progress towards improvement in production, performance and financial outcomes.
2. Promote development and adoption of relevant business practice innovations and improve adoption of applied R&D.
3. Provide feedback, direction and facilitate engagement with industry R&D including relevant on property research programmes.
4. Raise awareness of key biosecurity and animal welfare issues amongst indigenous cattlemen in Northern Australia
5. Engage with innovative technology such as augmented and virtual reality to develop enhanced learning and communication opportunities including –
6. Development of the Spotting Animal Disease Tool for Cattle
7. Facilitating a biosecurity and animal welfare education process
8. Utilising immersive technology tools
9. Develop education and career pathways within the cattle industry with support from UQ Skills and representatives of corporate and large family agricultural enterprises

The project utilises facilitation processes tailored to suit indigenous property managers and communities and involves group “in country” residential style workshops, peer to peer learning and exchange, specialist input, individual property work and ongoing mentoring. There is a strong focus on member participation, ownership and engagement. The project is currently working with seven indigenous businesses and will engage an additional four to six businesses over the next two years.

Indigenous group activities are integrated with the broader NB2 project which exposes participants to other aspects of the cattle industry and people from a range of backgrounds. These contacts enable the building of a range of networks across the spectrum of the cattle industry and facilitate a two-way cross fertilisation of ideas, experience and knowledge across groups and across the industry.

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*We acknowledge the support of MLA, ILSC, AHA and NQ Drought Hub and the indigenous communities and properties engaged with the project.*

# "And the winner is…" — The FutureBeef experience

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## Introduction

The FutureBeef website hosts information tailored for beef producers in northern Australia. Traffic is driven to the website using social media, webinars, videos, monthly e-newsletters, podcast episodes and newspaper features.

## Results

Content success is measured by engagement (e.g., link clicks, views, likes, comments, shares). Table 1, shows the most popular content since the last Northern Beef Research Update Conference in 2019.

**Table 1. Top performing content by platform**

| Platform | Content | Success |
|---|---|---|
| Social media  | Check out the size of this Rhodes grass (*Chloris gayana*) plant! Still rooted in the ground, this plant stands over 6ft tall. It was sown into a paddock that was severely affected by pasture dieback, nutrient rundown and overcome with Indian couch (*Bothriochloa pertusa*). | 3655 engaged users on Facebook |
| YouTube video  | How to raise poddy calves: Looking for ideas about how to raise a poddy calf? If you want to end up with a big, healthy calf like this one, watch as Matt Brown, FutureBeef Extension Officer, talks about the two ways to do this successfully. | 8212 views |
| Podcast episode   | Making your pasture make you money: Pasture specialists in Northern Australia have spent decades researching cost effective ways to improve soil quality, cattle production values and businesses' bottom lines. After a few good seasons and an even more buoyant cattle market, there's an exciting new broad uptake of pasture and legume varieties. | 300 plays |
| E-newsletter article   | Getting the best out of your weaners video: Setting weaners up for success means different things to every beef producer. In this short video, Sonya, Glen, and Trevor Shelley of Wandoo, located near Nebo, share what they've learnt over the years, including tips for accelerating weight gain after weaning, components of their handling program and the long term impact these strategies have on their business. | 328 unique clicks |

## Discussion and conclusion

FutureBeef will continue to draw traffic to web content by creating engaging social media, webinars, YouTube videos, podcast episodes, and e-newsletters, sharing the latest research findings and best practice messages with beef producers and their advisors in northern Australia. FutureBeef is a collaboration between Meat & Livestock Australia, Queensland Department of Agriculture and Fisheries, Northern Territory Department Industry, Tourism and Trade, and Western Australia Department of Primary Industries and Regional Development.

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# FutureBeef website activity remains strong

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## Introduction

FutureBeef is a collaborative project between Meat & Livestock Australia and the government agricultural departments of Queensland, Northern Territory, and Western Australia. Core to FutureBeef is an online hub tailored to northern Australian beef producers and their advisors. The website, futurebeef.com.au, hosts more than 1000 pages of technical information, research findings, and digital publications. Information on the site is categorised by both resource type and topic.

## Methods

FutureBeef relies on regionally-based extension officers and researchers to develop content that is of need and of interest to their clients. To ensure the created content reaches the desired audience, social media channels, e-newsletters, newspapers, webinars, videos, and podcasts are used to draw attention to these resources on the web. In broad terms, success is measured by website use.

## Results

FutureBeef website activity peaked during the toughest years of drought in Queensland (2018-2019) (Figure 1). At this time, the most frequently visited pages contained information regarding livestock nutrition and early weaning. Raising poddy calves and crossbreeding strategies are consistently within the top 5 most visited pages every month, irrespective of season.

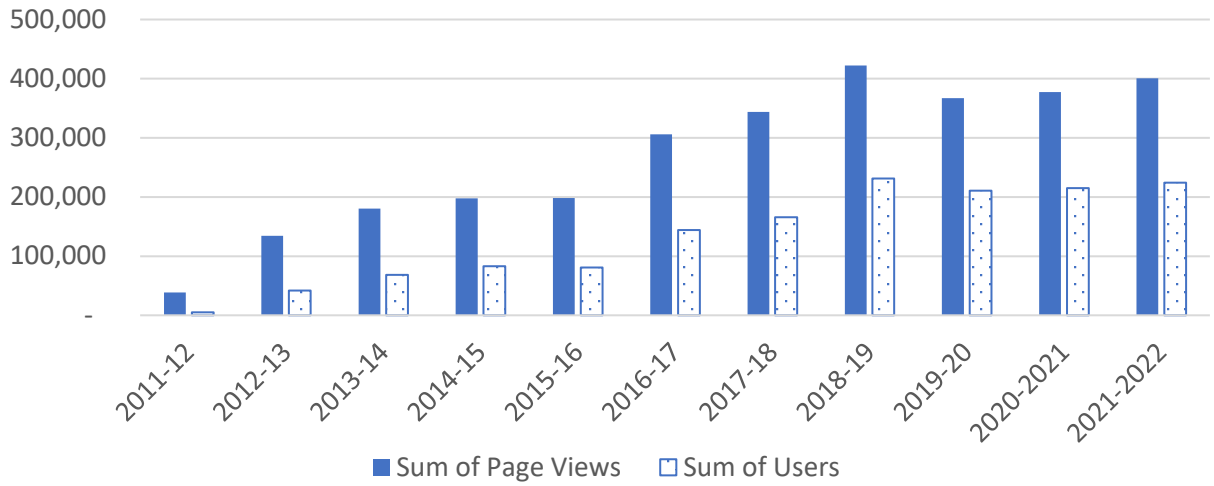


**Figure 1. FutureBeef website use**

## Discussion and conclusion

FutureBeef website activity has remained strong by utilising a multi-modal approach (for example podcasts, YouTube videos, webinars, etc.) for sharing information, organically drawing traffic to the website. The project has recently been funded to proceed until September 2027. During this period, the project team will continue to provide access to robust research findings and best practice recommendations.

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# MORE PASTURES PLEASE: WHAT'S NEW ON THE FEED BASE MENU?

# Effective management options for pasture dieback

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## Introduction

Pasture dieback is causing premature death of productive sown grass pastures in higher rainfall areas of eastern Queensland and north-east New South Wales. Beef production and profitability on affected properties are severely impacted. Research into management options to restore productivity on affected paddocks has been conducted since 2018. This paper summarises 4 management options that address pasture dieback and a decision support matrix created from results of trials conducted by the Department of Agriculture and Fisheries.

## Methods

Between 2018-2020, up to 10 research and demonstration sites on commercial beef properties and research station were established from Habana (near Mackay) in north Queensland, to Boonah in south-east Queensland. These sites were previously productive grass pastures which had either completely died or were heavily affected with mid-stage symptoms of pasture dieback. Treatments at each site were dependant on pasture dieback severity, research and industry needs, and equipment availability. Treatments included insecticides; fungicides; burning; cultivation; slashing; fertilising; sowing new grass pastures with and without legumes; sowing forage crops before re-seeding to grass pasture.

## Results

Results from all 10 sites have been consolidated into 4 groupings of management options and their suitability to small (random patches within paddocks) or widespread areas (part or whole paddocks) on arable or forest land (Table 1). Land managers select the management option(s) and practice(s), or combination of, applicable to their situation. Arable land is mostly flat and cleared of trees, enabling equipment access (e.g. tractor with plough or spray-rig). Forest land is treed and/or rocky and steep making equipment access difficult.

**Table 1. Pasture dieback management.**

| | | Small patch | | Widespread | |
|---|---|---|---|---|---|
| Management option | Practice | Arable | Forest | Arable | Forest |
| Manage for recovery | Adjust stocking rate (forage budget) | Yes | Yes | Yes | Yes |
| | Monitor & treat weeds in bare patches | Yes | Maybe | Yes | Maybe |
| Improve pasture | Sow legumes and tolerant grasses | Yes | Yes | Yes | Yes |
| | Apply fertiliser | Maybe | Maybe | Yes | Maybe |
| | Cultivate | Maybe | No | Yes | No |
| Sow a break crop | Annual forage (graze or hay/silage), grain | No | No | Yes | No |
| Control pathogen(s) | Spray pesticide | Maybe | No | No | No |
| | Burn | Maybe | Maybe | Maybe | Maybe |

## Discussion and conclusions

Conducting multiple research trials and assisting producers to successfully manage pasture dieback has been critical in developing a practical and user-friendly decision support tool. These management options have been extended to industry at extension events and through on-line media. Paddock productivity is being successfully restored through the strategic selection and application of these practical management options.

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# Irrigated mosaic agriculture for beef production in WA

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## Introduction

Until recently, the pastoral cattle industry in northern Western Australia has been based primarily on the extensive grazing of native vegetation under 'low input' production systems. Productivity gains are challenging due to nutritional constraints, especially improving productivity of breeding animals and weaners without providing supplements. Meeting target weights for live export or higher-value markets with consistency is also very challenging. Consequently, there has been significant investment in the last decade in the cultivation of high-quality fodder and forage crops under irrigation to replace imported fodder products and enable cattle to be sold into higher-value markets.

The Department of Primary Industries and Regional Development (DPIRD) has invested in research and development to identify the most suitable fodder species for this environment (Moore *et al*. 2021) and is building on this work to set production benchmarks and best management practice guidelines.

## Methods

At Skuthorpe near Broome, DPIRD established perennial grass trials in November 2020. These evaluated twelve varieties of subtropical grasses and created nitrogen response curves in Rhodes grass. Lysimeters measured nitrate leaching under five rates of urea, plus a zero-nitrogen control. Both trials were randomised and replicated three times. They were sampled and harvested approximately every 28 days, to measure fodder biomass yield and fodder quality. Data were collected from 23 harvests over a two-year period.

## Results

Rhodes grass (*Chloris gayana*) and panic grass (*Megathyrsus maximus*) varieties had the highest and most consistent growth rates and were less affected by cool temperatures compared to Digitaria spp. There was no significant difference in yield between Rhodes grass varieties Reclaimer, Callide and Epica, and panic grass varieties Gatton and Megamax. These achieved average daily growth rates between 112—118kg DM/ha/day, which equates to annual biomass production >40t DM/ha. Megamax panic grass had the highest digestibility (59.8%) and metabolizable energy (9.2MJ/kg DM).

The rate of nitrogen at which yield plateaud was 2kg N/ha/day (i.e. 60kg N/ha after each cut). This produced crude protein levels of 11% on average, while 3kg N/ha/day produced 13% crude protein. Levels increased steadily in response to nitrogen rate. However, it is estimated that the nitrogen-use efficiency of urea in this system is about 50% at this rate, and decreased as nitrogen rate increased. The pH of soil in the root zone, as well as nitrate levels in leachate collected after wet season rainfall indicated that exceeding 3kg N/ha/day is inefficient, and environmentally unsound.

## Conclusion

Subtropical perennial grasses can produce 40t DM/ha when managed in a 28-day cycle. We recommend capping nitrogen use at 3kg/ha/day to optimise yield and protein content of fodder and minimise nitrate leaching and soil acidification. Other forms of nitrogen fertiliser will be investigated to improve nitrogen-use efficiency compared to urea and foster good environmental stewardship.

## References

Moore *et al.* (2021) Technical Bulletin no. 4915, DPIRD, Perth.

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# Rotational grazing of gamba grass for control and cattle production

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## Introduction

Gamba grass (*Andropogon gayanus*) is an introduced perennial grass that is now a Weed of National Significance. It grows rapidly during the wet season and when un-grazed or grazed with set-stocking becomes tall and unpalatable to cattle and other herbivores, resulting in it dominating and spreading. Intense gamba grass fuelled wildfires are a danger to animals, people, property and a threat to biodiversity. While unmanaged gamba grass is problematic, many graziers view it as a valuable pasture.

Gamba grass has spread through large areas of the northern NT, including many areas that are difficult to access, and so eradication is unlikely and control using chemicals is difficult and expensive. This trial is investigating whether rotational grazing is effective in controlling the height and spread of gamba grass and improving the liveweight gain of cattle grazing it.

## Methods

In 2018 a 180 ha gamba grass infested paddock at Douglas Daly Research Farm, NT, was subdivided into 5 smaller (20-38 ha) paddocks to enable rotational grazing. The established gamba tussocks were burnt in November 2018 and spelled for about 6 weeks before grazing commenced. A mob of 360 cattle (yearling bulls and 2 year-old steers) rotationally grazed the paddocks with the aim of keeping the grass short and palatable, and then giving it time to recover before grazing it again. The overall stocking rate over the 180 ha trial area was 2 head/ha, however when the mob of cattle was in one of the small paddocks the grazing density in the paddock ranged from 9.5 to 18.5 head/ha. Paddocks were grazed for between 2 and 6 days (depending on the size of the paddock) before the mob was moved to the next paddock. The paddocks were grazed over the wet season months and spelled during the dry season (Table 1). Liveweight was recorded at the start and end of the grazing period to enable calculation of average daily gain (ADG).

## Results

In each year the gamba grass was kept short (< 1m) by rotational grazing and did not produce any seeds. The ADG of cattle grazing the gamba trial area over 4 years is shown in Table 1.

**Table 1. The average daily gain (ADG) of cattle rotationally grazing gamba grass at DDRF.**

| Grazing start date | Grazing end date | 1 y.o bull ADG (kg/day) | 2 y.o steer ADG (kg/day) |
|---|---|---|---|
| 18/12/2018 | 09/05/2019 | 0.58 | 0.71 |
| 04/12/2020 | 23/04/2021 | 0.53 | 0.52 |
| 06/12/2021 | 25/02/2022 | 0.86 | 0.74 |
| 23/11/2022 | 21/03/2023 | 0.56 | 0.43 |
| Average | | 0.63 | 0.60 |

## Discussion and conclusions

The average ADG of cattle grazing gamba grass (0.63 kg/day) is better than what occurs when cattle are set stocked on gamba grass but is lower than from other more preferred pasture species eg. buffel or pangola (A Cameron *pers. comm*.). The trial is demonstrating that rotational grazing controls gamba grass (limits its height, seed production and spread) and increases the growth rate of cattle grazing gamba grass, delivering a “win/win” for graziers and the environment. This suggests that rotational grazing can be a viable alternative to chemical control for managing gamba grass.

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# Crops for cattle- Increasing the efficiency of north Australian cattle production systems using local crops to improve dry season weight gain

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## Introduction

The recently commenced Crops for Cattle project aims to foster integration of the northern cropping and cattle production systems and intensification of the northern cattle industry. It will investigate the feasibility and profitability of supplementary feeding strategies using crops grown in northern Australia to increase weight gains of cattle during the dry season, to achieve a higher proportion of steers being turned off after one post weaning wet season and more efficient heifer performance (due to heavier pre-mating weights). The project is a partnership between the Cooperative Research Centre for North Australia (CRCNA) and the Northern Territory (NT) Department of Industry, Tourism and Trade (DITT), and will run from December 2023 to October 2026.

## Methods

The project has three main activities:

1) Feeding trials on 8 commercial properties and two DITT research stations to document the increases in dry season liveweight gain (LWG) that can be achieved through feeding different crop products and supplementary feeds produced in northern Australia. This data is needed for the other activities. Several feeds produced in northern Australia (eg. cotton seed, sorghum, maize, peanut tops) will be trialled to determine the level of increase in dry season LWG that they give. Commercial feed supply companies that produce pellets or supplementary feeds from feedstuffs grown in northern Australia will be involved in the project as partners and their feeds trialled in the project.

On the research stations, and where possible on commercial properties, the performance of two treatment groups (+ or – supplementary feed) will be measured. This will be done through the feeding period and also through the following year to determine whether the benefits of the feeding program are sustained after the post feeding wet season, ensuring that the effects of compensatory growth are taken into account.

2) Desk-top analyses will be undertaken using the production data collected on property to model the whole-of-herd impacts on the herd structure, productivity and profitability of a representative northern Australia case study property. This will enable assessment of the effect of variation in the sale price of cattle ($/kg) and feed cost ($/t) on the profitability of the various feeding strategies. This will be used to provide information to producers on which cost/price combinations are profitable and provide an attractive return on investment for each of the feeding strategies. This will ensure that the project findings remain relevant when cattle and feed prices fluctuate.

3) Investigating the potential of the feeding strategies as methodologies for obtaining carbon credits carbon credits through reducing whole-of-life methane emissions. Reducing the average age at turnoff and increasing the efficiency of the heifer phase of production (i.e. if females are more efficient then fewer breeders are needed) are both strategies that reduce lifetime methane output of cattle. This will be investigated through the project and the potential benefits from carbon credit production detailed. If the feeding strategies are approved as methods to obtain carbon credits then the economics of the feeding strategies would be further bolstered.

## Discussion

The project has only recently commenced and so there are no results to report yet. Feeding trials will commence in the second half of 2023 and project results will be reported from 2024 onwards.

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# A new, mixed microbial drench for detoxification of *Leucaena* cultivars

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## Introduction

The high protein, leguminous fodder shrub Leucaena, often became infested by sap-sucking insects (psyllids) when grown in high humidity regions. In response, a psyllid-resistant cultivar of Leucaena has been developed (Redlands). All Leucaena cultivars contain the non-protein amino acid mimosine, which is degraded in the rumen into the toxic metabolite, 3-hydroxy-4-(1H)-pyridine (3,4-DHP). The Department of Agriculture and Fisheries (DAF) produces a mixed microbial drench, to degrade mimosine, 3,4-DHP and its degradation product 2,3-dihydroxypyridine (2,3-DHP). To ensure the DAF produced rumen drench continues to be effective, a new mixed microbial drench (Trimix), tailored to assist cattle grazing the psyllid-resistant Leucaena cultivars , has been developed (Gravel *et al*. 2022) and its microbial activity determined.

## Methods

Multiple *in vitro* fermentations, of 30-day duration, were conducted to modify the microbial populations to better use leaf material from a combination of three Leucaena cultivars (Cunningham, Redlands and Wondergraze). The resultant Trimix formulation, was tested for (1) concentrations of the toxin-degrading microbe Synergistes jonesii (real-time PCR assays); (2) toxin breakdown over time (HPLC), and (3) microbial community composition (high throughput sequencing of microbial DNA).

## Results

The Trimix fermentations encouraged the growth of a complex microbial community, including S. jonesii, which could completely break down mimosine, 3,4-DHP and 2,3-DHP after an initial period 5-7 days of adaption to the fermentation system (Figure 1).

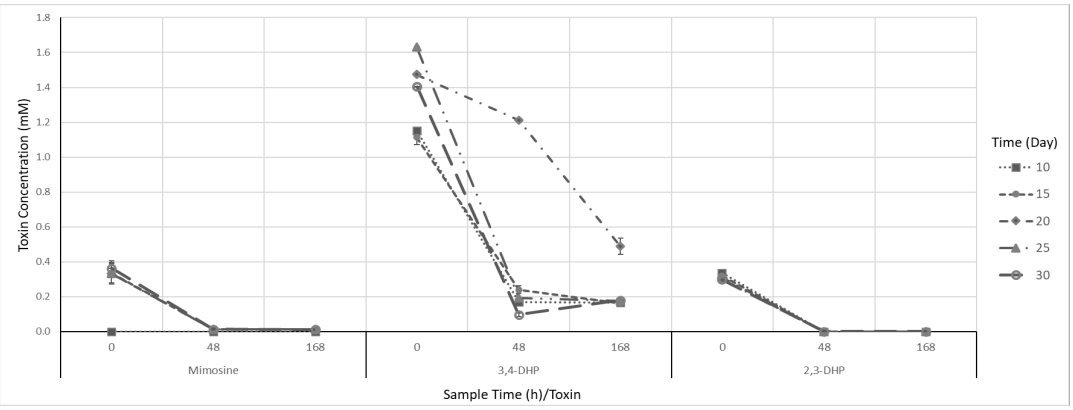


**Figure 1. Toxin breakdown over time by microbial populations in a Trimix fermentation (HPLC of mimosine, 3,4 DHP and 2,3 DHP, in degradation activity assays).**

## Discussion and conclusion

The Trimix fermentation process has been thoroughly characterised and tested to ensure effective breakdown of the toxins associated with feeding Leucaena including psyllid-resistant cultivars. The TriMix drench is now available for producers to use in their cattle to minimise any toxic side-effects and better utilise this important high protein fodder shrub.

## References

Gravel J *et al*. (2022) Proceedings, 34th Biennial Conference AAAS. Animal Production Science, 62.

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# Can Queensland cattle degrade *Leucaena* toxins in their rumen?

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## Introduction

The leguminous shrub *Leucaena leucocephala*, contains the non-protein amino acid mimosine, which is degraded in the rumen into the toxic metabolite, 3-hydroxy-4-(1H)-pyridine (3,4-DHP). For over 20 years, DAF has produced a mixed microbial drench (Leucaena inoculum), to degrade mimosine, 3, 4-DHP and its degradation product 2,3-dihydroxypyridine (2,3-DHP). Given that this drench has been used by producers for many years, and Leucaena has been widely adopted as a fodder crop, a field survey was conducted to determine whether microbes capable to degrading the three toxins, are now naturally established within the rumen of Queensland cattle.

## Methods

Animal ethics approval (SA 2021-08-796) was obtained for the survey which had a randomised experimental design with four treatment groups, representing different cattle production scenarios: 1. Never been inoculated, grazing Leucaena; 2. Previously inoculated, transfer managed cattle, grazing Leucaena; 3. DAF Leucaena inoculum used, grazing Leucaena; and 4. Naïve, cattle have never seen Leucaena. A mobile laboratory, including a portable incubator and micro-centrifuge, enabled crush-side processing for molecular analyses and immediate incubation of collected rumen fluid in toxin degradation assays. Toxin concentrations were determined by HPLC (Gravel *et al*. 2022).

## Results

The survey was able to collect rumen fluid from 72 animals across 14 sites (Figure 1). The toxin degradation assays found the three toxins were always degraded where the DAF Leucaena inoculum was used and cattle were grazing Leucaena, in contrast to naïve cattle, which were unable to fully degrade 3,4 DHP and 2,3 DHP.

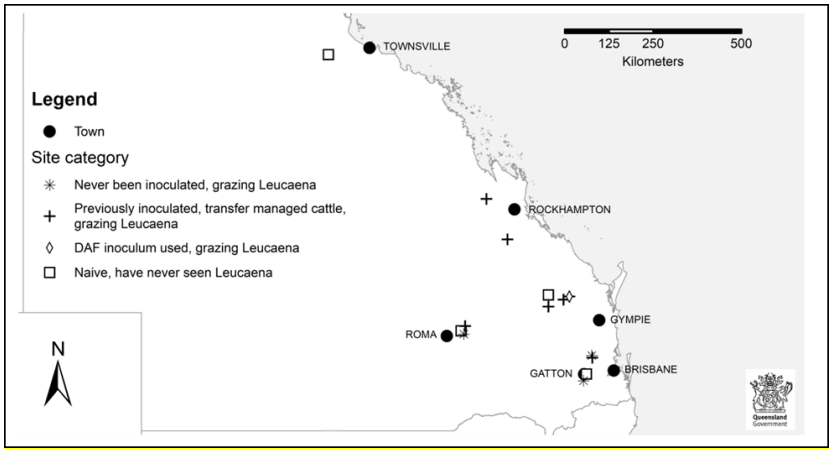


**Figure 1. Locations of properties included in the survey.**

## Discussion and conclusion

CONCLUSION This survey showed that cattle which had never been exposed to Leucaena did not possess rumen bacteria able to degrade the toxins 3,4 DHP and 2,3 DHP so would benefit from receiving the DAF Leucaena inoculum if being moved to a Leucaena-grass pasture grazing system.

## References

Gravel J *et al*. (2022) 34th Biennial Conference AAAS. https://www.publish.csiro.au/AN/issue/10598

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# Effects of pasture quality and herd structure on methane intensity

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## Introduction

Substantive differences in the source of emissions among classes of cattle were identified for the bioregions of northern Australia evaluated in a scoping study (Hunt *et al*. 2013). In their study, breeder cattle contributed from 39 to 53 percent of overall herd emissions. This variability suggests an opportunity to improve methane intensity in some regions by decreasing the relative proportion of emissions from breeder cattle. To test this, we conducted a modelling study comparing emissions intensity of a Brahman cattle herd where different calving rates were applied to represent differences in herd structure and the proportion of emissions from breeder cows.

## Methods

Hypothetical scenarios were set up using the GrassGro™ biophysical model, with Brahman cattle grazed on a panic grass (*Panicum maximum*) pasture at Broome in Western Australia. When required, sorghum grain was fed to maintain condition of cattle. Cow reproduction parameters were set for Low, Medium and High calving rates in GrassGro (57%, 74% and 87% calving rates), representing the range of those reported in Hunt *et al*. (2013). In addition, the quality (Dry Matter Digestibility) of panic grass was varied in a sensitivity analysis with Low, Medium and High-quality pasture (diet av. of 54%, 57% and 60%, respectively). Methane intensity (kg CO2-e/kg liveweight sold) was determined for each of the scenarios.

## Results

Methane intensity was 14% lower in cattle with High *v* Low calving rates (Table 1). There was a smaller effect of pasture quality, where High digestible pasture had 7% lower methane intensity compared to Low. Supplement fed was 32% lower with High *v* Low pasture quality.

**Table 1. Methane intensity (kg CO2-e/kg liveweight sold) modelled for Brahman cattle grazing sub-tropical pasture of Low, Medium, and High dry matter digestibility, at three calving rates.**

| | | Pasture quality | | |
|---|---|---|---|---|
| | | Low | Medium | High |
| Calving rate | Low | 16.9 | 16.4 | 15.9 |
| | Medium | 15.5 | 15.0 | 14.3 |
| | High | 14.7 | 14.3 | 13.5 |

## Discussion and conclusion

Higher calving rates produced a modest reduction in methane intensity, and overall emissions were higher for these systems due to the higher feed requirements. Higher pasture quality resulted in a small decrease in methane intensity, lessened because of lower levels of grain feeding for this treatment. The amount of supplement fed was reduced substantively for higher quality pastures. Overall, improving calving rates and pasture quality produced large benefits in cattle productivity, but more modest improvements in methane intensity.

## References

Hunt L, Bastin G, Handcock R, Liedloff A, McIvor J, Thomas D (2013) Exploring the potential for improving carbon management in Australia's grazed northern rangelands: A scoping study. Final Report, CSIRO Sustainable Agriculture Flagship. CSIRO Publishing, Clayton, Victoria.

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# New methods for mapping and monitoring pasture production, land types, and land condition in Australia's N rangelands

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## The partnership between Cibo Labs and AACo: A focus on production and sustainbility

Cibo Labs, established in 2018, has been investing in data science, high performance computing, machine learning systems, targeted field data collection, and most importantly strong engagement with producers, to routinely deliver paddock level estimates of pasture biomass on a weekly basis to over 55 million ha (see Scarth *et al.*, NBRUC 2023). The Australian Agriculture Company (AACo) has been a significant supporter of these developments which now underpin many management decisions across the company. In the last two years Cibo Labs and AACo have enhanced their partnership to use remote sensing for helping AACo achieve their production and sustainability framework goals, particularly on Landscape Carbon and Natural Capital.

## What are LRUs and how can they advance ecosystem monitoring?

Using long time series of satellite datasets Cibo Labs has developed "Landscape Response Units" (LRUs) that describe landscape variability across the AACo estate and improve on the manual and disparate land type mapping done by the state governments. The LRUs have been used in combination with a dataset of 3341 field observations of Land Condition taken between 2018 and 2022 for characterising Land Condition across the landscape. Using a random forest regressor and the richness of information used for generating the LRUs as covariates we achieved an overall accuracy of 80.4%. Land Condition complements pasture biomass estimates and underpins AACo's forage budgeting process.

Regular pasture biomass estimates together with the ability of mapping Land Condition also underpin AACo's sustainability goals. For example, the LRUs are being used for stratifying the landscape and guiding the field sampling process currently ongoing for characterising soil and woody vegetation carbon, and used as covariates for expanding field observations of landscape carbon using machine learning. The LRUs and Land Condition are also used as a broader descriptor of whole of ecosystem health and provides a basis for monitoring and assessing Natural Capital.

## Leading the way in rangelands science and innovation

Cibo Labs and AACo are at the forefront of the science and innovation landscape in Australian rangelands and their combined efforts are already extending benefits into the wider livestock sector.

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# Grazing land condition decline in Queensland's N Gulf

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## Introduction

The extensive grazing industry in Queensland's Northern Gulf area has an annual turnoff in excess of A$393 M based primarily on native rangeland resources. Land condition in this area has previously been identified as having declined (Shaw *et al*. 2007). Land condition reflects the lands capacity to respond to rainfall and produce useful feed for livestock productivity. This paper reports on the first ongoing assessment made for Queensland rangelands.

## Methods

Northern Gulf land condition was assessed for change at 250 - 262 sites, on 17 discreet land types, over 3 periods (2004, 2012 and 2016). Further, data from 29 QGRAZE sites (2006 – 2018) was analysed for land condition changes. Land condition assessments compared soil surface condition, pasture composition, woodland thickening, and exotic weed incidence indicators with their assumed original potential. Lastly, remote sensing datasets were analysed for ground cover dynamics across 23 regional land types and 29 QGRAZE sites (1990 – 2016).

## Results

Since 2004, we estimate the proportion of retained original carrying capacity declined from 72% to 66%. The trend was similar in both high and low grazing value land types, with high value land type condition always slightly lower. In 2004, 74% of Rapid Assessments (193 of 260) were discounted due to one or more of soil condition, pasture composition, tree thickening or weed invasion. In 2012, this had increased to 80% of sites discounted and, in 2016 90% of sites had been discounted. The average percentage discounts across the three rapid assessment periods for high grazing value land types were 24%, 73%, 38% and 24% for soil surface condition, pasture composition, timber thickening and weed invasion respectively. After accounting for the effects of rainfall and tree cover, all 23 land types showed a negative trend in remotely sensed ground cover. The average value, weighted for land type, suggests a total regional ground cover loss of 4.75% between 1992 and 2015.

## Conclusions

If current trends in land condition continue it is estimated that 50% of original carrying capacity will be lost by 2046. Industry endorsed rangeland monitoring programs are required, as well as resolve from producers, community and government to respond to declining land condition and rangeland productivity trends. Bowen *et al*. (2019), using a 30-year herd modelling analysis based on weighted 2006-2018 prices, demonstrated an improved cumulative 30-year cashflow of (+) $388,300 for a Northern Gulf property managed to steadily improve land condition through reduced stocking rate and wet season spelling, compared to the business-as-usual land condition decline scenario.

## References

Bowen *et al*. (2019) Northern Gulf production systems: Preparing for, responding to, and recovering from drought. https://futurebeef.com.au/projects/improving-profitability-andresilience-of-beef-and-sheep-businesses-in-queensland-preparing-for-responding-to-andrecovering-from-drought/
Shaw *et al*. (2007) Tropical Grasslands **41**: 245-252.

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# Seeing is believing – Barkly Mitchell grass recovery project

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## Introduction

Mitchell grass is a major component within the alluvial cracking clay grasslands on the Barkly Tablelands in the Northern Territory. Mitchell grasses are palatable, productive and perennial pasture species which contribute significantly to the diet quality and quantity in the region. Several years of below average rainfall has resulted in a noticeable reduction in Mitchell grasses, with some areas experiencing a 'dieback' where large areas of Mitchell grass have completely disappeared.

## Methods

The Barkly region component of the Rain Ready Rangelands project aims to trial the commercial scale application of wet season spelling to promote Mitchell grass recovery. The producer led demonstration at Anthony's Lagoon Station involves wet season spelling paddocks where Mitchell grasses have declined. Wet season spelling will be achieved using a three paddock rotation. A nearby set stocked paddock will also be monitored as a control. Each paddock has a 100 m x 100 m fenced exclosure to monitor and quantify changes of pasture species under no grazing (inside exclosure) compared to wet season spelling and set stocking (outside exclosure). On ground assessments will collect pasture composition, yield, grass basal area and soil health data before and during the demonstration. New technology including a multi spectral drone to monitor ground cover change, Farmbot rain gauges and cameras have been incorporated to provide real time visual data.

## Results and discussion

The project will be documented and presented as a case study and include field days and a suite of extension activities to increase awareness and interaction with other producers. The project aims to bridge the gap between research-derived management strategies and adoption from producers using a "seeing is believing" method supported by tangible scientific data.

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# The Sweet Spot: Impact of pasture utilisation on the fertility of female cattle

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[D] Qld Department of Environment and Science

## Introduction

Extensive grazing remains the predominant production system for beef cattle in northern Australia. The long-term sustainability of this production system, both from a profitability and natural capital standpoint, is based on livestock producers implementing appropriate grazing management strategies to ensure the optimal utilisation of the grass growth. Varying stocking rate is the main tool available to livestock producers to address. Stocking rate has a large impact on animal performance through its effect on forage availability and quality, dietary intake and subsequent liveweight gain. While it is widely accepted that pasture utilisation has a dominating effect on animal performance, demonstrated with non-pregnant and non-lactating cattle, few publications exist describing its effect on fertility. The Sweet Spot project, funded by Meat & Livestock Australia, gathered appropriate datasets containing both pasture and animal performance information to examine the relationship between pasture utilisation rates and reproductive performance. This paper presents the preliminary results.

## Methods

To identify appropriate datasets, known researchers based in northern Australia were contacted. Identified datasets were evaluated for the availability of animal performance records and stocking rate records, which were necessary for calculating intake and breeder performance. Out of the 166 sites and 25 breeder herd datasets identified and reviewed, 17 datasets that represented 60 sites and the reproductive performance of 75,000 females were identified and modelled for pasture utilisation using GRASP (Cowley *et al.* 2023). All animal performance metrics were derived using individual animal data performance measures as defined by McCosker *et al.* (2020). The association between pasture utilisation rate and animal performance was examined by employing mixed logistic regression models.

## Results and Discussion

This study found that rates of annual pregnancy and breeders pregnant within four months of calving declined, and foetal and calf mortality increased as pasture utilisation rate increased. Additionally, the dominant effects of breed and age class were evident in this study, demonstrating their importance when developing targeted management systems to support reproductive performance – such as adjusting stocking rate to match animal equivalent requirements to pasture availability.

## References

Cowley et al. (2023) Modelling SchMOOodelling – What's grass got to do with it? Getting the most out of your animal production datasets. 2023 NBRUC Proceedings.

McCosker et al. (2020) Anim. Prod. Sc. 63, 311-319.

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# Pasture succession planning through improved land condition in the north

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## Introduction

'Land condition' is defined as the capacity of grazing lands to produce useful forage in response to rain. Good land condition requires both pasture and soil to be in good health. Unfortunately, overgrazing (especially during drought) can cause long term damage to land condition, causing death of favourable grass species that do not multiply quickly (O'Reagain *et al*., 2023). This increases soil erosion, decreases soil fertility, and encourages less productive weed species to invade the pasture.

Land condition decline is ongoing across northern Australia. Farm debt is a substantial pressure that can cause producers to run higher stock numbers and run down pasture condition to reduce debt, but this causes both medium and long-term productivity decline. Unfortunately, land condition decline occurs over several years (or decades), and it is difficult for producers to observe the increased damage when managing their pastures from one year to the next.

## Lessons from the cropping sector

The Australian cropping sector underwent a significant transformation that began in the 1960's. While tillage was once standard practice, nearly all broad-acre grain cropping today is conducted under minimum or zero tillage. The cropping sector has come to realise that maintaining ground cover through fallow periods (by retaining crop stubble) improves the growth of the next crop.

No-till farming improves storage of water in the soil profile. Stubble retention helps cover the soil and maintains a connection between the soil surface and the sub soil (through root penetration pathways), increasing the rate of water infiltration into the soil profile while reducing soil evaporation and runoff. This gives a significant advantage to the following crop, which has a much greater capacity to produce grain under variable rainfall due to the 'buffer' provided by water stored in the soil profile.

## Understanding the importance of ground cover in grazing systems

Many graziers in northern Australia do not yet realise the advantages of retaining ground cover in their pastures at the end of the dry season. It is possible that having a lack of ground cover at the end of the dry season has become normalised for some producers. Yet this practice reduces the ability of the pasture to soak up water once the wet season begins and increases soil erosion because the pasture is poorly protected from heavy downpours.

Lack of quality feed is probably the biggest factor preventing beef producers in northern Australia from increasing reproductive efficiency. Innovative producers have shown they can increase profits by reducing the number and size of breeders, to conserve feed and increase reproductive rates. Improved grazing management techniques are also being used by some producers to ensure that pasture is grazed less heavily. This protects the underlying structural parts of pasture plants (stems, roots, and growing points) which are energy intensive to replace, allowing plants to use maximum resources to produce new leaf biomass, and creating a more efficient and profitable feedbase.

## Conclusion

MLA will continue to progress investments in northern Australia to address declining land condition due to the significant threat it poses to farm productivity for future generations, and because it is regularly raised as a high priority through the MLA-NABRC consultation process.

## References

O'Reagain *et al.* (2022). Wambiana Grazing Trial Final Report, MLA, Sydney, Australia.

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# An improved model for animal units and estimating intake in northern rangelands

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## Introduction

Presently there are varying and inconsistent definitions and applications of animal units in Australia. This presents challenges in meaningful comparisons of business, livestock and landscape measures across different applications. An animal unit methodology that caters for multiple species grazing across the grazing landscape, providing common units of measurement for use across multiple applications is therefore necessary.

## Methods

The animal units used are an Animal Equivalent (AE) and Dry Sheep Equivalent (DSE), being a 450kg *bos taurus* steer and a 45kg wether respectively. This results in a conversion factor of 8.4:1 and the two units can be used interchangeably.

Animal unit equivalence are derived by calculating the metabolisable energy demand of animals (or groups of animals) and expressing it relative to the standard animal, with both calculations performed using the same formulae and base assumptions. This methodology allows for national comparison across species and will accommodate any future changes to the estimation of energy demand.

The methodology can be applied simply through generic tables based on animals age groups, more detailed tables for various liveweights and levels of production, or through more complex multivariate tools which account for all variables influencing energy demand, and therefore equivalence.

Animal units can be converted to dry matter intake by applying an intake constant, which can vary with productivity and location, with a default figure of 8kg DM/AE.day or 0.92/DSE.day suggested for northern and rangelands Australia.

## Results

This methodology allows for more consistency and accuracy across the following applications:

1. Describing and summing the energy requirements of domesticated animals within, and between species;
2. Describing and summing the energy requirements of non-domesticated animals in order to quantify total grazing pressure;
3. Calculating stocking variables such as stocking rate (animal units per land area);
4. Describing forage supply and demand in common terms for the purpose of matching supply and demand in the short and long term;
5. Quantifying the long-term carrying capacity of properties for management and valuations;
6. Undertaking business and enterprise analysis and decision-making using broadly accepted units.
7. Describing and analysing the number of stock an enterprise is running in “common currency” terms.

## Discussion and conclusion

The various and inconsistent applications of animal units currently in Australia limit their utility in managing livestock, landscapes and businesses. This methodology provides a basis for common measures to be consistently applied across various applications.

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# KEEPING THE POT FROM BOILING OVER- CLIMATE, CARBON AND SUSTAINABILITY FOR NORTHERN AUSTRALIA?

# Carbon Neutral by 2030 – opportunities for northern producers

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## Introduction

The Australian red meat industry's carbon neutral initiative (CN30) is an ambitious target to achieve net zero GHG emissions by 2030. This means that the amount of GHGs released by the industry is to be equivalent to, or less than, the amount of additional carbon stored in grazing land. Emission sources include animals, fertiliser, land management and waste management. There will be multiple benefits to stakeholders from improved genetics and nutrition, legumes in pasture systems, stored soil organic carbon and more trees in the environment. These benefits include increased productivity, profitability, and environmental sustainability. The red meat industry has already made great progress with almost 65% reductions in emissions since 2005.

## What does carbon neutral mean?

Under CN30e, carbon neutral means net zero greenhouse gas (GHG) emissions on an annual basis. The three most relevant GHGs from the Australian red meat industry are Carbon dioxide (CO2), Methane (CH4), and Nitrous oxide (N2O).

Emission sources from the Australian red meat industry include:

- Cattle, sheep and goats (enteric methane, methane and nitrous oxide from waste management)
- Fertiliser use in production of livestock feed (nitrous oxide emissions from fertiliser use in some pasture and crop production)
- Land management practices (deforestation, savanna burning). Land management practices (revegetation, avoided deforestation) also represent a carbon sink, or store.
- Waste management in meat processing and energy use (including transport)

## Work areas paving the way to carbon neutrality

There are four work areas that provide a framework for MLA's CN30 research, development, and adoption activities. These are:

1. Leadership building - Building leadership capability and competency across industry is vital to enabling the transition to a carbon neutral position by 2030. By investing in our people, industry will develop the skills and knowledge to adopt the technologies presented in the CN30 Roadmap.
2. GHG emissions avoidance - Involves research, development and adoption of technologies that avoid carbon dioxide (CO2), nitrous oxide (N2O) and methane (CH4) emissions from grazing management, lot feeding and processing.
3. Carbon storage - To achieve CN30, technologies that avoid GHG emissions and increase carbon storage in grazing lands are required. Increasing carbon storage can provide multiple benefits, including increased land and animal productivity, land remediation, increased biodiversity and improved water quality through reduced sediment run off into waterways.
4. Integrated management systems - Involves activities that enable environmental, economic and social impact measurement, accounting and reporting (MAR) throughout the red meat value chain.

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# Taking the North to Net Zero

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## Introduction

Net Zero Emissions refers to the balance between greenhouse gas emissions produced (e.g. enteric methane from cattle) and the removal of greenhouse gases from the atmosphere (e.g. through carbon sequestered in soils and vegetation) over a specified period of time – often one year. The Australian Federal, State and Territory Governments in northern Australia have committed to Net Zero Emissions by 2050. These targets involve specific strategies for the land sector and pastoral industries, supported by frameworks such as the Queensland Low Emissions Agriculture Roadmap 2022-2032 (State of Qld 2022). This paper provides a brief overview of the opportunities for northern beef systems to contribute to Net Zero goals.

## Greenhouse gas emissions from northern beef systems

Most greenhouse gas emissions from northern beef production systems are from enteric methane and vegetation management (Table 1). Enteric methane is responsible for 77-80% of agricultural emissions across the Northern Territory and Queensland, and 12-16% of net state and territory emissions. The vast majority of these emissions are from grazing beef cattle (2.32 Mt $CO_2$ equivalents ($CO_2e$) in the Northern Territory and 14.0 Mt $CO_2e$ in Queensland), with the volume of emissions directly related to animal numbers. Grazing beef cattle also contribute the majority of emissions from manure management in these regions.

**Table 1. Greenhouse gas emissions (Mt $CO_2$ equivalents) from the Northern Territory and Queensland in 2021. The main sources of emissions from the beef industry are highlighted in grey (Australian Government 2023).**

| Emissions category | Northern Territory | Queensland |
|---|---|---|
| Energy | 12.6 | 114.6 |
| Agriculture | 2.90 | 20.7 |
| *Enteric methane* | *2.32* | *15.9* |
| *Manure management* | *0.45* | *2.30* |
| *Other emissions* | *0.12* | *2.44* |
| Waste | 0.20 | 3.10 |
| Industrial processes | 0.12 | 5.81 |
| Land use, land use change, forestry | -1.73 | -4.52 |
| *Forest land* | *-1.84* | *-15.8* |
| *Cropland* | *0.01* | *1.83* |
| *Grassland* | *-1.09* | *8.91* |
| | | |
| Total state/territory emissions | 14.1 | 139.7 |

Emissions from vegetation management are mostly from grasslands. This is predominantly emissions from land converted to grasslands through clearing and reclearing of woody vegetation. Grazing systems are also a carbon sink, with carbon in soil and woody vegetation offsetting other land use and land use change emissions, at least in the short-medium term. Unless excessively enriched in nutrients or overgrazed, perennial grasslands can contain similar carbon stocks to forests due to their dense and deep root systems. Research in California has also shown that grasslands and tree-sparse rangelands are better able to survive drought, rising temperatures and fire than forests, and so appear to be a more reliable carbon sink (Dass *et al.* 2018).

## Opportunities to reduce emissions and store carbon

There are a range of activities that beef cattle producers can use to decrease emissions and increase carbon storage in northern landscapes. Key activities of relevance to the northern beef industry are summarised in Table 2.

**Table 2. Overview of the potential effectiveness and feasibility of key mitigation strategies in northern grazing systems**

| Strategy | Effectiveness | Feasibility | Considerations |
|---|---|---|---|
| Anti-methanogenic compounds (e.g. feed additives) | Moderate. Likely to be less effective than in intensive systems. Possible productivity changes. | Currently low, but will increase as new products enter market | Several companies testing sustained-delivery options suitable for extensive grazing. |
| Vaccination | Unknown. Research is targeting ~20% reduction. | No current products available, but would be easiest way to reach large number of animals | Research is on-going but substantial barriers to development exist |
| Animal breeding | Unknown, likely low | Low-moderate | Possible undesirable associations between low methane and other traits |
| Herd management | Low-moderate | Moderate | Most practical option available to target enteric methane in extensive systems |
| Vegetation management | Moderate | Moderate | Huge regional variation |
| Soil carbon | Low-moderate | Linked to vegetation and grazing management | Small stock change translated across a large area may result in large increase |

### *Reduced enteric methane production*

Several compounds that reduce the production of enteric methane by ruminants have been identified, including 3-nitrooxypropanol (3-NOP, sold as Bovaer) and bromoform (synthetic versions and naturally occurring derived from Asparagopsis species). When supplied as a feed additive, these compounds have been shown to reduce enteric methane in intensive operations by up to 90% (Kinley *et al.* 2020). However, there are currently no on or near-to-market solutions which substantially reduce emissions from livestock in extensive grazing systems. The biggest challenge in delivering these compounds to extensively grazed animals is that they need to be supplied in small amounts every day in synchrony with feeding events. There are currently several research groups and private companies investigating delivery options, including water delivery, lick-blocks, and slow-release intra-ruminal devices, though it is likely to be several years before suitable options are commercially available. Recent trials have also highlighted potential decreases in feed intake and productivity associated with the use of methane-reducing compounds (e.g. Cowley *et al.* 2023), and research into management strategies and productivity primers is required to overcome these challenges and facilitate adoption.

Significant investment has been directed at developing vaccines to reduce enteric methane fermentation, and identification and selection of low-methane producing animals. Importantly, it may be possible to combine these approaches with the provision of feed additives, further increasing reductions in enteric methane. While vaccine trials have so far failed to demonstrate a decrease in methane production, research is on-going given the potential industry-wide impacts if a vaccine could be incorporated into existing vaccination schedules. Genomic research, capitalising on the natural variation in methane emissions between individuals, suggests that 10 years of selection could lead to a 4-5% reduction in methane (Arthur 2015). While animal breeding is possible in extensive systems, long timeframes, lack of practical proxies for predicting methane production, and possible associations with undesirable traits will limit widespread industry uptake.

*Increased efficiency of red meat production*

Herd management activities to increase efficiency of production provide the most practical means to reduce enteric methane production in extensive systems. Improving production efficiency reduces emissions intensity (volume of methane per kg beef produced) and can reduce absolute emissions if herd size is reduced, whilst maintaining productivity. There are a range of practices that can be used to increase efficiency through improvements in growth rates, reproduction, and survival. These activities generally align with best management practice for the region; feedbase improvement, supplementation, improving herd genetics, culling of unproductive animals, and improved joining practices.

*Changes to landscape management to reduce emissions and sequester carbon*

Reductions in emissions can be achieved through reduced clearing of land and fire management. Land clearing in northern beef systems is often cyclical, with carbon stored in regrowth partially offsetting emissions from clearing. While a sustained reduction in the amount of woody vegetation cleared would be required to meet net zero targets, this needs to be balanced against how increases in woody vegetation impact grazing land condition, fire risk, the water balance of the landscape, and other impacts. This is also true for projects promoting sequestration of carbon in woody biomass through afforestation, and there is huge regional variation in the appropriateness and feasibility of these approaches. In the northern savannas, fire management can be used to reduce emissions from wildfire, with controlled, low-intensity fires at the start of the dry season releasing less methane and nitrous oxide compared to wildfire later in the season.

There is also the potential for soil carbon to offset emissions from beef production. On a per ha basis, current soil carbon stocks are low across northern Australian grazing regions compared to southern and coastal systems, but small increases across a large area may result in large benefits at the industry level. The turnover and stabilisation of soil carbon is driven by microbes and influenced by management, other soil properties such as clay content, and climate. As noted previously, while forested areas hold more 'visible' carbon, native grasses are capable of pumping large amounts of carbon below-ground. Management practices that maximise below-ground inputs, promote native perennial grass regeneration, and minimise soil disturbance would be expected to reduce losses, or increase stocks, of soil carbon. However, year to year variability in temperature and soil moisture can overwhelm any response to changes in land management and range condition, and the recent review by Henry (2023) highlights uncertainty in scope for sequestering additional carbon in northern grazing landscapes.

## Carbon markets and accounting

To contribute to Net Zero goals, changes in greenhouse gas emissions from beef production need to be accounted for. At the state or national level, changes need to be captured by the Australian national greenhouse gas inventory. Some activities, like changes in herd numbers or canopy cover, can be captured through existing datasets (e.g. cattle numbers from the Australian Bureau of Statistics and remote sensing of land use change), but the National Inventory have not yet published information on how they will capture changes in emissions associated with novel activities like feeding methane-reducing supplements.

At the sector level, commodity-specific greenhouse gas accounts can be used to track progress towards emissions reduction targets (Sevenster *et al.* 2023). These accounts generally align with the national greenhouse gas inventory, with emissions disaggregated using an attributional approach. Within an industry, carbon credits sold to the government can be counted towards net zero claims, while credits sold to secondary markets cannot. This is largely to avoid issues of double counting between industry sectors.

At the enterprise level, producers and land managers can use tools such as the Greenhouse Accounting Framework spreadsheets (University of Melbourne, 2022) to self-audit their carbon footprint to aid decision making and assist in conversations relevant to environmental, sustainability and governance (ESG) responsibilities. They can also undertake more formal auditing processes to participate in Emissions Reduction Fund (ERF) projects or other carbon trading schemes, but these

typically come with high administrative burdens. The cost of implementing emissions reduction activities may also outweigh income from selling carbon credit units.

## Conclusion

The beef industry is a major source of greenhouse gas emissions in northern Australia, so any reductions in greenhouse gas emissions will make an important contribution to Net Zero goals. However, the bulk of state-level emissions are from energy (electricity production, transport), and rapid decarbonisation of this sector is required.

A Net Zero northern beef industry is also an ambitious goal given the currently available options. Landscape management initiatives are unlikely to be sufficient in scale to offset emissions from enteric methane, and continued investment in technologies appropriate for northern systems is required.

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# The Northern Australia Climate Program: Measuring and managing the northern climate

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## Introduction

Much of northern Australia has highly variable rainfall leading to droughts and floods, with serious impacts on the region's red meat industry. The Northern Australia Climate Program (NACP) is tasked with improving climate models (research, R), creating useful climate tools (development, D), and communicating climate science (extension, E) to the northern red meat industry. A critical aspect of R&D is raising awareness of these new products to producers, providing them with the knowledge to use the products in a way that facilitates resilience and promotes best practice management on-property. Similarly, producers need a mechanism whereby they can provide feedback to product developers to ensure that the products meet end-user needs.

## Methods

NACP is composed of: Research, led by the Bureau of Meteorology (Bureau) and UK Met Office (UKMO); Development and Extension both led by the University of Southern Queensland (UniSQ). Climate Mates, regionally-located extension officers, are critical to the knowledge transfer of climate information from researchers to red meat producers (Cobon *et al.* 2021; Lavender *et al.* 2022). They were hired not for their climate knowledge, but rather for their connections with the local red meat industry and related networks. The Climate Mates provide presentations at workshops to red meat producers in their area, allowing direct interaction between producers and climate researchers. An initial week-long intensive climate training included presentations from NACP-Bureau and NACP-UKMO associates, which not only imparted knowledge, but also built relationships.

## Results

NACP research has led to climate model improvements and over 50 papers published in peer-reviewed journal articles. NACP development created the 'Burst' forecast product based on producer feedback, which is now live on the Bureau website. NACP extension has reached over 6,000 producers and related supply chain via over 400 presentations (workshops, field days). This has resulted in 310 instances of documented practice change (e.g., a producer using a forecast as part of a decision). To date, NACP-Bureau associates have participated alongside the Climate Mates in over 10 NACP climate workshops and roadshows, aimed at producers.

## Discussion and Conclusion

The NACP structure of a combined RD&E program has been instrumental in its success, ensuring R&D meet the needs and is guided by end-users. Producers and supply chain then use the information in their own decision making, resulting in practice change and increased resilience.

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# FIRST CATCH YOUR BEAST: LIVESTOCK PERFORMANCE AND MANAGEMENT

# Productivity of breeding cattle in N Australia

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## Introduction

The productivity of breeding cattle herds in northern Australia has not changed appreciably for several decades, despite a large amount of scientific research and economic analysis to identify drivers of the profitability of breeding enterprises. We recently summarised the available data on productivity and considered limitations to improvements and technologies that might assist (Bell and Sangster 2022, 2023). This paper focuses on several key areas that require either further research or more effective approaches to increase adoption of existing research and development outcomes.

## Discussion and conclusions

Further research is required to reduce the incidence of cow and calf mortality, particularly in harsher regions such as the 'Northern Forest'. Priority should be given to improved understanding of the linkages between risk, causation and death to enable the design of interventions to break these linkages. This work should include field-testing of practical methods for remote monitoring of cow movement and behaviour to identify timing and location of calving, and postnatal events. Interventions to mitigate calf loss should be designed with the following questions in mind: (i) are they researchable? (ii) how large an effect is expected? (iii) are they practical to apply? (iv) will there be a clear economic benefit? (v) will there be demonstrable improvements in animal welfare?

Strategies to promote the economic and environmental benefits of sustainable grazing management practices should be the primary focus of work on feedbase RD&A for breeding herds. Specific R&D priorties should include: (i) further development and deployment of tools for remote sensing of land condition, feed on offer and pasture growth rate; and (ii) integration of the principles of sustainable grazing management, especially matching stocking rates to long-term carrying capacity, into best management practices for the northern breeding herd.

Despite an abundance of technical and economic evidence for the benefits of phosphorus (P) supplementation of breeding herds in phosphorus-deficient regions, use of wet-season P supplementation has not been widespread. Key elements of approaches to increase adoption should include: (i) increasing awareness of, and access to, diagnostic tools for identifying soil/plant and animal deficiencies; (ii) development and demonstration of practical and effective wet-season feed-out practices; and (iii) use of appropriate production metrics and economic analysis to demonstrate impacts on herd performance and profitability.

For these examples and others, such as introduction of regionally suitable perennial legumes, genomic selection for polledness and other traits, and mitigation of environmental impacts on fertility and mortality, a useful framework to plan for improvement of adoption might be summarised as: (i) give me a clear reason for change; (ii) show me how it is done; (iii) show me others doing it; and (iv) make it easy by providing clear and simple instructions or tools.

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# Relationship between vegetation index and home range of cattle in northern rangelands

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## Introduction

Cattle grazing the extensive landscape of northern Australia are rarely monitored outside of a couple of mustering and processing events per year. Similarly, pasture availability is not often monitored to identify periods of low nutritional availability and how this impacts the spatial behaviour of grazing livestock. Home range is the area that animals spend the majority of their time (Seaman and Powell, 1996) and can provide information on paddock use and animal behaviour. Vegetation indices measuring the greenness or biomass in an area can be used to monitor feed availability in extensive grazing systems. Within a larger study on a commercial property in the western Victoria River District, this study aimed to ascertain how cows utilised the paddock at different times of year and if this was impacted by pasture availability.

## Methods

Pregnant cows due to calve between May and 1st September 2018 (n = 157) were placed in a 33 km² paddock with 20 cows wearing Global Navigation Satellite System (GNSS) tracking collars. GNSS collars were direct to satellite and geolocations were recorded every 30 minutes. Google Earth Engine (GEE) was used to retrieve satellite vegetation data at 10 m spatial resolution every 5 days. Home range was calculated from GNSS data in R using the *adehabitatHR* package for each cow on a monthly basis.

## Results

The home range of animals increased as pasture greenness and biomass increased ($P < 0.05$). Home range was also much smaller during the dry season (Apr-Oct) compared with the wet season (Nov-Mar), with the first rainfall >25 mm falling on the 28th of November 2018 (Figure 1).

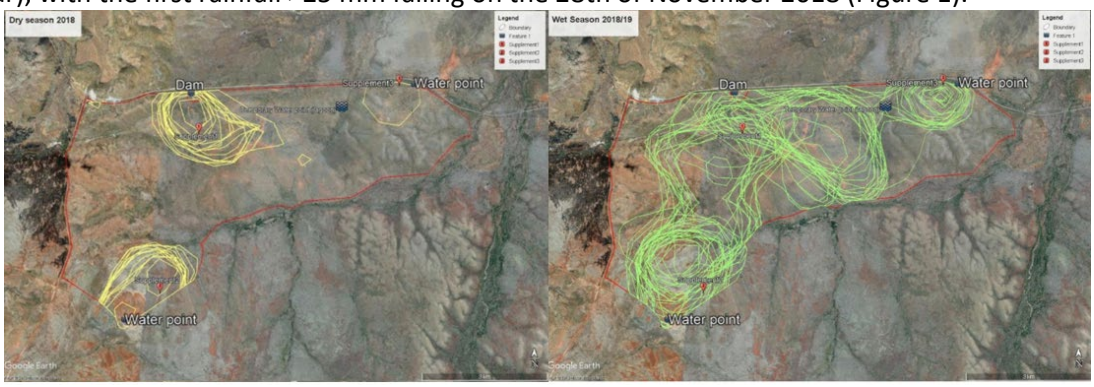


**Figure 1. Home range of animals in the same paddock in the dry season (L) and wet season (R).**

## Conclusion

Animals tend to occupy smaller areas when there is limited feed on offer. This information may help producers to make management decisions regarding supplementation locations during the year, and paddock utilisation of animals with varying levels of forage availability. The results of this study may be used to make decisions around paddock infrastructure planning, supplement location and developing ways to increase feed intake of animals in the dry season.

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# Detection of maternal behaviours associated with suckling in beef cattle

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## Introduction

Reproductive wastage is a major contributor to decreased productivity in northern Australia beef breeding herds. Suckling, a behaviour that typically occurs within 1-3 hours after birth, is an indicator of calf well-being, as it requires the calf to be able to stand, locate the udder, attach to the teat and suckle. This study aimed to assess the ability of an ear tag sensor containing an accelerometer to recognise suckling when attached to calves.

## Methods

This study involved 24 two-year-old Brahman heifers which were equipped with a GNSS eGrazor collar, containing GPS and accelerometer componentry and a Ceres tag, one month prior to expected calving. Within 12-24 hours of birth, calves were identified with a visual ear tag and data recorded for birthweight, sex and general health. A Ceres tag and a paired BLEAcon bluetooth device, supporting data transfer via a LORAwan network was affixed to each calf. The data obtained from the cow-calf pairs' sensors were compared with corresponding observations derived from a comprehensive behavioural sampling protocol, including video recordings and direct observations. Machine learning techniques were utilised to identify distinct accelerometer patterns associated with calf suckling and a cow being suckled.

## Results and discussion

A calf suckling recognition algorithm was successfully developed and used to infer the suckling behaviour ear tag accelerometer data from eleven calves. This algorithm was used to infer the suckling time of calves per day over the study period. Age was found to have a quadratic relationship with predicted daily suckling time derived from the recognition algorithm. This relationship was highly significant ($p<0.001$; Figure 1).

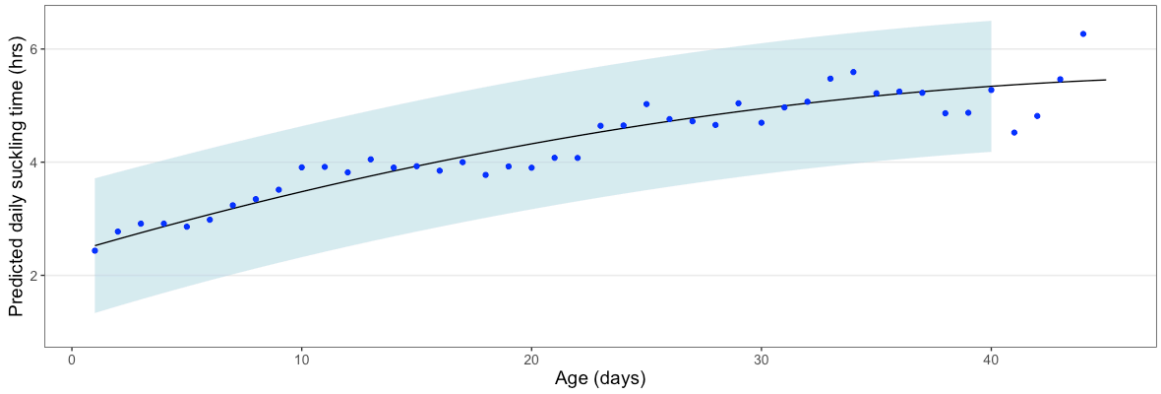


**Figure 1. Average predicted daily suckling time by age of calf.**

## Conclusion

The findings of this study suggests that ear tag accelerometers can be a viable option for monitoring suckling behaviour of calves. However, further exploration and validation of this approach is needed to confirm its effectiveness.

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# Quantifying the mortality-risk associated with age at first calf in breeding herds

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## Introduction

The occurrence of breeding female mortality has substantial economic repercussions for northern beef pastoral operations. Whilst breeding programs can adopt early breeding programs, heifers calving <3years of age are especially at risk of mortality, due to foetal-maternal disproportion resulting in dystocia and increased nutritional requirements associated with pregnancy and lactation. Within the Calf Alive study, we aim to leverage existing commercial animal performance datasets to gain insights into the prevalence of breeder mortality and identify the contributing factors, including age at first calf. This paper presents the outcomes of a pilot analysis conducted using a single commercial dataset.

## Methods

An analytical dataset was created by combining Gallagher TSI™ backup data files, which included five data types: Life, Trait, Event, Activity, and Note. These data types were recorded transactionally, with multiple rows per day or muster event for each individual animal. The data were organised so that all information recorded for an animal on a given day was contained in a single row. When multiple values were recorded for a trait on a single day, the last recorded value was considered the most accurate. Pregnancy status was determined by assigning the expected month of calving in whole months. Animals that had not attended any muster for at least 2 years, without any records of being culled, sold, or transferred, were classified as "missing". Data were analysed using a mixed model with age category and pregnancy specified as fixed effects and observation year specified as a random effect. All analyses were performed using R (version 4.3.0) and R Studio (version 23.03.1).

## Results

The resulting mortality dataset contained information summarising 106924 annual production data points and produced a data subset summarising the performance of 50258 <4-year-old females. Overall, the occurrence of missingness in first-calf heifers was 2.6% (95% CI 1.3, 5.5). There association between pregnancy and age at first calving, and their interaction was statistically significant ($P<0.01$, $P<0.01$ and $P<0.01$, respectively). The occurrence of missingness was predicted as 4.3%, 2.3% and 1.6% higher in yearling (<2-year-old), heifer (2-year-old) or and joiners (3-year-old), respectively, when compared to non-pregnant females of similar age.

## Conclusion

The results of this analysis further demonstrate the mortality risk associated with calving heifers at younger ages. To ensure the well-being and success of the pregnant heifers, it is essential to prioritise appropriate nutrition and diligent herd management practices to minimise losses.

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# Impact of bottle teat score on calf mortality in extensively managed NT herd

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## Introduction

Many studies have identified bottle teats as a significant contributor to calf mortality in northern Australian beef production systems. Most northern breeder herds are extensively managed, making it difficult to identify cows with bottle teats at birth and quantify post-natal mortalities (Schatz, *et al*., 2022). Scoring, selecting and culling cows based on teat and udder conformation is an effective method to increase productivity by increasing breeder longevity and calf performance, and reducing calf ill-health and mortalities (Rasby 2009). The effect of bottle teats on calf mortality rate was studied over 3 years (2019-2021) in the CalfWatch project (Schatz *et al*., 2022).

## Methods

Three cohorts of Brahman (n = 361) and F1 Senepol (n = 167) cows (>5 years old) in an October to December calving window were monitored at calving in a 22.15km2 paddock in the Katherine Region, Northern Territory. Remote monitoring devices including intra-vaginal birth sensors and Smart Paddock GPS tracking collars allowed cows and calves to be monitored. Immediately after birth, calving details were recorded and cow-calf pairs were scored on attributes such as bottle teat score (BTS), maternal behaviour, calf size and calf health. BTS after birth was graded on a scale of 0-2 (0=normal udder, 1=mild bottle teats, 2=severe bottle teats). During the calving period, frequent observations were made on cows with high BTS or low vigour calves over the following weeks to monitor welfare and identify calf mortality events. Using a generalised linear model in R (R Core Team, 2023), calf mortality was analysed relative to BTS, with calf survival as the dependent variable and cow ID as a random effect in an unbalanced nesting design.

## Results

No difference in calf mortality was seen in cows with a BTS of 0 or 1 (p=0.86), but those with a BTS of 2 experienced significantly higher mortality rates (p=<0.001). Cows with severe bottle teats were over 3 times more likely to lose a calf than cows with mild bottle teats (Figure 1).

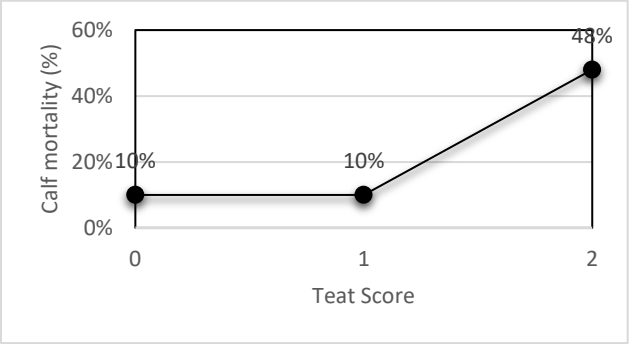


**Figure 1. Calf mortality risk based on cow udder score.**

## Discussion and conclusion

This study's findings suggest that while poor udder conformation may be associated with calf mortality, the presence of normal or mildly bottle-shaped teats appears to have little impact on calf loss.

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# Paddock-shade shelters for reducing calf loss in the treeless Barkly Tableland

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## Introduction

There are substantial areas in northern Australia where large numbers of cattle graze open grassland where the distances between water points are large, there is very little shade, and temperatures are very high (>40°C) during the summer months. This paper presents the findings from a study comparing the occurrence of calf loss across three year groups of wagyu heifers.

## Methods

This study utilised 2 relatively treeless paddocks of very similar size (56 km2) and production potential on Avon Downs Station, Barkly Tableland. The paddocks were well watered with distances to water less than 4km and were pastured predominantly by Mitchell and Flinders grasses. Paddock shade shelters (50 m x 25 m in size) were installed within 500 m of each water point in 1 of the 2 trial paddocks.

Three cohorts of heifers were monitored between 2019 and 2022. Each year, heifers were selected at the annual pregnancy test muster of a large maiden heifer mob, with individuals (predicted to calve between Oct and Jan) randomly allocated to either the paddock with (S) or without (NS) installed shade shelters. Heifers inducted into the study were typically observed for approximately 12 months, from pregnancy diagnosis (Aug-Sep) to weaning (Jun-Jul). At induction, predicted month of calving, body condition score (BCS) and lactation status was recorded. At the weaning muster, heifers were assessed visually for BCS and lactation status, pregnancy tested and foetal age estimated if pregnant.

Differences between treatment groups means for foetal and calf loss (FCL) were compared after employing a generalised linear mixed model with treatment fitted as a main effect and year as a random effect using R and RStudio, version 1.4.113.

## Results and discussion

An outcome for foetal and calf loss was successfully described for 688 heifers during the study. Consistently lower foetal and calf loss was observed for the 'Shade' treatment group and ranged between 0.7 and 9.6 across years (Table 1). However, despite this consistent response and overall estimated reduction in foetal and calf loss of 5.9%, this finding only tended towards statistical significance (p=0.08; Table 1).

**Table 1. Average predicted daily suckling time by age of calf.**

| Cohort | Limited Shade | | | Shade | | | Diff (%) | P-value |
|---|---|---|---|---|---|---|---|---|
| | N | Mean | 95% Conf. Limits | N | Mean | 95% Conf. Limits | | |
| 2019/20 | 72 | 29.2 | (19.0, 44.7) | 74 | 28.4 | (18.5, 43.5) | -0.7 | NS |
| 2020/21 | 147 | 38.1 | (29.3, 49.5) | 123 | 28.5 | (20.4, 39.6) | -9.6 | 0.12 |
| 2021/22 | 133 | 21.1 | (14.9, 28.8) | 139 | 16.5 | (11.2, 23.7) | -4.5 | NS |
| **Overall** | **352** | **29.5** | **(21.7, 38.7)** | **336** | **23.6** | **(16.8, 32.0)** | **-5.9** | **0.08** |

## Conclusion

This study did not demonstrate a statistically significant impact on reproductive wastage from the provision of artificial shade. While there may be potential benefits for animal welfare associated with providing artificial shade in treeless rangelands, it is advisable to conduct an economic evaluation prior to considering the installation of such capital infrastructure.

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*The contribution of both the AACo and MLA are gratefully appreciated.*

# Impacts of paddock watered areas on home range and spatial behaviour in extensive rangelands

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## Introduction

Many paddocks in extensive systems of northern Australia are large and poorly watered, and cattle must travel large distances to access feed and water. Watered area of a paddock is the proportion of land area which is within a certain radius from a water point. Home range is the area in which animals spend the majority of their time, and can be measured based on the density of geolocation fixes within a certain area (Seaman and Powell, 1996). This study is part of a larger project 'Paddock Power' which investigated the impact of watered area on productivity of animals. The objective of this study was to explore the home range of animals in large commercial paddocks to see the impact that watered area may have on the spatial behaviours of animals.

## Methods

GPS collars were deployed on 100 pregnant Brahman cows in June 2022, with half (n=50) the collared cows placed in one trial paddock and half (n=50) in the other trial paddock. GPS collar data was collected in May 2023, and collated per animal to summarise the spatial density of recorded locations and calculate kernel density using QGIS. Kernel densities of 50, 75 and 95% were generated to show the area in which animals spent the majority of their time over the period of a week.

## Results

Preliminary results from this study show the 50, 75, and 95% kernel density for two different animals in adjacent paddocks over one week during October 2022 (Figure 1). The 95% kernel density polygon shows the area in which each animal spends 95% of its time for the week of data presented.

## Discussion

Home range has impacts on paddock utilisation, grazing management and water point infrastructure. Understanding the spatial behaviours of animals in large commercial paddocks may help producers to make better management decisions such as water, fencing, and subdivision of paddocks.

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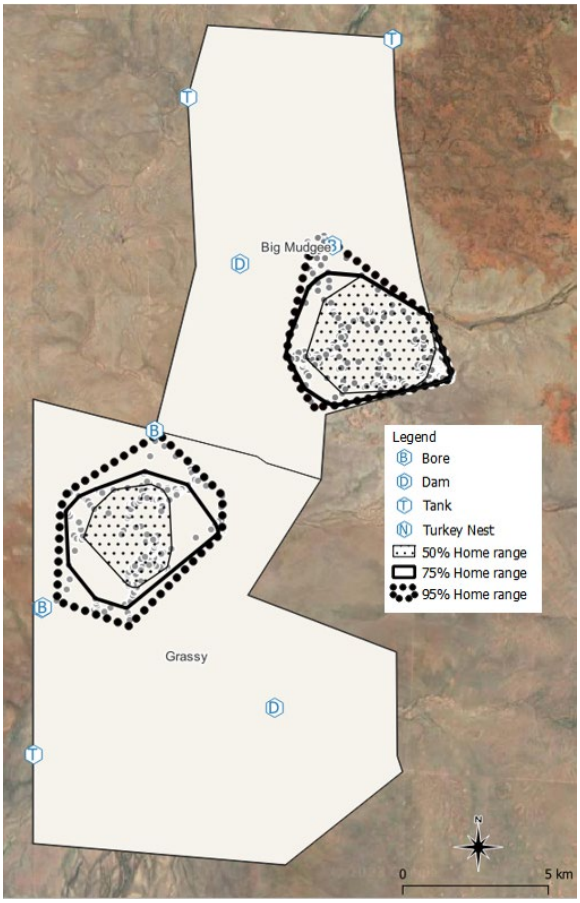


**Figure 2. Fifty, 75 and 95% kernel density of two cows grazing adjacent paddocks during a week in October 2022.**

# Is Caltrop the cause? Investigating 'staggers' in a Northern Territory breeder herd

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## Introduction

In May 2022, two 3-year-old cows in a paddock at Victoria River Research Station (Northern Territory, Aus.) were observed to have ataxia, hypermetria and a swaying gait, most severe in the hind end, with affected animals 'wobbling' and 'staggering'. By August 2022, two additional cows in the same paddock were observed displaying similar clinical signs. The cows had been vaccinated for 5-in-1 and botulism, and were receiving mineral supplementation by a dry loose lick year round. As multiple animals had been effected, a disease investigation with full post mortem examination was conducted on one animal.

## Methods

One of the cows was euthanised, a post mortem conducted and samples were sent to the Berrimah Veterinary Laboratory (NT) for testing. Fresh and fixed samples collected during post mortem included: heart, lungs, liver, kidney, spleen, skeletal muscle, rumen, reticulum, omasum and abomasum wall, ileocecal valve, mesenteric lymph nodes, cervical spinal cord, lumbar spinal cord, rumen content, small intestine, fresh blood (clotted and EDTA) and whole brain.

## Results

Nothing visually significant was observed during post mortem. Blood chemistry revealed a slight elevation in Creatine Phosphokinase, which is common in cattle that are staggering or recumbent. Lead toxicity and transmissible spongiform encephalopathy (TSE) result was negative. Histopathology examination revealed moderate spinal Wallerian degeneration and no notable findings in other tissues.

## Discussion and conclusion

The likely causes of Wallerian degeneration in cattle are: 1) traumatic injury or, 2) caused by a toxin. Traumatic injury was ruled out as multiple animals were effected, and cases were isolated to one paddock. Bovine ephemeral fever (BEF) was also suggested as a potential cause of injury to the spine, due to affected animals remaining recumbent for a prolonged period of time, as documented by Hill & Shultz (1977). BEF analyses of the spleen and blood serum were positive, with a suggested exposure time of the 1-2 months prior to euthanasia. However, as animals with 'staggers' were only seen in one paddock and acute BEF had not been observed on the property, it was deemed unlikely to be the cause. A toxin seemed a more likely cause. Wallerian degeneration has been noted to be caused by plants in the cycad family (*Cycas, Macrozamia* and *Bowenia*) and grasstrees (*Xanthorrhea spp.*). These plants are not naturally found in this region and none could be found in the paddock. Other species previously documented to cause ataxia and Wallerian degeneration in ruminants are *Phalaris spp., Sorghum spp.* and *Tribulus terrestris* (caltrop) (Finnie *et al.* 2011). *Phalaris* and *Sorghum spp.* were ruled out as they were not present on the property. Further investigation of the paddock confirmed the presence of *T. terrestris* (confirmed by NT herbarium). While *T. terrestris*-induced ataxia is documented in sheep, not in cattle, the absence of other causes and *T. terrestris's* presence suggest it could potentially cause these observed cases of 'staggers'.

## References

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# Opportunities to increase production and profit from young breeding cattle

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## Background

Considerable components and systems research has been conducted in northern Australia which needs to be incorporated into northern beef business practice, especially where it will substantially improve business performance. Examples of this include the Beef CRC studies (Barwick *et al*. 2009) and Northern Beef Genomics (Hayes *et al*. 2022) which underpin commercially available breeding values for traits of high business value. Further examples include the Cash Cow studies (McCosker *et al*. 2023) and Bull Power research (Holroyd *et al*. 2005) all which have demonstrated bounteous potential both biological and financial, by adapting the benefits from improving the feed base, strategic lactation management, managing stress, animal health, and targeted breeding, will drive the business.

## Methods

Growth and business practice needs to include maintaining accurate livestock scheduling, recording transactions, and analysing these data points and costs to calculate whether live weight production, animal performance (growth, survival, reproduction) and costs and returns per kg are at real and achievable levels. Coupling this with animal genetics monitoring (Herd Profile from Northern Beef Genomics) and feed base monitoring will dictate opportunities for improvement which will include astute application of key management practices that enable breeding cattle to raise a calf to weaning following their first two mating opportunities, e.g.:

- Using no more than 1% bulls that pass a full BBSE and have average or better genetic merit for the primary traits driving production. This includes GBVs for puberty and P4M (pregnant within four months of calving), days to calving EBV, 600-day growth EBV or GBV, and adaption traits such as GBVs for tick resistance, fly lesions and temperament.
- Controlling stock numbers for optimal pasture utilisation and production in the short and long term.
- Targeted supplementation to rectify primary nutrient deficiencies especially P and N.
- Mating and weaning management that maximise live weight production and minimise risk and costs.
- Appropriate vaccination against major infectious diseases, especially botulism, vibriosis, pestivirus and tick fever, and managing tick and again fly infestations.

## Changing business practice

The key to change is, for businesses to accurately understand their own business, most northern beef producers inadvertently adopt the "Stockdale Paradox" – *Prepare for the worst, while hoping for the best.* Methods and support agencies are now focusing on this, e.g., MLA's NB2 (Northern Beef Business) initiative. Change is difficult to approach, especially in family-owned situations in the absence of demanding shareholders. Analysing business, assessing opportunity, and implementing change may be best done by staging the processes and with support of peers and professional advocates.

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# The effect of nitrogen use efficiency on productivity in tropical beef

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## Introduction

Seasonal conditions can result in periods of poor nutrition, and nitrogen (N) has been reported as a limiting nutrient during these periods. Some cattle can consistently put on more weight during these harsh conditions, than others. Cantalapiedra-Hijar *et al*. (2015) demonstrated that the ratio of 15N to 14N stable isotopes enrichment ($\delta^{15}N$) of ruminant plasma proteins was correlated with Nitrogen use efficiency (NUE) in cattle. Silva *et al*. (2022) reported a variation in $\delta^{15}N$ in cattle, and that $\delta^{15}N$ influenced reproductive performance. This paper presents preliminary results examining if $\delta^{15}N$ influences winter live weight change measured in tropically adapted beef breeds.

## Methods

Tail hair was collected in December 2021 from 111 Droughtmaster, Santa Gertrudis and Brahman heifers that are part of the Repronomics™ 2021 cohort, and animal age was on average 410 days (range=365-454). A section of the tail hair representing the growing period during low nutritional intake (approximately 26/08 to 09/09/2021) was analysed with a mass spectrometer to determine the $\delta^{15}N$ ratio. Fixed effects considered were breed and dam age (DA) (as class terms) and heifer age (HA) and heifer weight (HW) (as covariate terms), with sire fitted as a random effect. Linear mixed models and step-wise reduction were used to test the significance ($P<0.05$) of fixed effects and $\delta^{15}N$ ratio on liveweight (LW) gain. R2 values were obtained from models with and without $\delta^{15}N$ (as a covariate term) were obtained to determine the amount of variation explained by $\delta^{15}N$.

## Results

Summary statistics for $\delta^{15}N$ and LW gain are shown in Table 1. A significant negative correlation was observed between $\delta^{15}N$ and liveweight change, indicating that animals with higher weight gains had lower $\delta^{15}N$ values. Other significant fixed effects included DA, HA and HW. The R2 difference indicated that $\delta^{15}N$ explained approximately 3% of the variation observed for both liveweight change traits.

**Table 1. Summary statistics for Liveweight, $\delta^{15}N$, solution for $\delta^{15}N$ and R2 model difference.**

| Trait | Mean | Std dev | Coeff. of variation | Range | Solution $\delta^{15}N$ | $R^2$ diff. |
|---|---|---|---|---|---|---|
| $\delta^{15}N$ | 6.31 | 0.42 | 0.07 | 5.25 - 7.6 | - | |
| LW (kg) change Jul-Dec 21 | 59 | 13 | 0.23 | 7 - 87 | -5.95 | 0.026 |
| LW (kg) change May-Dec 22 | 48 | 14 | 0.30 | -20 - 79 | -6.81 | 0.034 |

## Conclusion

$\delta^{15}N$ showed a significant but small effect on the LW change between Jul-Dec 21 and May-Dec 22. However, with a small number of records and a low coefficient of variation for $\delta^{15}N$, more samples are required, especially during harsher conditions to understand the potential impact of $\delta^{15}N$ better.

## References

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# A comparison of abrupt and fenceline weaning methods for beef cattle

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## Introduction

Most calves are abruptly weaned. Two-step weaning using an intermediate separation step of nose-flaps or a fenceline aims to decrease the negative impact for both cows and calves. However, previous evaluations of weaning method have been limited in duration and/or data collected for producers to make an informed decision.

## Methods

Thirty-two Angus cow-calf pairs were allocated to two weaning method groups (n = 16 pairs/group), 1) fenceline (FL) where cows and calves were separated by a single fence for the first 7 d after separation then fully separated and 2) abrupt (AB) where cows and calves were fully separated at weaning. Groups were balanced for age, weight, and calf sex. All cow-calf pairs were fitted with ear tag sensors to record behaviour. After separation, FL calves were maintained in a pen adjacent to the FL cow paddock allowing cessation of suckling with minimal contact through the fence. The AB calves were transported to a pen 2 km away removing all contact with cows. After 7 d, FL cows were transported 2 km from all calf pens. Body weights and salivary samples were collected for all animals on experimental days -1, 7, and 14.

## Results

Fenceline calves had similar ADG to AB calves throughout the experiment. Cortisol levels were similar between groups at all timepoints for cows and calves. Through visual observations, abrupt calves had a greater occurrence of pacing. For the 3 days after separation, AB calves had greater high activity durations and less resting and ruminating time compared to FL calves. Fenceline cows had greater resting times but less eating, ruminating, and high activity times compared to AB cows for two days after separation.

## Discussion and Conclusion

Cows in the fenceline treatment had greater eating and rumination durations across the first 2 to 3 days after weaning but decreased rumination levels after full separation. Implementing full separation by day 3 could improve and prevent the second decrease in rumination but future work is necessary to test this hypothesis. Abrupt cows had greater high activity time compared to FL during the first 3 d and FL cows had a delayed increase high activity until day 3 suggesting their stress behaviour occurred during this time. Although FL calves also had a stress response, it was less than AB calves and resolved after the first 2 d with an increase in rumination and consistent resting. To decrease the negative impact on FL cow weight gain during part 1 separation, full separation occurring after the first 3 d could prevent the decrease in eating time after day 3 and rumination after full separation which affects weight gain. Overall, abrupt weaning is more stressful for both cows and calves when compared to fenceline weaning with greater behavioural stress responses. The use of a fenceline for the first 3 days followed by full separation appears the appropriate method for weaning cattle to minimise the impact of this process on both cows and their calves, but further work is required to test this hypothesis and if the recommendation holds for other environments.

## References

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# New diagnostic tools for bovine vibriosis

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## Introduction

Vibriosis or Bovine Genital Campylobacteriosis (BGC) is a venereal disease with known economic impacts on herd fertility worldwide. Investigations of outbreaks has been hampered by the availability of sensitive and specific laboratory tools. In the absence of such methods, the IgA ELISA is employed which indicates previous but not active infection by the pathogen Campylobacter fetus subspecies venerealis. Control of BGC relies upon annual VibroVax® vaccination regimes which tend to be applied to bulls prior to mating. A five year Meat & Livestock Donor Company research program commenced in 2018 which aimed to develop novel diagnostic methods, identify novel genital pathogens, develop diagnostic assays which could differentiate BGC infected from vaccinated animals, and potentially identify BGC resistant cattle to develop Estimated Breeding Values for disease resistance.

## Methods

Genome sequencing of Australian *C. fetus* isolates led to the identification of targets for molecular diagnostic development screened using laboratory and field samples. Two VibroVax® vaccination and challenge studies in heifers and bulls under UQ Animal Ethics Project Numbers 2021/AE000054 and 2021/AE001138, respectively. These trials examined quantitative PCR (qPCR) pathogen detection, microbiome/metagenomics analyses, and serum proteomes associated with challenge using a *C. fetus* subspecies *venerealis* isolate, in both vaccinated and unvaccinated cattle.

## Results

A qPCR was demonstrated to be specific and is currently under evaluation by an Australian Veterinary Diagnostic Laboratory. The VibroVax® cattle vaccination and challenge trials demonstrated that both vaccinated and un-vaccinated cattle are transiently *C. fetus* subspecies *venerealis* positive after challenge, with un-vaccinated cattle negative by ~5-7 weeks after challenge. Metagenomics sequencing was found to be a more sensitive diagnostic approach than qPCR and also confirmed the clearance of *C. fetus* subspecies *venerealis* organisms in vaccinated and unvaccinated cattle. Vitamin B binding protein is a putative serum biomarker for vaccinated and recently infected heifers and bulls.

## Discussion and conclusion

This study demonstrated that cattle exhibited transient qPCR positivity to *C. fetus* subspecies *venerealis* which highlights the importance of testing bulls prior to mating and that the delayed investigation of a herd infertility outbreak may yield negative results. Metagenomics methods were found to be superior to qPCR in terms of sensitivity but are not yet amenable to diagnostic laboratory adoption. Diagnostic methods and a putative protein biomarker for BGC unvaccinated cattle continue to be under evaluation using field sample submissions. Improved diagnosis of BGC/vibriosis and the development of a BGC immune biomarker assay will improve the management of this venereal disease.

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# The effect of collection method on post-thaw bull semen quality

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## Introduction

Whilst the practice remains relatively low in northern Australia, artificial insemination (AI) provides a practical method of introducing superior genetics into a beef herd. One of the main reasons for the low adoption is thought to be associated with logistical constraints of running AI programs during a challenging time of the year with relatively poor outcomes compared to natural mating. In such programs, the chance of a successful conception is heavily reliant on the quality of the semen used, specifically its morphology and motility. Using an electro ejaculator (EE) is the commonly accepted method for collecting semen samples from bulls, however prior to the development of the device, semen was collected using an artificial vagina (AV). Cryopreservation of semen is a common practice used to store genetic material and, within reason, provides cattle producers with access to superior genetics regardless of their geographical location. Using existing data, this paper reports the results of a retrospective analysis to identify factors influencing semen quality.

## Methods

This retrospective study evaluated bull ejaculate data collected between 2004 and 2021 from a single breeding service centre located in central Queensland. Data described 5878 individual semen collected from bulls of several different breeds. Data contained information on collection method, progressive motility, concentration and full morphological analysis of the semen both freshly collected and post thaw after cryopreservation. The collection methodology has previously been described (Austin, *et al*., 1961) and the analysis was completed by an accredited morphologist. Univariate associations between semen quality and candidate factors were examined by employing generalised linear regression models using R (version 4.3.0) and R Studio (version 23.03.1).

## Results and discussion

Motility score and percent normal were not dissimilar between collection methods for fresh samples ($P>0.05$). However, semen concentration in fresh semen were found to be much higher when collected using AV, compared to EE ($P<0.01$). Motility, normal and concentration scores were all higher in thawed samples when collected using AV, compared to EE ($P<0.05$). Additionally, the degradation of progressive motility post thaw was 24% and 36.4% for AV and EE respectively, which was significant ($P<0.01$). The samples collected with the AV had a better post thaw recovery and progressive motility performance.

## Conclusion

In our small-sized study group the motility score of fresh semen obtained by electroejaculation was not significantly different from that obtained by AV. However, post thaw survival and quality were significantly greater for samples collected by AV. These findings align with existing literature across various species, including humans, and indicate that the use of AV, to enhance post-thaw semen quality is likely to improve outcomes of AI programs.

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# The performance of P deficient mature cows improves with supplementation

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## Introduction

This study investigated how long it takes for the performance of P deficient mature cows to improve once they are supplemented, and if long-term performance is compromised by early P deficiency.

## Methods

Schatz *et al.* (2023) compared the performance of Brahman females that received Phosphorus (P) supplement continuously from weaning (P+) to those that never received any supplemental P (P-) in a study at Victoria River Research Station. At the conclusion of the study in May 2019 (when the cows were 5.5 years old), 42 cows were randomly selected from each treatment and grazed together in the same P deficient paddock for 3 years. They were given supplements containing P year round and performance attributes were measured twice a year. Data from the Schatz *et al.* (2023) study was used to compare the performance of the treatments before and after May 2019.

## Results

Mean Annual Liveweight Production (change in cow weight over a year plus the weaning weight of any calves produced) in the 3 years prior to May 2019 was significantly higher in P+ (P- = 83.6 kg, P+ = 121.7 kg, $P<0.05$) while it was not in the 3 years after May 2019 (P- = 142.3, P+ = 131.9, $P>0.05$).

**Table 1. Summary of the performance of the P- and P+ treatments before and after May 2019.**

| | P- Lactating | P+ Lactating | P- Non Lactating | P+ Non Lactating |
|---|---|---|---|---|
| Liveweight May 2019 (kg) | 324 [A] | 444 [B] | 412 [C] | 549 [D] |
| Liveweight May 2022 (kg) | 440 [A] | 479 [B] | 517 [B] | 574 [C] |
| BCS May 2019 (5 point system) | 2.00 [A] | 3.00 [B] | 3.17 [B] | 4.04 [C] |
| BCS May 2022 (5 point system) | 3.14 [A] | 3.16 [A] | 4.00 [B] | 4.17 [B] |
| Preg. Rate May 2019 (%) | 17.5 [A] | 70.7 [B] | 96.7 [B] | 97.9 [B] |
| Preg. Rate May 2020 (%) | 41.3 [A] | 56.4 [AB] | 96.2 [AB] | 97.6 [B] |
| Preg. Rate May 2021 (%) | 82.1 [A] | 83.3 [A] | 95.0 [A] | 97.1 [A] |
| Preg. Rate May 2022 (%) | 83.3 [A] | 77.6 [A] | 95.5 [A] | 80.8 [A] |

Means with a different letter superscript in each row are significantly different ($P<0.05$)

## Discussion and conclusions

The pregnancy rate in lactating cows was 53% higher in P+ in May 2019 ($P<0.05$), but the differences between treatments were not significant post May 2019. While the mean liveweight (LW) of P+ cows remained heavier than P- over the 3 years post May 2019, the differences between treatments diminished (Table 1). This is likely because the BCS of P- cows improved after they started receiving P supplement but that some stunting of P- cows had occurred prior to May 2019. The difference in mean hip height (cm) between the treatments was similar in May 2019 (P+ = 140, P- = 136, $P<0.05$) and May 2022 (P+ = 140, P- = 137, $P<0.05$), while the mean BCS of P+ cows was higher than P- cows in May 2019 ($P<0.05$), but in May 2022 there was no difference between treatments. These results show that the performance of P- cows improved rapidly with P supplementation and became similar to P+.

## References

Schatz *et al*. (2023) Animal Production Science. 63, 544–559.

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# Phosphorus supplementation using water medication or lick-blocks

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## Introduction

Water medication can supply regulated amounts of supplementary phosphorus (P) to cattle through the drinking water. Although water medication is a well-established approach, there are few controlled trials demonstrating and testing this technology for grazing cattle under north Australian industry conditions. This report presents preliminary results of a demonstration conducted at Spyglass Beef Research Facility as a collaboration between DAF and DIT AgTech using a uDOSE medicator, which allows remote monitoring of dosing and automatically corrects any mis-dosing.

## Methods

*Bos indicus* cross cows (n= 30) and steers (n=20) initially 2.5 and 0.6 years of age that grazed a paddock (260 ha; soil P in the paddock: 15% 2-5 mg $P_B$/kg, 85% <2 ppm mg $P_B$/kg) on Spyglass were allocated to two supplementation treatments. An auto-drafter separated the cattle into the treatment groups with either access to P medicated water or a lick-block P supplement. Supplemental P intakes are expressed per adult equivalent (AE; 450 kg dry animal). Table 1 reports results from a wet season, 22 Jan 2021 – 4 May 2021.

## Results

The supplemental P delivered by water medication was close to the target amounts. However, cattle offered lick-blocks consumed on average only 2.5 g supplemental P/day (Table 1).

**Table 1. Estimated supplemental phosphorus intakes of cattle.**

| Treatment | n | Target g P/AE.day | Actual g P/AE.day (SE) |
|---|---|---|---|
| Medicator | 22 | 8 | 7.1 (0.5) |
| Blocks | 28 | 8 | 2.5 (0.3) |
| P value | | - | < 0.001 |

## Discussion and conclusion

The phosphorus delivery by blocks was much lower than the recommended range of 8–12 g P/day to meet requirements of lactating breeders (from LW maintenance to gaining up to 0.5 kg LW/day; Jackson *et al*. 2012). This project demonstrates that water medicator technology can be used to achieve target phosphorus delivery to cattle during the wet season.

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# The Easy P – Producer Demonstration Sites aiming to increase Phosphorus supplementation in areas that are difficult to access during the wet season.

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## Introduction

Research at Victoria River Research Station (VRRS), Northern Territory (NT), showed that Phosphorus (P) supplementation of Brahman females resulted in large improvements in growth, pregnancy rate, weaning rate, average weaner weight, weaner production, mortality rate and gave an excellent return on investment (Schatz *et al.* 2023). However, adoption of P supplementation has been limited in areas where access is difficult during the wet season. The "Easy P" strategy was designed to overcome this problem. It involves including P in dry season supplement and putting out enough bulk P supplement before the rains start to last through the wet season. The Easy P project has a research component at VRRS and several Producer Demonstration Sites (PDS) across northern Australia where the strategy is being demonstrated and performance monitored.

## Methods

The Western Australia Department of Primary Industries and Regional Development (WA DPIRD), in collaboration with the Northern Territory Department of Industry, Tourism and Trade (NT DITT) and the Queensland Department of Agriculture and Fisheries (QLD DAF), are participating in Producer Demonstration Sites (PDS) across northern Australia. The PDS compares an Easy-to-Supplement Phosphorus method (Easy P) established by research done at Kidman Springs (*Schatz et al.* 2023) to a wet-season phosphorus supplementation.

There are currently three PDS sites established one at Bullo River in the NT, Dampier Downs in WA and one in Wycheproof, Mt Larcom in QLD. The different treatments which will be compared to Easy P are shown below in Table 1.

**Table 1. The treatments that will be compared to Easy P at the PDS sites.**

| Bullo River | Dampier Downs | Wycheproof |
|---|---|---|
| *Wet Season P* | *Wet Season P* | *No P over wet* |
| P out in the wet when access allows, with a dry season lick with no P included | P out in the wet when access allows and no dry season lick | Both groups will be fed dry season urea supplement with P if required |

## Results and discussion

The research component of the project is showing that performance under the Easy P strategy is as good as, or better than traditional supplementation (Schatz *et al.* in press). The PDS component of the project is in the early stages. The treatments have been set up at the different locations and performance is being recorded, but little data is available at this stage. Data will be recorded over the next 3 years and field days and extension activities are planned to communicate the findings to industry. It is hoped that the project will increase adoption of P supplementation across northern Australia.

## References

Schatz *et al.* (2023) *Animal Production Science*. 63, 544–559.
Schatz *et al.* (in press) NBRUC 2023 Conference proceedings.

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# Increasing the adoption of P supplementation in N Australia

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## Introduction

The project aims to increase phosphorous (P) supplementation in northern Western Australian cattle herds by improving producer awareness of P deficiencies and their supplementation benefits. A study conducted by the Northern Territory Department of Industry, Tourism and Trade at the Victoria River Research Station (VRRS) has shown that P supplementation in Brahman females has increased productivity and boosted a return on investment significantly (*Schatz et al.* 2023). Despite the proven advantages, P supplementation in the northern regions remains low and is sometimes misunderstood. To address this issue, the project will involve the collection of heifer blood and soil samples from volunteer stations in the Kimberley and Pilbara regions. These samples will undergo analysis to determine the concentrations of phosphorus. If a deficiency is detected in the samples from a particular station, the stations will be offered a consultation session with a livestock nutritionist to determine a suitable supplementation program.

This project is in addition to the current Producer Demonstration Site project titled "The Easy P – Producer Demonstration Sites aiming to increase Phosphorus supplementation in areas that are difficult to access during the wet season" (*Bone et al.* 2023). The project is funded by the Meat and Livestock Australia (MLA) Donor Company and the Western Australia Department of Primary Industries and Regional Development (WA DPIRD).

## Methods

In early 2023, an expression of interest was released to cattle stations in northern Western Australia encouraging producers to assess the phosphorus concentrations in their herds and soils. Producers who express an interest in testing for P deficiency will have an experienced DPIRD employee or consulting Veterinarian collect blood samples from a subset of 30 heifers, along with soil samples from the corresponding land system. A random subset of faecal samples will also be collected. These samples will be sent for analysis to determine the levels of P. If the results indicate a deficiency, the station will have the opportunity to participate in a one-on-one consultation session with a livestock nutritionist to develop an updated or new supplementation program. Additionally, a P-deficient station will have the opportunity to host a producer demonstration site (PDS) trial on their station which will compare the nutritionist's recommended supplementation program against current station practice.

## Results and discussion

As this part of the project has only started up this year there are no results to date. There has been a lot of interest in signing up for this project component. To date there have been nine pastoralists signed up to have heifers sampled, on writing this (26/07/23) eight stations have been sampled to date. The stations involved spread over the north of WA, with some being in the Pilbara and the Kimberley regions. The anticipated outcomes are, to raise awareness about the importance of phosphorus testing and retesting in the herds and secondly, to promote the adoption of phosphorous use in the Pilbara and Kimberley regions.

## References

Bone *et al*. (in press) NBRUC 2023 Conference proceedings
Schatz et al. (2023) Animal Production Science. 63, 544–559.

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# Increasing P supplementation in areas that are difficult to access during the wet

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## Introduction

Research at Victoria River Research Station (VRRS), Northern Territory (NT), showed that Phosphorus (P) supplementation of Brahman females resulted in large improvements in growth, pregnancy rate, weaning rate, average weaner weight, weaner production, mortality rate and gave an excellent return on investment (Schatz *et al.* 2023). However, adoption of P supplementation has been limited in areas where access is difficult during the wet season. The "Easy P" strategy was designed to overcome this problem. It involves including P in dry season supplement and putting out enough bulk P supplement before the rains start to last through the wet season. The Easy P project has a research component at VRRS and several Producer Demonstration Sites (PDS) across northern Australia where the strategy is being demonstrated and performance monitored.

## Methods

The Western Australia Department of Primary Industries and Regional Development (WA DPIRD), in collaboration with the Northern Territory Department of Industry, Tourism and Trade (NT DITT) and the Queensland Department of Agriculture and Fisheries (QLD DAF), are participating in Producer Demonstration Sites (PDS) across northern Australia. The PDS compares an Easy-to-Supplement Phosphorus method (Easy P) established by research done at Kidman Springs (*Schatz et al.* 2023) to a wet-season phosphorus supplementation.

There are currently three PDS sites established one at Bullo River in the NT, Dampier Downs in WA and one in Wycheproof, Mt Larcom in QLD. The different treatments which will be compared to Easy P are shown below in Table 1.

**Table 1. The treatments that will be compared to Easy P at the PDS sites.**

| Bullo River | Dampier Downs | Wycheproof |
|---|---|---|
| *Wet Season P* | *Wet Season P* | *No P over wet* |
| P out in the wet when access allows, with a dry season lick with no P included | P out in the wet when access allows and no dry season lick | Both groups will be fed dry season urea supplement with P if required |

## Results and discussion

The research component of the project is showing that performance under the Easy P strategy is as good as, or better than traditional supplementation (Schatz *et al.* in press). The PDS component of the project is in the early stages. The treatments have been set up at the different locations and performance is being recorded, but little data is available at this stage. Data will be recorded over the next 3 years and field days and extension activities are planned to communicate the findings to industry. It is hoped that the project will increase adoption of P supplementation across northern Australia.

## References

Schatz et al. (2023) Animal Production Science. 63, 544–559.
Schatz *et al.* (in press) NBRUC 2023 Conference proceedings.

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# The impact of prepartum supplementation on the liveweight of cows

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## Introduction

In the Calf Alive project, the impact of prepartum nutrition on calf loss and total liveweight (LW) production is being evaluated on 10 north Australia beef cattle stations. Providing high-protein supplements to pregnant cows around calving is likely to increase energy and protein intake, leading to higher LW. The aim of this study was to assess the impact of protein supplementation on the LW changes of Brahman cows maintained in a single paddock.

## Methods

A walk-over-weighing system equipped with an auto-drafter (WoW) was installed near the only permanent water point of a 2,200-ha paddock on Manbulloo Station, NT. Cows were stratified by LW and randomly assigned to receive a protein supplement (Trt – 56 cows) or not (Ctr – 43 cows). The supplement was offered from 07 November 2022 to 17 January 2023; however, only the period up to 17 December 2022 is considered, as use of the WoW was infrequent after the onset of the wet season. Cows were routinely inspected for calving events and assessed for lactation status. LW data, not adjusted for the conceptus were regressed as repeated measures over time with the MIXED procedure of SAS to evaluate the effect of protein supplements.

## Results

There was a significant effect of supplementation on LW change of both wet and dry cows (Figure 1, $P < 0.05$). For wet cows with known calving dates, cows in the Ctr group lost 20 kg during the first three weeks after calving, while cows in the Trt group lost only 10 kg (Figure 1A). For dry cows, supplementing for 40 days increased LW by 21 kg versus only 10 kg in the Ctr group (Figure 1B).

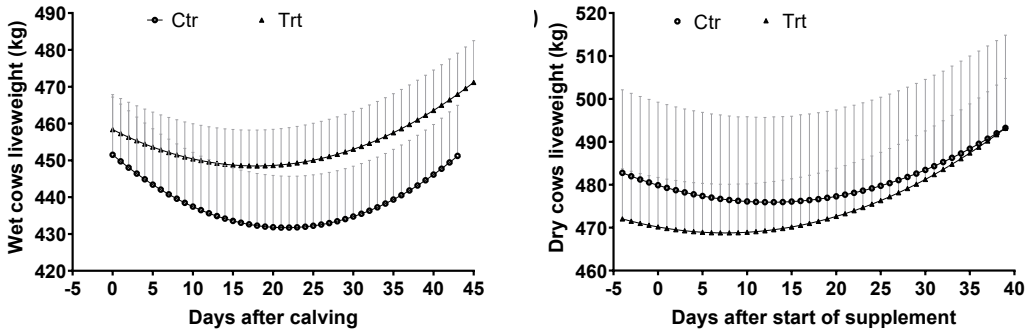


**Figure 1. The impact of supplementation on liveweight change of (A) lactating and (B) dry cows.**

## Discussion and conclusion

Improving the nutrition of late-pregnant cows can be beneficial not only in reducing calf losses and increasing re-conception rates but also in increasing the LW of cows. Considering the recorded average intake of 262 g of supplement per day during the first 40 days the cost of the supplement was $15.70 per cow. As there was ~ 10 kg difference in LW between the groups, if this difference persists, then it is likely that the extra saleable LW from the cows alone would be enough to pay for the supplement cost. These results support the economic feasibility of supplementing prepartum cows and the use of WoW to assess the impact of nutritional treatments.

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# CAMP OVEN OR A THERMOMIX: TECHNOLOGY, DATA MANAGEMENT, AND APPLICATIONS

# Data and alerts from real-time remote water monitoring boosts efficiency, saves costs, and improves animal welfare

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## Introduction

In an era marked by technological advancements, the Beatrice Hill Government research property has embraced innovation to improve water management practices. Through the implementation of Farmbot, Beatrice Hill has witnessed significant improvements in efficiency, cost savings, and animal welfare. By utilising a network of tank monitors, trough monitors, and a rain gauge, Beatrice Hill has automated their water monitoring and rainfall leading to improved data-driven decisions.

Prior to the introduction of Farmbot, water management relied on regular manual checks of all troughs and tanks, often resulting in lengthy delays in detecting and troubleshooting issues. Over the past 12 months they have endured five major water leaks, in some cases, these leaks persisted for weeks undetected, resulting in substantial water waste.

## Harnessing the power of rainfall, flow and water level data

The data obtained by the Farmbot Rain Gauge has proven invaluable for various purposes at Beatrice Hill. It assists rangelands and agronomy researchers in their studies, serves as a reliable record-keeping tool, and contributes to government reporting requirements. The Rain Gauge data holds particular significance for their yearly calendar, where if they have insufficient rainfall by their 'Green Day', December 9, this can result in a shortened growing season. This, in turn, affects the amount of dry matter produced and the stocking rates for the upcoming year. Additionally, the correlation between rainfall and buffalo fly counts has become apparent, with low rainfall resulting in increased fly populations. By leveraging rain data, Beatrice Hill can anticipate and manage high numbers of buffalo fly by timing the application of chemical fly tags for minimising the negative impact of buffalo fly on the cattle. The reduction in fly bites not only improves animal comfort but also reduces energy loss through the animal not being aggravated by the flies reducing the constant movement of its tail, head, and ears. The result with no biting flies is a content animal that can consume more pasture, partition more body weight and ultimately provide a better return to the farmer at sale.

Beyond rainfall monitoring, Farmbot's flow sensor data, combined with trough levels and herd size, enables Beatrice Hill to calculate average water intake per day, per animal. Water consumption increase of 20-litre-increase per animal, per day leads to a notable average daily weight gain of 0.4kg. Considering a herd of over 100 cattle, this translates to an impressive overall weight gain of 40kg per day (Ahlberg *et al*. 2019). By accurately measuring water intake, Beatrice Hill can optimise cattle growth and productivity, benefiting both the animals and the businesses bottom line.

Data on water levels enables the detection of issues in water supply, highlighting the critical importance of fast intervention. A mere 24-hour period without feed and water can result in a significant loss of 6% liveweight. To illustrate, a 400 kg cow would experience a weight loss of 24 kg within a single day. Real-time alerts play a pivotal role in averting such losses. By leveraging these alerts, Beatrice Hill can guarantee adequate water supply for their herd.

## Conclusion

The seamless integration of remote water monitoring technology has significantly improved efficiency, reduced costs, and enhanced animal welfare at Beatrice Hill. With instant data and alerts, they can respond to water-related issues, preventing livestock dehydration, optimising animal growth.

## References

Ahlberg, Cashley M., *et al*. (2019): "Characterization of water intake and water efficiency in beef cattle." *Journal of Animal Science* 97.12 4770-4782.

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# Real Time Feed Efficiency, in Extensive Systems

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## Not all cattle are built alike.

Feed efficiency is a critical factor that significantly influences the productivity, sustainability, and profitability of extensive livestock systems. Traditionally, these systems have been disadvantaged due to a lack of real-time data at the individual animal level under real word grazing conditions. The inability to differentiate performance within the same herd or paddock posed a significant challenge to improvement. While intensive systems, such as dairy farms and feedlots, have begun harnessing technology to obtain these insights an accessible solution that enables the same level of detail in extensive systems has been elusive, until now.

## Combining innovative technologies to find efficient animals

Utilising the Ceres Tag, a state-of-the-art direct-to-satellite livestock monitoring platform with a built-in Pasture Feed Intake (PFI) algorithm, coupled with the Optiweigh mobile front foot livestock weighing system, we've been successful in gathering individual animal feed efficiency data right in the field, in real-time, with the help of commercially available technologies.

The combination of these pioneering technologies has enabled us to amass, analyse, and share crucial feed efficiency data with owners and managers (Figure 1) and shed light on the performance of cattle under grazing conditions.

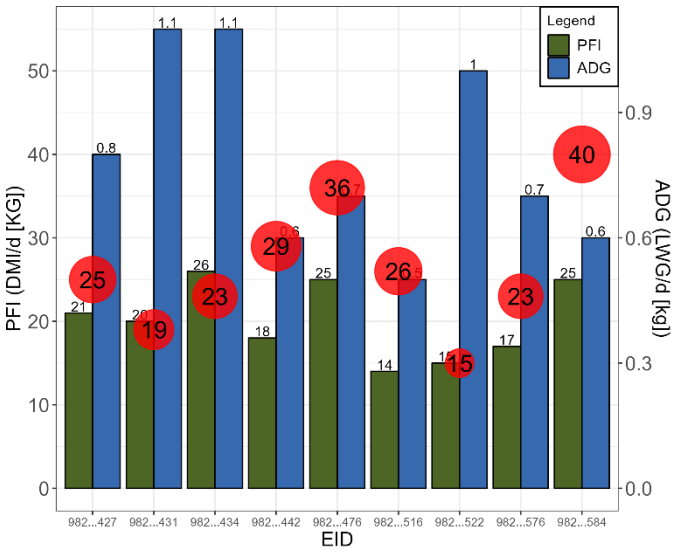


**Figure 4. Feed efficiency values captured using the combination of Ceres Tag and Optiweigh technologies. Red bubbles denote feed conversion efficieny, lower is better.**

Within our preliminary trials, day-to-day and animal-to-animal variability was observed. We've found that an animal's PFI is remarkably consistent over time, but the average daily weight gain varies more. This suggests that continuous monitoring provides a more nuanced view of feed efficiency compared to traditional weight measurements at two disparate points.

The valuable insights gleaned from these initial trials will guide us in defining the optimal protocols for collecting precise Feed Conversion Efficiency (FCE) data under real-world, commercial grazing conditions.

## The future of livestock management

As these technologies gain more traction and are increasingly adopted within the industry, they will catalyse a transformation in livestock management. The promise is a heightened productivity, a step towards sustainability, and enhanced profitability. The insights gained will serve as a key for refining breeding programs, and optimising performance, all while contributing to a greener future for large-scale livestock operations.

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# Observing grazing habits of cattle on Leucaena utilising GPS collar data

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## Introduction

The GPS data for this observational report was obtained during a grazing study to determine the response in animal productivity from cattle when fed Leucaena under grazing conditions.

## Methods

Two 6.8ha paddocks of established mixed pasture were utilised. One paddock was planted with the Redlands variety in 12m double rows, the other with the Wondergraze variety. The grazing trial ran from 2 April to 3 September 2020. The collars were placed on 6 animals in each cultivar for a period of 4 weeks (5 August – 3 September 2020) to determine spatial grazing behaviour after a period of good rain.

## Results

Initial visual observations indicated ample Leucaena (Figure 1A). While not all movement is associated with grazing, it can be assumed that grazing activity was associated with movement, particularly when movement is slow as identified by point density. Resulting GPS data shows a preference for fence lines and avoidance of other areas and marked differences in how the cattle were spatially arranged within the paddock at the start and end of the grazing period. Heat maps (Figure 1B, Figure 1C) show the concentrations of all animal positions over 24 hours on the 6 August and 2 September 2020 and demonstrate that certain areas of the paddocks were avoided by cattle at the beginning of the grazing period (Figure 1B). However, by the end cattle were utilizing most of the paddock area in both cultivars (Figure 1C). Botanal data confirm these avoidance areas were dominated by weeds, but further analysis is required to fully characterise grazing behaviour in the Leucaena paddocks.

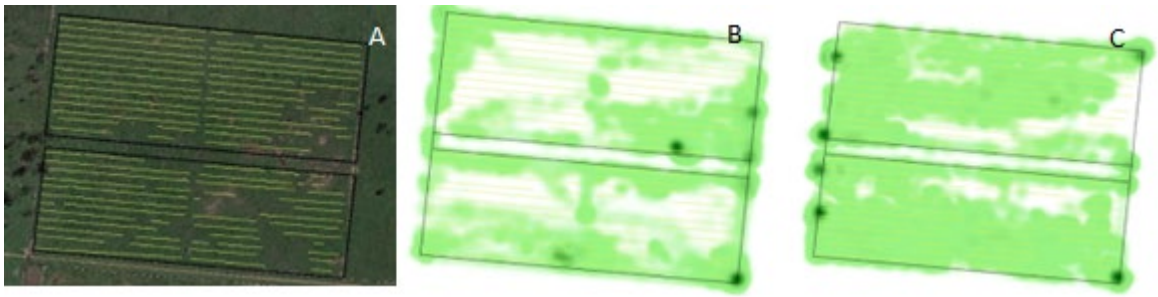


**Figure 1. Spatial Representations: (A) Leucaena plantations in Wondergraze (top) and Redlands (bottom) paddocks; (B-C) Heat maps of animal position density on 6 August and 2 September 2020, respectively.**

## Discussion and conclusion

It was not clear that animals were spending more time at the Leucaena, with ample grass available. The difference between heat maps is most likely due to cattle being reintroduced to the paddock on the 6 August 2020 and walking the fence lines versus familiarity and searching the paddock due to lower levels of feed available on the 2 September 2020.

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# Calf Alive: Attendance of study animals at walkoverweigh and autodrafting

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## Introduction

Quantifying the production benefits derived from implementing mob-level interventions poses challenges due to paddock variations. Researchers often replicate paddocks to control this bias. Alternatively, in-paddock remote technologies like the walk-over-weighing system with an auto-drafter (WoW-A) can be used. WoW-A autonomously drafts livestock using RFID, enabling comparison of animal performance when co-grazing a single paddock. The Calf Alive project utilized this technology for in-paddock nutritional comparison. This paper summarizes cattle attendance rates in the late-dry and early-wet seasons.

## Methods

A Tru-Test WoW-A was installed near the only permanent water point of a 2,200 ha paddock on Manbulloo Station, NT. Cows were stratified by LW and randomly assigned to Treatment (56 cows) or Control (43 cows). All cows had access to a mineral supplement external to the WoW-A. A 6-week training program was conducted and cows were auto-drafted between 07/11/2022 to 17/01/2023. Data captured by the WoW-A was transmitted, providing near-real-time access. Daily attendance of animals was determined using RFID scan data from the WOW-A. All analyses were performed using R (version 4.3.0) and R Studio (version 23.03.1).

## Results

Daily attendance of study animals is summarised as Figure 1. The initial high attendance can be attributed to the lack of surface water elsewhere in the paddock, and as the wet season started, cows were less motivated to frequent the WoW-A. On average, 17.8% higher attendance was observed for the treatment group (P<0.01), with ~33% and 15% of cows with daily attendance to the WoW-A for the treatment and control group, respectively.

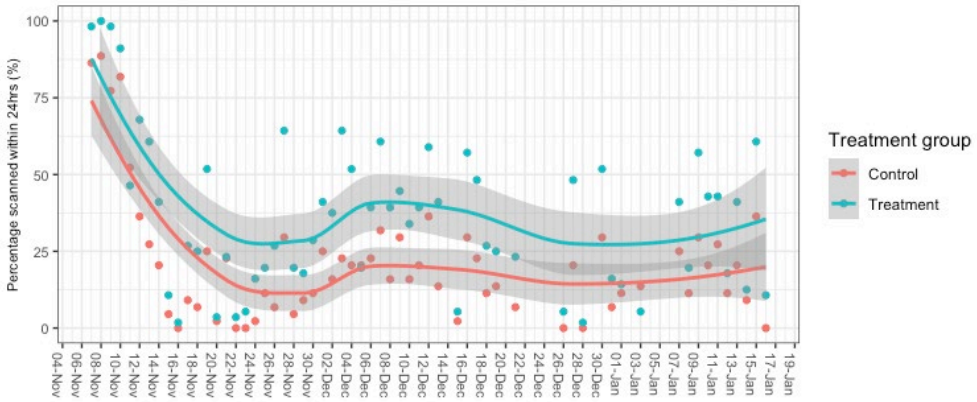


**Figure 1. Attendance of study animals at walk-over-weighing system equipped with an auto-drafter.**

## Conclusion

The results of this study highlight the challenges associated with conducting in-paddock comparisons during the wet season. Additionally, highlights the influence of a highly palatable diet as a motivating factor for the use of WoW-A.

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# Satellite assisted pasture budgeting supporting best management practices at brian pastures research facility

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## Introduction

Forage budgeting is the process of calculating the forage supply and livestock demand over a set period, a critical period for northern Australia is from the end of the growing season until the start of the next growing season, or the production date (Campbell, 2018). Having the knowledge of how much feed base is available is critical for producers to prepare for key decisions such as selling cattle, organising feed, and ensuring paddocks are rain ready. Brian Pastures Research Facility (BPRF), located near Gayndah in South-East Queensland, utilises forage budgeting as a pasture management tool to develop a grazing plan. BPRF completes forage budgeting annually when pastures have senesced, and nutritional values have begun to decline. Previously staff at BPRF have manually collected data and calculated pasture biomass. Satellite biomass predictor technology provides an opportunity to improve the accuracy of pasture budgeting and allow monitoring of pastures more regularly.

## Methods

Within a paddock, transects are selected considering land type, variation in Total Standing Dry Matter (TSDM) based on satellite imagery from CIBO Labs PastureKey (CIBO labs Pty Ltd, 2023), and pasture composition. By using the data from CIBO Labs, we can determine the most representative area to begin the 100m transect. Quadrants are recorded at 10m intervals within the transects with the following being measured in each: dominant and sub dominant species, unpalatable plant and pasture species, green fraction and total dry matter biomass yield (kg/ha). Total estimated unpalatable species, detachment, and target residual (kg DM/ha) are subtracted from the estimated Total Standing Dry Matter available for grazing.

## Conclusion

Using modern technologies such as CIBO labs PastureKey (CIBO Labs Pty Ltd, 2023), ensures we are getting up-to date data from across each paddock to allow for more precise decision making. Currently, the satellite imagery cannot identify pasture species; therefore, it is still important to ground truth. This method has increased accuracy by allowing more representative transect locations to be selected, picking up yield variability. Completing an annual forage budget is crucial for BPRF for drought preparedness, reducing overgrazing, monitoring pastures over time and supporting pasture improvement initiatives.

## References

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CIBO Labs Pty Ltd, 2023, 'PastureKey', CIBO Labs, viewed 31 May 2023, https://support.cibolabs.com.au/en/knowledge/breakdown-of-pasturekey-images

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# No connectivity? No problem for capturing collar data in Northern Grazing Systems

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## Introduction

From Sept 2019 to Apr 2022, 173 heifers were fitted with monitoring collars as part of the Repronomics II project at Brian Pastures Research Facility (BPRF). Activity and rumination data was collected for a total of 530 days over two Department of Agriculture and Fisheries managed properties (BPRF & Clearlands), approximately 9km apart. Commercially available collar technology was developed to monitor health and production parameters in dairy herds, but little investigation had been conducted on the systems suitability in northern grazing systems with tropical cattle breeds.

The objective of this project was to apply the currently available collar technology, combined with available wireless networking technology and attempt to collect continuous data on reproductive behaviours of heifers in a northern grazing system with no internet connectivity.

## Methods

A total of four remote, solar powered collar reading stations were constructed, transferring data back to a mains powered base station. Each station was surrounded by four cattle panels to protect them from animal interference. Due to terrain and vegetation variation in paddocks, the stations were situated around watering points therefore paddocks did not need 100% coverage or with a direct line of sight with other stations, to ensure the raw data was collected at a minimum of once within 12 hours.

A wireless local area network (WLAN) was configured due to the remote location and low-quality phone signal. The WLAN allowed the raw data to be transferred between stations and between properties. There was an average distance between stations of 2.7km and a total coverage area of 13.48km² on BPRF and 12.50km² on Clearlands.

## Discussion

There were numerous challenges in the development of this system and adapting the technology to a northern grazing system. Although climatic conditions did not impact signal strength, data was lost during November 2021 after severe storms damaged equipment on three stations. The amount of vegetation present in grazing areas (particularly Leucaena) impacted not only the signal strength and line of sight, but also increased the incidence of lost or misaligned collars. The system could be further improved by reconstructing each station onto a trailer, enabling the stations to be moved more efficiently.

The mobility of the stations means they can be relocated as cattle move paddocks. Establishing a long-range wireless connection between Brian Pastures and Clearlands enabled real time surveillance remotely in comparison to the previous system of manual checks. The remote wireless network has the potential to be utilised in many other locations and in other research.

## Conclusion

Through the construction of the remote network of collar reading stations, real time data was successfully able to be recorded in a northern grazing context. This system has the capacity to support the data transfer of different recording devices over long distances and has the potential to cover larger areas with additional stations. This work illustrated the potential for industry to adopt this system to large, remote properties whilst reaping the benefits of real time data collection.

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# Insight to individual breeder performance using paddock-based technology

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## Introduction

In most commercial breeding herds, individual breeder performance (except for pregnancy status) is often not explored due to the need for collecting maternal pedigree information. Walk over weighing (WOW) technology used in research has provided the ability to show breeder efficiency differences. A commercial breeder WOW demonstration has been established at Echo Hills, Roma, to gain insight into individual breeders and assist producers make objective decisions for drought preparedness.

## Methods

High content Angus females (2018-2020 drop) have been monitored over two calving seasons (commencing August 2021 and 2022) to weaning. The Ultrablack sired 2022 calf drop comprised of 95 head and the 2023 drop, 162 head. During August and September (main calving), project staff visited the mob every 7-10 days to make birth date and other calving related observations. Simultaneously, WOW unit datasets were being stored and analysed in the Datamars system, with a significant drop in dam live weight indicating date of birth. Paddock observations and cleaned dam weights have been cross referenced. Cow-calf units were identified by staff using management tags. A match was allocated if a calf was seen sucking or clearly isolated from the mob with a dam. To investigate the ability to remotely identify cow-calf units, the RFID tag order of dams and their progeny passing by the WOW unit panel reader was sent to Sapien Technology for analysis using the Pedigree Matchmaker algorithm, that was created by the Sheep CRC. The 2022 drop was monitored from late December 2021 (branding) to late March 2022 (weaning). Due to a tag mishap, only 63% of the 2023 drop were initially tagged at branding in late October 2022, with the rest tagged late January 2023. The majority (130 head) of the 2023 drop were weaned in late March, with 32 head returning to their dams and readings collected until 1 May 2023. The algorithm used in the analysis groups results in confidence levels, from Score 1 (high) to Score 4 (low). Score 1 and 2 are generally trusted, with Score 1 defined as 100% of 11 or more matches between cow and calf RFID, and Score 2 100% of 4-10 or 75% of matches.

## Results and discussion

In the 2023 calf drop, 88 paddock observations for birth date lined up (within 2-3 days) with a significant drop in dam live weight in the Datamars cleaned weights file. In 3 instances, accurate birth date observations were not reflected in a live weight drop. Cow-calf units were intermittently identified in the paddock by the project team, with 84% and 68% mothered up in the respective calf drops. Using birth dates, mothering up information and an assumed 36kg birth weight, 57 head of the 2023 calf drop averaged 1.15kg/day (0.78kg/day – 1.43kg/day) from birth to weaning in late March. This variation provides valuable insight into the high and low performing breeders. The Pedigree Matchmaker algorithm generated 66 score 1's for the 2022 calf drop; 51 of these matched the team's paddock observations and 15 were simply not observed as a unit by staff overtime. Eight score 2's arose, with 5 matching and 3 pairings not observed. A set of twins was also confirmed. In the 2023 drop, there were 53 score 1's; 37 matched, 15 were not observed, however 1 pairing was different to the paddock observation. A further 35 score 2's had 19 matches, 14 not observed and 2 pairings different. Very positive findings on the whole, but aware the dataset was limited by demonstration resourcing and surface water in trial paddocks in late Winter/Spring 2023. This demonstration has provided the Echo Hills team and the wider community with insights into how paddock-based technologies such as a WOW unit can aid with decision making to have an efficient breeding herd.

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# Navigating on-animal sensor technologies: A guide for graziers wanting to generate new insights on their property.

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## Emerging technologies in agriculture: the rise of 'smart tags' in the rangelands

The rapid integration of technology into agriculture has precipitated a significant shift in the dynamics of livestock management, particularly in intensive systems. At the forefront of this development are on-animal sensor technologies, often referred to as "smart tags." As emerging data-gathering tools, these devices have the potential to revolutionise extensive grazing systems, contributing to improved livestock management and informed on-property research.

Smart tags allow for the continuous monitoring of animal behaviour and location, providing invaluable insights into grazing patterns, health status, and significant production events such as calving. This granular level of data equips graziers with previously inaccessible information that can prove essential for informed decision-making, thereby enhancing the robustness of livestock management practices.

## Navigating the complexities of smart tags

Despite the considerable potential of these technologies, graziers face a complex decision-making landscape when considering the integration of these devices into their operations. The financial implications, technical specifications, data handling requirements, and the practical considerations of deploying these devices necessitate careful deliberation. Understanding the distinctions between commercially ready, under-development, and research-grade devices, the types of data recorded, modes of communication, and the overall costs is paramount. These elements not only impact the successful integration of the technologies, but they also affect the validity and utility of the data collected, thus influencing the overall outcomes of on-property research.

## Guiding the deployment of smart tags

Recognising the challenges inherent to this decision-making process, CQUniversity's Precision Livestock Management group, has taken the initiative to develop a set of guidelines for the procurement and deployment of on-animal sensor technologies. This resource delineates the critical aspects to consider when selecting and deploying these devices, thus serving as a practical roadmap for graziers venturing into this innovative aspect of livestock management.

The guidelines encapsulate key practical considerations and potential hurdles associated with the use of smart tags. They aid in identifying the most suitable technologies aligning with specific research objectives and highlight the importance of commitment to maintenance and data management. This comprehensive resource provides a foundation upon which graziers can build a data-driven approach to livestock management, mitigating the risks associated with improper technology adoption.

## Towards sustainable, data-driven grazing

The advent of on-animal sensor technologies presents a transformative opportunity for extensive grazing systems. The correct deployment of these devices can offer fresh insights into livestock behaviour and health, and potentially drive the development of best management practices. However, realising these benefits requires careful consideration of the available technologies and a commitment to ongoing data management. The guidelines developed by CQUniversity serve as an invaluable resource in this regard, aiding graziers in making informed decisions and promoting the advancement of sustainable, data-driven grazing.

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# Assessing pasture dieback with a drone

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## Introduction

Pasture dieback causes the premature death of highly productive grass-pastures in coastal areas of Queensland and New South Wales, significantly impacting beef production in these regions. Early symptoms of pasture dieback are leaf discolouration including yellowing and reddening. Currently leaf discolouration is assessed using visual estimations by a team of people, but this produces subjective data and is impractical and time consuming for large areas. This paper investigates the feasibility of using a drone and orthomosaic processing techniques to produce images and indices that can be used for statistical analysis of plant health.

## Methods

A DJI Mavic 2 drone was used to capture aerial and orthoimages of pasture dieback research sites. Flights were planned to produce a 70% overlap between orthoimages for subsequent orthomosaic generation. GeoTiff processing was conducted for the Green Leaf Index (GLI; Louhaichi *et al*. 2001).

## Results

Imagery produced by the drone has high accuracy with an average resolution of 0.98 cm (Figure 1). Analysis of orthomosaic images has provided indicative imagery (Figure 1) and quantifiable data for GLI as an assessment of plant health.

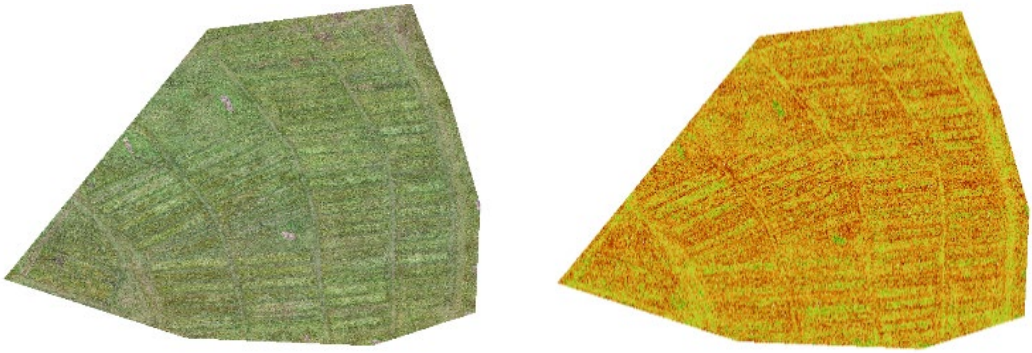

**Figure 1. Normal drone image (left) and GLI image (right) of the same pasture dieback trial site**

## Discussion and conclusion

This process enables rapid identification of pasture dieback affected areas and produces quantitative plant health data that can be statistically analysed. Repeating this process over time will produce multi-temporal comparisons to monitor of the progression of pasture dieback symptoms. While this approach shows promise, certain limitations must be acknowledged, including the need for optimal weather and light conditions for drone flights, and camera calibration and image processing algorithms that may influence the accuracy of data produced. Future research will focus on refining the image processing techniques, exploring the integration of multispectral or hyperspectral data, and developing automated workflows for large-scale assessments.

## References

Louhaichi, *et al*. (2001). Geocarto International. 16. 10.1080/10106040108542184.

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# FIREGRAZE: Using strategic patch burning to influence cattle landscape preference and improve land condition

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## Introduction

Fire can be used to better distribute grazing pressure into underutilised areas, reducing the potential degrading impacts of high utilisation rates surrounding water points, or preferred soil types (Dyer *et al.* 2003). At Victoria River Research Station in the Northern Territory, the FireGraze project is trialling prescribed burning to alter landscape preference of cattle, to draw cattle to underutilised parts of a paddock with fire and reduce grazing pressure on preferred land types.

Conkerberry paddock is 14km$^2$ and a mix of calcareous red earths with black spear grass (*Heteropogon contortus*) and alluvial cracking clays dominated by ribbon grass (*Chrysopogon fallax*) and Flemings bush (*Flemingia pauciflora*). In 2020 most of the paddock was in B to C condition with some areas of the alluvial clays in D condition. There has been a decrease in palatable, productive perennial (3P) grasses since 2003 at long term monitoring sites in the paddock. It is hoped fire will reduce grazing pressure in areas where 3P grasses have noticably declined on the alluvial clays and move cattle grazing onto the burnt area which was previously dominated by large areas of underutilised black spear grass.

## Methods

In September 2022, 20 GPS collars were deployed randomly within a herd of 55 pregnant Brahman cows. In November 2022 a prescribed burn was conducted in a 1.5km$^2$ area within the red earth land units dominated by underutilised black spear grass. Five photo monitoring points were established in the burnt area prior to the burn and are revisted monthly. Species composition, grazing intensity and ground cover will also be assessed across the paddock in June 2023 at pre-existing long term monitoring sites. The methodology will continue in Conkerberry paddock and begin in Box paddock in May 2023.

## Results and discussion

GPS Collars were collected during first round mustering in May 2023. Analysis of GPS data began in June 2023. Photo monitoring points will document any visual changes and an assessment of long term monitoring sites will occur in June 2023. 50 GPS collars were redeployed into Conkerberry and Box paddock in May 2023.

The project will provide insights into how cattle interact with different land types before and after fire and how fire can be used to improve grazing distribution, alter the grazing preference for non-preferred pastures and how this influences land condition change and animal performance.

## References

Dyer R, Café L, Cobiac M and Cowley, R (2003) Developing sustainable grazing management systems for the semi-arid tropics of the Northern Territory. Final Report, Project NAP3.211 Meat & Livestock Australia

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# “Paddock Power”: a user-friendly tool for planning new pastoral infrastructure

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## Introduction

Are you looking for a simple way to:

- Keep your own property maps up to date?
- Plan new water points, fences or pipelines and cost them out before you build them?
- Compare different infrastructure development options to see which one/s will deliver the best “bang for buck”?
- Generate reports to take to owners, shareholders or banks to secure funding for your development plans?

With funding support from Meat & Livestock Australia and the NT Department of Industry, Tourism & Trade, we have collaborated with Trailmarker, Holmes & Company and Bush AgriBusiness to develop a user-friendly Mapping Tool and Investment Calculator to do all these things.

## Why did we develop this tool?

Many properties in northern Australia contain paddocks that are too big and under-watered, which constrains livestock productivity and effective animal-level management. Paddocks with few water points exhibit both over- and under-utilisation of forage (depending on distance from water) and limited opportunities to impose management practices for optimum pasture performance, animal welfare and livestock production.

To overcome these problems, the owners and managers of large properties are actively installing additional fencing and water points. However, the impacts of any given infrastructure development on pastures, livestock and business performance are often still based on “gut feel”.

Given the expense of development at scale, producers have told us that they require evidence-based planning to better articulate the costs and benefits of proposed infrastructure investments to owners and financiers.

## How can you use this tool to improve your decision-making?

The first step is to map your development plans using the Paddock Power Mapping Tool. You then enter data generated from the Mapping Tool and your own records into the Paddock Power Investment Calculator. The Investment Calculator compares the costs and benefits of your selected infrastructure development options and evaluates their financial performance in the context of your property’s specific land types, carrying capacity, cost base and livestock productivity.

The tools are supported by a one-day training workshop in your region, or via one-to-one assistance provided by skilled users.

Curious to know more? Contact us if you are ready to start using these tools for data-driven decision-making in your business!

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# Stocktake GLM app assists graziers in South East Queensland

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## Introduction

The Stocktake GLM app is logical and intuitive decision-support tool that generates a five-star experience for the user as they manage and monitor their grazing land. The app has undergone numerous updates since its inception in 2013, including the most up-to-date land type mapping and pasture growth modelling. Most recently, the Stocktake GLM app has incorporated the latest adult equivalent calculation methodology (McLeannan *et al.* 2020) for beef cattle, sheep and goats. The app is mobile based, instead of web based, meaning that it can be utilised in areas outside of internet coverage. All user data is stored on servers located within Australia with strong data security protocols.

The Stocktake GLM app is supported by a face-to-face workshop. In South East Queensland, these workshops are delivered in partnership with the local natural resource management group, Healthy Land and Water. Supporting workshops have been held in at least two locations annually since 2018.

## Methods

The Stocktake workshops showcase the features of the Stocktake GLM app—land condition monitoring and forage budgeting. A typical agenda for Stocktake workshops can be seen in **Table 1**.

**Table 1. Stocktake workshop agenda.**

| | |
|---|---|
| Session 1 | The science behind the principles of grazing land management |
| | An introduction to Adult Equivalents and basic forage budget concepts |
| | Setting up a property and paddocks on the Stocktake GLM app |
| Session 2 | Pasture identification activity including palatable, perennial, and palatable species |
| | Land condition monitoring |
| | Setting up land condition monitoring sites on the Stocktake GLM app |
| | Discussion and review of learnings |
| Session 3 | Forage budgeting — balancing supply and demand |
| | Forage condition, assessing yield and animal demand |
| | Discussion and review of learnings |
| Session 4 | Process data from field in the classroom |
| | Generate a land condition and forage budget report using the app |
| | Review, evaluate and questions. |

## Results

As of May 2023, the app has had 547 downloads. On average, workshop attendees rate their experience as 6.8 out of 7, with the large majority indicating that they will change something about their current management because of attending the workshop and learning about the Stocktake GLM app.

## Discussion and conclusion

The Stocktake GLM app and supporting workshop assist both experienced and less experienced graziers to manage their natural resource sustainably.

## Reference

McLennan *et al*. (2020) Final Report, Project B.GBP.0036, Meat & Livestock Australia, Sydney.

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# Modelling SchMOOodelling – What's grass got to do with it? Getting the most out of your animal production datasets

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## Introduction

Pasture utilisation impacts cattle growth (Ash and Stafford Smith 1996), but the effect of utilisation on breeder performance has often been overlooked in cattle production studies.

## Methods

We retrospectively modelled pasture utilisation using GRASP for existing breeder herd performance datasets containing 75,000 cattle records collected between 1991 and 2022, at 60 sites from across northern Australia. Sites were located from the arid shrublands in central Australia (125-250mm rainfall) to the tropical Eucalypt savannas of Katherine and Cape York (>900mm rainfall). They include observational studies on commercial stations, to studies designed to measure the impacts of the provision of shade, infrastructure development, breed, supplementation, grazing system, stocking rate and utilisation on breeder performance.

## Results

Annual pasture utilisation was simulated for 350 site years and ranged between 0.5% and 114% of annual pasture growth (Fig. 1). Breeder performance declined with higher relative pasture utilisation.

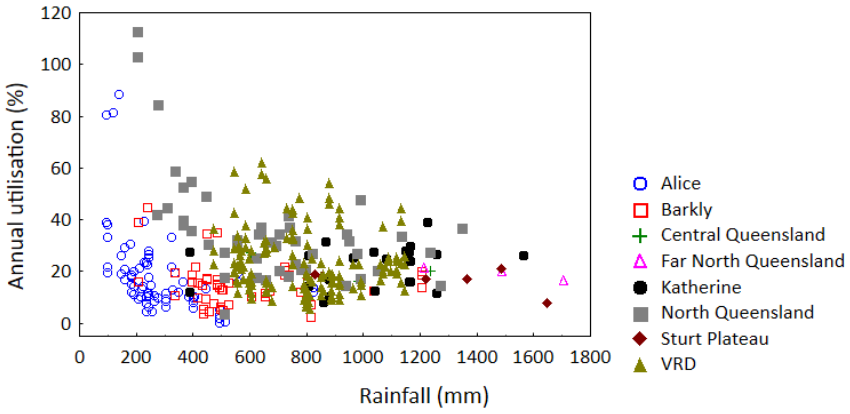


**Figure 5. Annual pasture utilisation for each site and year vs. annual rainfall by region**

## Discussion and conclusions

The land condition and financial implications of varying pasture utilisation in breeder operations will be extrapolated via bioeconomic modelling. Insights gained will then be used to develop breeder herd management guidelines. This study has developed a repeatable methodology to model pasture growth and utilisation in extensive rangeland paddocks. It shows the importance of designing and reporting animal production studies in a way that facilitates the modelling of pasture utilisation as part of the environmental factors considered when analysing and interpreting animal performance.

## References

Ash AJ, Stafford Smith DM (1996) *The Rangeland Journal* 18, 216-243.

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# Are production measures a good indication of pregnancy success?

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## Introduction

Management of replacement heifers including considered selection for breeding is important to ensure good conception rates and a positive pregnancy experience. The assessment of age, liveweight, average daily gain (ADG), and hip height measurements have been widely used to assess the suitability of heifers for mating (Jones *et al.* 2018). Body Mass Index (BMI) is an indication of body size and is calculated using body weight and height. BMI has been linked to infertility in human females with a decreased likelihood of pregnancy at the extreme ends of the BMI scale (Zhu *et al.* 2022).

## Methods

This study involved 40 maiden Brahman heifers, approx. 2.5yo who cograzed a single paddock at Queensland Animal Science Precinct, Gatton. Liveweight (LW) and hip height (HH) were recorded one week prior to a 10-day FTAI program. Heifers were inseminated by the same experienced technician with semen from the same sire, a grey polled Brahman, with LW recorded and pregnancy determined (PD) via ultrasound 40 days afterwards. ADG was calculated to represent the period between pre-mating PD. Body mass index (BMI) was calculated by dividing pre-mating LW with HH. Logistic regression analyses and predicted probability of pregnancy were completed by employing R (version 4.3.0) and R Studio (version 23.03.1).

## Results

At pre-premating heifers averaged 322kg LW and 134.9cm HH. At PD a 417kg average LW was recorded. From one round of FTAI, 52.5% of heifers were confirmed pregnant. A significant association between pregnancy for individual heifers was not determined for the parameters pre-mating LW, HH and ADG. However, a strong relationship for BMI existed (P<0.04).

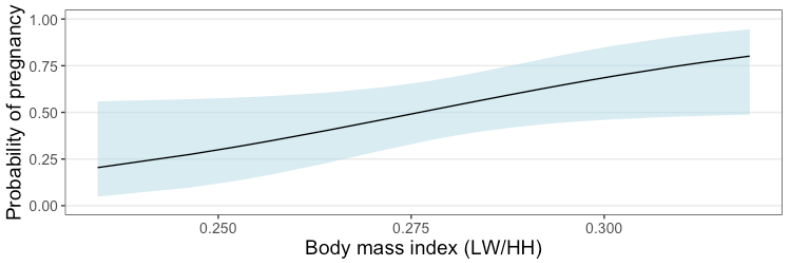


**Figure 1. Predicted probability of pregnancy for body mass index**

## Discussion and conclusion

This study demonstrated that BMI was a stronger univariate predictor of pregnancy success than pre-mating LW, HH or ADG at the time of mating in a group of similarly aged Brahman heifers. These findings align with existing knowledge that HH is a practical and informative measure associated with livestock performance.

## References

Jones AL, *et al.* (2018) Translational Animal Science. 2, 74-80.
Zhu L, *et al,* (2022) International Journal of General Medicine. 15, 1821-1831.

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*The support provided by QASP staff and Meat and Livestock Australia is acknowledged.*

# Applying AE ratings to cattle by class and productivity in northern Australia

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## Introduction

The animal unit concept evolved from a need to assess the overall effect of different classes of animals, separately or in combination, on the pasture they were grazing, with an overriding aim of achieving responsible land management (McLennan *et al*., 2020).

The Animal Equivalent (AE) unit is used in northern Australia, with the standard animal defined as a 450 kg *Bos taurus* steer with zero liveweight gain. This paper outlines a set of generic ratings for the simple, yet accurate, application of AE's to cattle grazing in northern Australia.

## Methods

The growth path and production data compiled by Bray *et al*. (2015) provided the necessary information to calculate whole herd AE ratings for different levels of productivity. The Bray data was applied to the AE methodology in McLennan *et al*. (2020) where metabolisable energy demand is used to determine Animal unit equivalence. This resulted in the development of generic whole herd AE ratings. The animal production data from the regions used in the Bray data were combined based on the annual weight gain of weaner steers in the 12 months following weaning. The weight ranges used were high productivity (>150 kg LW gain/year), moderate productivity (110-150 kg LW gain/year) and low productivity (<110 kg LW gain/year). These data were then used to develop the AE ratings in Table 1.

## Results

**Table 1. Cattle AE ratings according to age and sex.**

| | Low (<110 kg/year) | Moderate (110-150 kg/year) | High (>150 kg/year) |
|---|---|---|---|
| Females <1 | 0.57 | 0.68 | 0.77 |
| Females 1-2* | 0.72 | 0.91 | 1.10 |
| Females 2-3* | 0.96 | 1.12 | 1.74 |
| Females 3-4* | 1.18 | 1.49 | 1.61 |
| Females 4+* | 1.09 | 1.29 | 1.53 |
| Steers <1 | 0.60 | 0.72 | 0.80 |
| Steers 1-2 | 0.78 | 1.03 | 1.31 |
| Steers 2-3 | 1.02 | 1.27 | 1.60 |
| Steers 3-4 | 1.15 | 1.39 | 1.52 |
| Bulls | 1.48 | 1.73 | 1.78 |

***** includes calf to weaning and accounts for reproductive rate.

## Discussion and conclusion

This approach provides AE ratings for northern and rangelands Australia in an easy to look up table that does not require estimates of weights or other production variables. More accurate AE ratings can be derived for individual circumstances as required.

## References

Bray *et al.* (2015) Desktop research project to provide data on liveweight and liveweight gain in the beef cattle sector in Queensland and the Northern Territory: Final Report, Queensland Government.

McLennan *et al.* (2020) Final Report, B.GBP.0036, Meat & Livestock Australia, Sydney.

[A] Corresponding author: ian@bushagri.com.au

# New generation NIRS calibrations to predict diet quality and performance

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## Introduction

Near Infrared spectroscopy (NIRS) allows the rapid and inexpensive prediction of nutritional traits. The method involves the development of statistical relationships between measured traits and light absorbance in the near-infrared region of the electromagnetic spectrum. Our project was initiated to (1) broaden the diversity of plant species that are predicted accurately with 160 species of pasture, crop and shrub species utilised in the Australian feedbase, (2) increase the number of forage traits predicted, (3) test accuracy of handheld machines for in-field scanning, and (4) expand capacity of faecal NIRS (fNIRS) to predict diet selection, intake and performance.

## Methods

We identified gaps, leveraged historical plant and faecal samples (sheep and cattle) from across Australia and conducted research to generate new samples. Data for more than 70,000 samples were utilised during the project. The project utilised FOSS 6500, SpectraStar XT & XTR, Bruker MPA and several in-field machines. Calibrations were developed using the partial least squares approach.

## Results

A subset of preliminary data predicting diet selection, diet quality, intake and methane is in Table 1.

**Table 1. Predictions of diet quality and performance from a faecal sample.**

| Parameter | Unit | Species | n | Min | Max | SEC | $R^2$ | SECV | $R^2CV$ | RPD |
|---|---|---|---|---|---|---|---|---|---|---|
| Diet ash | %DM | S + C* | 454 | 69.5 | 94.9 | 1.06 | 0.95 | 1.27 | 0.93 | 3.7 |
| Diet CP | %DM | S | 576 | 3.8 | 18.3 | 1.1 | 0.87 | 1.24 | 0.84 | 2.5 |
| Diet NDF | %DM | S+C | 140 | 30.7 | 72.6 | 1.14 | 0.98 | 1.75 | 0.96 | 5.0 |
| Diet ADF | %DM | S+C | 139 | 17.5 | 27.7 | 0.63 | 0.99 | 1.13 | 0.96 | 4.8 |
| *In vivo* DOMD | % | S | 506 | 26.5 | 72 | 2.5 | 0.93 | 3.1 | 0.90 | 3.2 |
| CH4 | g/kg LW | C | 79 | 14 | 23.1 | 1.13 | 0.76 | 1.26 | 0.69 | 1.9 |
| OMI | g/day | S | 516 | 246 | 1032 | 55.1 | 0.89 | 62.4 | 0.86 | 2.7 |
| DOMI | g /kg LW.d | S | 414 | 1.8 | 16.2 | 0.85 | 0.92 | 1.03 | 0.90 | 3.1 |
| Diet P | % | S | 156 | 0.1 | 0.3 | 0.02 | 0.87 | 0.03 | 0.77 | 2.1 |

*Sheep (S) and/or cattle (C).

## Discussion and conclusions

We have developed broad calibrations for a greater range of forage traits that include the majority of species (160) in the Australian feedbase. These is a very high prospect for NIRS calibrations to predict dietary CP intake for sheep and cattle. Diet ADF and NDF content was predicted with excellent results, for sheep and cattle combined. We generated a quality control level calibrations for *in vivo* DOMD in sheep, with an error of prediction of 3.1% units. We were able to generate evidence that methane could be predicted with fNIRS, although low sample numbers is a constraint. We utilised the highest quality, laboratory grade, hand-held NIRS sensors and found there is a significant statistical and biological relevant loss of accuracy, presumably associated with 'noise' created by ambient light, moisture content and sample heterogeneity.

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*Thanks to MLA Donor Company and the Livestock Productivity Partnership.*

# Use of ultrasound to determine lung health changes of calves during weaning

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## Introduction

Stress-induced immunosuppression can be related to sudden environmental or dietary changes, especially during weaning, which may predispose calves to a greater risk of bovine respiratory disease (Taylor *et al.* 2010). Ultrasound is an accurate diagnostic tool to assess lung lesion scores of calves during weaning in response to different nutritional and health management strategies.

## Methods

Two hundred and forty, seven-month-old weaners were housed 8-days in yards and 28-days in paddocks (day 0-35=Overall). Diet 1 (**D1**) loose lick with *Saccharomyces cerevisiae* fermentation product (NaturSafe, Diamond V); Diet 2 (**D2**) loose lick (control). Two vaccine groups/diet: (**a**) no BRD vaccine, (**b**) BRD vaccine (n=50 weaners/diet). Lung lesion score (score 0-5) via ultrasound was collected for 15 weaners/Treatment (**TRT**, D1a, D1b, D2a, D2b; n=60) on day 0, day 7 and day 35. Dry matter intake (**DMI**), DMI as a % of live weight (**DMILW**) and average daily gain (**ADG**) was determined.

## Results

Lung score significantly ($P < 0.0001$) increased from day 0-35. At yard entry, 90% of weaners had a lung score of 0, 10% had score of 1. At paddock exit, 3.33% had a lung score of 0 and 96.67% had score ≥1 (Figure 1). No TRT differences ($P \geq 0.10$) in magnitude for change in lung score. Overall, mean DMI and DMILW was greater ($P \leq 0.04$) for D1a/b versus D2a/b, no differences for mean ADG ($P \geq 0.14$).

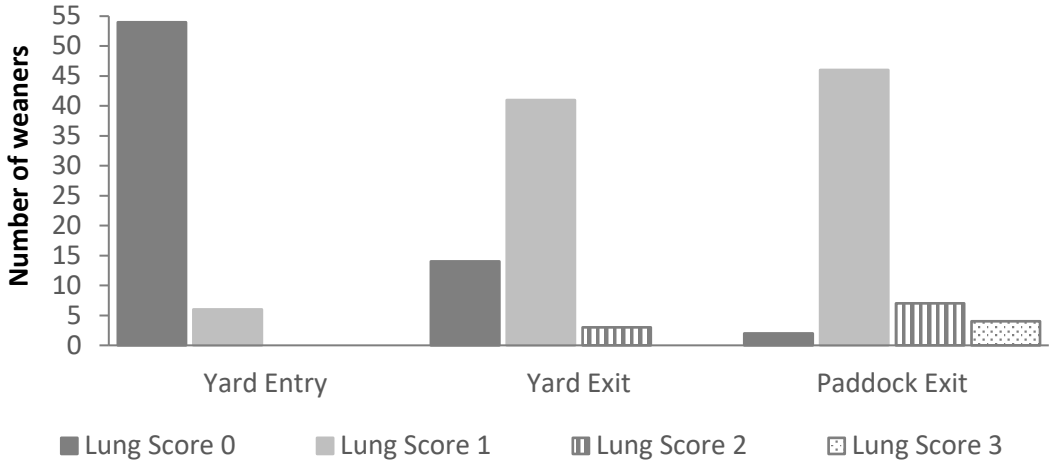


**Figure 6. Number of weaners per lung score category at yard entry (day 0), yard exit (day 7) and paddock exit (day 35). Lung score 0 (normal/healthy), 1 (pleural thickening), 2 (lobular lesion), 3 (lobar lesion).**

## Discussion and conclusion

Enhancing calves feed intake is an important strategy to help boost calf health and performance. This trial showed that incorporating the *Saccharomyces cerevisiae* fermentation product increased feed intake, suggesting a possible intake stimulatory effect. The large increases in lung score up to 36-days post-weaning, highlights the importance of implementing both health and nutritional management strategies to support lung health and improve performance of beef calves during weaning.

## References

Taylor, J, *et al.* (2010) The Canadian veterinary journal 51 (10) 1095-1102

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# Preliminary analysis of immune competence traits in northern Australian tropically adapted beef breeds

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## Introduction

Disease has welfare, production and cost implications for beef enterprises. Immune competence traits have been developed for the genetic evaluation for general disease resistance in the Angus Australia national genetic evaluation (Hine *et al.* 2019). Immune competence has not previously been recorded in northern Australian beef breeds. This paper reports preliminary results, including if there were genetic variation for immune competence traits in tropically adapted beef breeds.

## Methods

Immune competence traits were recorded on 362 northern BIN steers from 3 tropically adapted beef breeds (Brahman, Droughtmaster and Santa Gertrudis) located at 2 DAF herds (Brian Pastures and Spyglass). At each herd, immune competence was recorded at weaning, over 14 days, following the protocols outlined by Hine *et al.* (2019). Two traits were scored; cell-mediated immune response (CMIR) and antibody-mediated immune response (AMIR), with an immuneDEX index calculated combining both CMIR and AMIR. Herd, breed, birth month, dam age (years), animal age (days), weight at the start of the test (kg) and change in skin thickness during the immune competence test were all considered as fixed effects and tested for significance. For each sire, least squares means were calculated for each of the 3 traits.

## Results

Steers were, on average, 187 days of age and 223kg at the start of the immune competence test and the immune competence traits were normally distributed with average CMIR and AMIR of 30.3 log(mm) and 92.8 optical density units recorded, respectively, and the average immuneDEX value was -0.02. There was variation recorded in CMIR and AMIR with coefficient of variation of 29% and 19%, respectively. For all traits, the herd, birth month and dam age were not found to be significant. Breed was significant for all 3 traits. The change in skin thickness was significant for CMIR, with the biggest changes in skin thickness resulting in higher CMIR. For AMIR, animal age was significant, with older animals having higher AMIR. Animal age and weight at the start of the test was significant for immuneDex. Older animals had higher immuneDex and heavier animals (of the same age) had lower immuneDex values after accounting for the other significant effects. Sire least squares means showed variation in immune responses between sires, with sires within each breed having higher and lower immune responses. The relationship between all 3 measures of immune competence were very strong.

## Discussion and conclusion

Preliminary analysis of immune competence traits suggests there is genetic variation in tropically adapted beef breeds and that it is worth collecting further data to fully assess the suitability of immune competence traits for genetic evaluation in tropically adapted beef breeds.

## References

Hine *et al*. (2019) Journal of Animal Science 97:4053-4065

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# The impact of previous lactation and pregnancy status on tail hair isotopes

*Karen Eyre [A,B], Gemma Somerset [A], Joanne Campbell [A], Kieren McCosker [A], Luis Prada e Silva [A]*
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## Introduction

Cows grazing rangelands in northern Australia are put under nutritional stress throughout late gestation and early lactation. Silva *et al*, (2022) recently reported that the concentration of $^{15}N$ isotopes in tail hair can indicate the nutritional resilience of breeders and is correlated with reproductive performance. As part of the Calf Alive project, we are collecting tail hair from a population of breeding females across northern Australia to validate the prediction of reproductive potential. This pilot study looked at 100 cows to verify if $^{15}N$ levels in tail hair were correlated with previous calving history.

## Methods

Tail hair was randomly collected from *Bos indicus* cross cows at pregnancy testing (48 in calf and 48 empty) at Rocklands Station, Camooweal, Queensland (approved by The University of Queensland Animal Ethics Committee). Tail hair was processed to remove contaminants as per Schwertl *et al.* (2003) then isotope ratio measurements performed using an IsoPrime100 isotope-ratio mass spectrometer (Isoprime Ltd, Cheadle, UK). Calving history was recorded based on lactation status (wet or dry) and pregnancy status (empty or in-calf) for 2020 and 2021. Data were analysed as a randomised design (SAS, v9.4).

## Results

Cows that demonstrated an ability to become pregnant both years were observed as having a significantly lower $^{15}N$ tail hair level than cows that were not observed as pregnant in both years, suggesting increased ability to recycle N. There was no evidence that current pregnancy status (empty or in-calf) affected $^{15}N$ concentrations.


**Figure 1. Differences in $\delta^{15}N$ concentrations in tail hair of cattle that had a calf every year (grey, Yes) or did not have a calf every year (black, No), * indicates significant difference $P < 0.05$.**

## Discussion and conclusions

This study provides further validation of the use of tail hair $^{15}N$ concentrations as a method of identifying cows that are more resilient and productive in nutritionally challenging environments.

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# SERVE CAREFULLY: ANIMAL WELFARE AND BEST PRACTICE

# Continuing the search for a tick vaccine

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## Abstract

The need for a vaccine against ticks on cattle is intensifying. Relying on the indicine genotype to keep tick numbers in check in the northern Australian beef herd is becoming less attractive, due to consumer meat eating quality demand. Relying on chemicals to "make up the deficit" is not sustainable. There are more species than just the Cattle Tick to consider.

The answer might be closer than we think. Bm86 needs a makeover, but other antigens and new possibilities have been described. Novel transformational technology might deliver a longer-lasting immune response.

The pharmaceutical industry is an unlikely partner in this quest. Vaccines are seldom “blockbuster” products. IP protection ambiguity is a disincentive. Expectations of vaccine efficacy are disadvantaged by an unrealistic comparison with past chemical performance.

## Background

Ticks on cattle need to be managed, to mitigate the multiple risks they pose to profitable production. Reliance on innate host resistance and chemicals have been combined with attempts to induce adaptive immunity (Bock et al. 1997; Jonsson *et al*. 2000; Abbas *et al.* 2023). No single approach to tick control has thus far been successful.

The Bm86 antigen, isolated from the midgut of Cattle Tick (*Boophilus microplus* ticks [syn. *Rhipicephalus australis*]; Johnston *et al*. 1986, Willadsen *et al*. 1992) has not yet been equalled commercially, and continues to be considered a success in several Caribbean countries, where vaccination of cattle has lowered the incidence of babesiosis and acaricide use (De la Fuente *et al*. 2007; Suarez *et al*. 2016; Rodríguez-Mallon 2023). But it did not meet the needs of the Australian northern beef herd in two commercial formulations, mainly due to the need for repeated re-vaccination during one season. Bm86 is now an orphaned molecule in Australia and a good example of market failure.

Elsewhere, Bm86 has displayed inconsistent efficacy. This can be ascribed to the system used for expressing the antigen (*E coli*, Baculovirus, *Pichia pastoris* or pKLAC2-*Kluyveromyces lactis*) (Tabor 2021), but could also be due variations in the midgut protein sequences of different tick isolates (Freeman *et al*. 2010; Cunha *et al*. 2011). Variations of up to 3.65% were seen in the nucleotide sequences of the Bm86 gene, and 6.08% in the amino acid sequences of the Bm86 protein in thirty *R (B) microplus* strains from Brazil, Argentina, Uruguay, Venezuela and Colombia. Amino acid sequence variations greater than 2.8% are deemed sufficient to confer vaccine inefficiencies (Sossai *et al*. 2005). Sequencing the Bm86 cDNA gene from 125 field isolates revealed 3.1 to 7.4% divergence from the Yeerongpilly reference vaccine antigen, which was thought to account for the poor efficacy of the vaccine in many parts of Mexico (Martínez-Arzate *et al*. 2019).

Much time, money and effort have been expended on the search for novel alternative tick antigens in Australia, with funding provided by the Beef CRC, MLA and the MDC (Lew *et al*. 2008; Tabor *et al. 2017;* Anon. 2021; Mahony 2021). None of these has excited commercial interest due to disappointing efficacy, for a variety of possible reasons. Attempts thus far to formulate a depot injection of Bm86 that will confer protective immunity lasting at least one year have not succeeded (Mahony *et al*. 2019).

A confluence of three circumstances seem to provide the incentive for renewed efforts in the search for a vaccine against ticks on cattle in Australia. Australian cattle face an escalating challenge of tick infestation, not confined to the Cattle Tick. Recent technological developments offer tantalising possibilities for relatively quick access to a tick vaccine. The global pharmaceutical industry has consistently shown lukewarm enthusiasm for this quest, which may be the incentive for a concerted local effort.

## The need is escalating

The innate immunity of Zebu cattle to tick infestation was described in 1932 (Kelly), and confirmed by elegant molecular biological research in Australia (Lew *et al*. 2008) and has for several decades provided the northern Australian beef industry with the mainstay of its tick management. Increasing market demand for beef of a better eating quality is threatening the continued success of this approach. A hump on a cattle carcase is the first penalising factor in the MSA grading process (Anon. 2023). As the northern herd's genotype changes to meet this consumer demand, its susceptibility to tick infestation will increase.

The apparently prevalent assumption that this threat can be met with the use of chemicals is unrealistic and not sustainable. Most cattle acaricides are blighted by resistance in the ticks they are aimed at (Willadsen 2008), and the constant stream of new molecules which characterised the last few decades of the previous century seems to have largely dried up. With sustainability the current catch-cry (Anon. 2022), and concerns about environmental pollution and residues in foodstuffs, the future use of chemicals must be acknowledged to be under a cloud.

Until the end of the twentieth century, ticks on Australian cattle meant the single-host Cattle Tick (*B microplus* → *R microplus* → *R australis*), infesting cattle north of the tick line. The latter has to be acknowledged no longer to be the impregnable barrier it was long regarded to represent. The first two decades of this century have also brought the realisation that there are multi-host ticks transmitting an emerging disease on the east and west coasts of the continent that need serious consideration (Schröder 2021). Oriental theileriosis presents a tick-borne problem outside Queensland and the Northern Territory. What is also disconcerting, are evidently increasing, albeit sporadic, anecdotal reports of tick paralysis affecting large numbers of calves. Whereas Cattle Tick in Australia is fairly host specific to cattle, the multi-host vectors of Oriental theileriosis and tick paralysis spend considerable periods of their life cycles away from cattle, which makes their management difficult.

## A solution might already be at hand

Possibilities for revitalising Bm86 in Australia should include addressing the gene sequence variation, optimising the protein expression, and investigating formulation innovations. Examples could include formulating a vaccine containing a "cocktail" of expressed antigens reflecting the diversity of sequences, making it a globally attractive product, or exploring the possibility of novel and persistent presentations of the vaccine, to enable longer lasting immune protection.

The scientific literature already contains descriptions of several proteins that hold promise as vaccines against more than just the Australian Cattle Tick, in more countries than just Australia (Parthasarathi *et al*. 2023). These proteins are physiological components vital to tick survival, are neither excreted nor secreted, and are not under normal circumstances exposed to the host's immune system, making them as attractive as Bm86:

| Protein | Target effect | Tick(s) | Author(s) |
|---|---|---|---|
| Subolesin | Multiple cellular processes | R microplus (decreased Babesia bigemina infection in vaccinated cattle) | De la Fuente et al. 2008; Merino et al. 2011 |
| Ferritin-2 | Preventing iron transport to peripheral tick tissues | Ixodes ricinus, R microplus, R annulatus | Hajdusek et al. 2010 |
| BmVDAC (voltage-dependent anion channel) | Mitochondrial protein with multiple functions | R microplus | Rodríguez-Hernández et al. 2015; Ortega-Sanchez et al. 2020 |
| 20 AA synthetic peptide of the acidic ribosomal P0 protein | Essential role in protein synthesis | R microplus, I ricinus | Rodríguez-Mallon et al. 2015; 2020a, b |
| TROSPA (tick receptor outer surface protein A) | Possibly plays a role in B bigemina's invasion of and persistence in the tick salivary gland | R microplus, R annulatus | Antunes et al. 2012; Hajdušek et al. 2013 |

The realisation that arthropod vectors rely on a stable microbiome for their health and vector competence is a relatively recent discovery. Dysbiosis is the disruption of this harmony, either by the pathogen transmitted by the vector (Adegoke *et al*. 2020), or by transgenic manipulation of arthropod vector microbiota (Ratcliffe *et al*. 2022), or by ingestion of host antibodies to vector microbiota antigens in the blood meal (Azelyte *et al.* 2022). Vaccines against tick microbiota alter vector feeding, the functional profile of their microbiome, and the development of pathogens in their vectors (Maitre *et al*. 2022; Mateos-Hernandes *et al*. 2020, 2021).

Bm86 was our first exposure to a recombinant subunit antigen – a protein encoded by a bit of tick DNA that's been spliced into a yeast or bacterium that can be grown in bulk. The technology has evolved to the point where recombinant subunit vaccines can be synthesised rapidly. These antigens do not pose the risks of reversion to pathogenicity or genotoxicity, but they can be less immunogenic (Chahal *et al*. 2016).

The concept of an mRNA vaccine is to identify the target antigen of choice, sequence the encoding gene in the pathogen, synthesise and clone it into a DNA template plasmid, and transcribe the mRNA *in vitro*. When delivered into the subject, the vaccine utilises the host cell for *in vivo* translation of the mRNA into the corresponding antigen, mimicking a viral infection. Gene-based vaccines are synthetic and rapidly customisable. Virtually any sequence could be designed *in silico*, synthesised, delivered as an RNA vaccine and tested rapidly *in vivo* in animal models. Antigen-encoding mRNA vaccines have been shown to elicit antigen-specific humoral and cellular immune responses. The duration of expression of mRNA is limited (Chahal *et al*. 2016; Maruggi *et al*. 2019), but can be circumvented by mRNA replicons which function as a mechanism for mRNA self-amplification (Sethna *et al*. 1989), leading to sustained translation and reducing the size of the required vaccine dose. Continued expression of therapeutic proteins for as long as seven weeks *in vivo*, moderating the need for repeated injections, can be advantageous (McCafferty *et al*. 2021) e.g., for months-long protection against tick infestation in cattle. DNA-based vectors used for gene-based vaccination raise concerns about mutagenic integration into the patient's genome (Chahal *et al*. 2016), which have to be addressed.

## We face market failure – the pharmaceutical industry is disinterested

This disinterest is not openly expressed, but can be ascribed to at least three possible reasons. The cost of investing in the development of a new livestock product and the limited period of patent protection present serious barriers to entry for anything other than a potential "blockbuster" in a livestock pharmaceutical market dominated by multinational concerns that largely rely on their synthetic organic chemistry expertise. For an animal health remedy in 2015, that was considered to be a product with annual sales in excess of US$100 million (1/10 of the same definition for a human pharmaceutical) (Anon. 2015). The development required for a food animal remedy takes more than twice as long as for a companion animal product and costs at least twice as much. Vaccines are seldom blockbusters.

Chemical molecule inventions enjoy patent protection for 18 years. In the case of genomic material (e.g., the nucleotide sequence of the gene encoding for an antigenic protein), the discovery of a pre-existing natural phenomenon is not as readily patentable as is an invention. Protectable intellectual property is likely to reside in innovative use of that pre-existing phenomenon, or the production process, but it is more difficult to define defensibly.

Successful chemical molecules in the past 4 to 5 decades have proven to be remarkably potent, giving rise to high expectations with regard to levels of efficacy. If less than 95% of a parasite population is killed by the recommended dosage or concentration of a chemical, that parasite is deemed to be resistant. The resultant expectation thus seems to be that a vaccine needs to be at least 90% effective (Playford 2005). One needs to consider for a moment the precipitous reduction in numbers if an intervention was consistently 95% effective, year after year, to realise that these expectations might be unrealistic in the case of a vaccine, and might have to be dialled back. The need has also been expressed for better coordination of global research efforts, and standardisation of tick vaccine efficacy testing methodology (Schetters *et al*. 2016).

## Conclusion

There is an undeniable need for a vaccine against ticks on cattle, not just in Australia, but also further afield. Exploiting knowledge that has already been published, in the face of apparent pharmaceutical industry disinterest, an efficient vaccine development program might be planned at a fraction of the cost of developing a new chemical for use in/on livestock. Until a committed commercial partner can be found, the funding for such an endeavour might have to be sought in a concerted and collaborative push by beef producers.

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# Biomarkers for cattle tick resistance

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## Introduction

Cattle ticks are one of the main ectoparasites affecting cattle in tropical and sub-tropical regions of the world with an estimated annual impact in northern Australia at $130m (Shephard *et al*. 2022). One difficulty in identifying tick resistant cattle for Estimated Breeding Value development is the need for accurate tick counting or scoring to identify phenotypes. An alternative is to identify a biomarker which can used as a laboratory assay to predict tick susceptibility or resistance in young cattle prior to tick exposure. This research was a component of a large MDC project investigating host ectoparasite biomarker identification.

## Methods

Thirty Brangus steers (~9 months old) sourced from a non ticky region of Central Queensland were transported to UQ's farm and artificially infested with cattle tick larvae for 12 consecutive weeks to identify the top 6 resistant and top 6 susceptible steers (Animal Ethics QAAFI/469/18) for biomarker identification experiments. Samples such as skin biopsies and bloods were collected pre and post exposure (24 hours and several time points including after the final infestation). Proteins and expressed RNAs were extracted and analysed using quantitative bioinformatics approaches to identify significant biomarkers.

## Results

Resistant naïve cattle were found to have markers associated with immune response, blood coagulation and wound healing compared to tick susceptible naïve cattle (Mantilla Valdivieso *et al*. 2022, Raza *et al*. 2023). There were less significant differences identified between tick resistant and susceptible cattle after tick infestation with delayed responses identified in susceptible cattle.

## Discussion and conclusion

Biomarkers which can be used to predict the tick susceptibility/resistance of tick naïve cattle were identified. Tick resistant cattle showed enhanced abilities to respond to tick infestations and to heal wounds in comparison to tick susceptible cattle. Assays have been developed using serum ELISA and blood expression analyses. Current research is focussing on field evaluations of these assays using cattle previously not exposed to ticks.

## References

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# The effect of insecticidal fly tags and Bovine Ephemeral Fever infection on cattle liveweight gain

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## Introduction

A study was conducted at Beatrice Hill Farm, NT to determine the effect of TRI-ZAP® fly tags on the growth of young cattle and investigate the impact of Bovine Ephemeral Fever (BEF) on growth.

## Methods

On 13/12/22, yearling Brahman heifers were randomly allocated to either a CONTROL (n=118) or TAGGED (n=118) treatment group. TAGGED animals were fitted with two TRI-ZAP® sustained-release plastic ear tags (Y-Tex®). The CONTROL group did not receive any treatment for fly control. The treatment groups grazed in separate but similar paddocks with *ad libitum* access to mineral lick blocks and were managed in the same way throughout the study. Blood samples were collected from all animals on 13/12/22, 17/01/23 and 15/05/23, and sent to the Berrimah Veterinary Laboratory for BEF virus neutralisation testing to determine which animals had been infected (seroconverted) with BEF prior to the start of the study and during the periods between blood sample collections. The liveweight gain (LWG) of the CONTROL and TAGGED groups were compared over the study period (13/12/22 to 15/05/23) and the LWG of animals that contracted BEF at different times was compared using the fly tag treatment as a covariate.

## Results

After 21.9 weeks the average LWG of the TAGGED group was 23 kg more than the CONTROL ($P<0.001$) ie. the growth rate was 0.149 kg/day higher in TAGGED. Within the fly tag treatments there were no significant differences in LWG between (a) animals that contracted BEF between 13/12/22 and 17/01/23, (b) animals that had BEF prior to the start of the trial, or (c) animals that had never had BEF; either during the period between 13/12/22 and 17/01/23 or over the whole trial (Table 1).

**Table 1. The effect of BEF infection and fly tag treatment on cattle liveweight gain (LWG) (kg).**

| Treatment | BEF status | Avg. LWG 13/12/22-17/01/23 | Avg. total LWG |
|---|---|---|---|
| CONTROL | a) Had BEF prior to 13/12/22 (n=56) | 14.4 | 71.8 |
| | b) Had BEF between Dec-Jan (n=19) | 16.4 | 75.9 |
| | c) Have not had BEF (n=33) | 12.7 | 68.9 |
| TAGGED | a) Had BEF prior to 13/12/22 (n=62) | 24.4 | 94.7 |
| | b) Had BEF between Dec-Jan (n=21) | 24.9 | 96.7 |
| | c) Have not had BEF (n=28) | 23.0 | 92.2 |

## Discussion and conclusions

The increase in LWG from using fly tags in this study is more than previously reported by Schatz *et al.* (2019) in the NT (0.085 kg/day) and less than reported by Spradberry and Tozer (1996) in Queensland (0.247 kg/day). At the current cattle price ($4.00/kg) and fly tag cost (9.90/head), the increase in LWG of 23 kg gave a 929% return on investment. BEF infection had little effect on LWG.

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# The effect of worm infestation and treatment on cattle growth on NT flooplain

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## Introduction

Intestinal worms can reduce cattle performance through impaired growth, reproduction, lactation, and feed use efficiency. Young cattle in moist environments are more susceptible. Estimates of the impact on growth of different levels of worm infestation, as measured by worm egg counts (WEC), are; a 3% reduction at 25-50 eggs per gram (EPG), 5% reduction at 50-150 EPG, 10% reduction at 150-500 EPG, and >15% reduction at >500 EPG (George *et al*. 2022; Shephard *et al*. 2022). This study was conducted to monitor the level of worm infestation over time in a herd of 1 year-old heifers in a tropical environment during the wet season, and to examine the effect of worm control on WEC and growth.

## Methods

On 14/12/22 a mob of 1 year-old Brahman heifers was randomly allocated to a CONTROL (n=108) or TREATED (n=111) treatment at Beatrice Hill Farm (55 km south-east of Darwin, NT). On this day the heifers were weighed, a faecal sample was collected per rectum from 15 heifers per treatment and the TREATED group received injectable doramectin (Dectomax® Injectable, Zoetis Australia) at a dose rate of 1 ml/50 kg body weight. The heifers then all grazed together in the same paddock until 24/4/23. They were weighed on the 20/2/23 and 24/4/23 and faecal samples were collected from the same 15 animals on each of these dates. All weights were un-curfewed. The TREATED group was given a second Dectomax® Injectable treatment on 20/2/23. All heifers were tagged with Patriot$^{R}$ (Bayer) insecticidal fly tags on 8/2/23. The faecal samples were stored individually and sent to the Dawbuts parasitology laboratory for WEC and pooled larval cultures.

## Results

The average daily gain (ADG) of the TREATED group (0.53 kg/day) was significantly higher ($P<0.0001$) than the CONTROL group (0.49 kg/day) between 14/12/22 and 24/4/23. The 5.2 kg (7%) lower growth observed in the CONTROL group during this period was similar to what is expected at the level of worm infestation (George *et al*. 2022; Shephard *et al*. 2022). The mean WEC (Strongyle genera) for the treatments were; 61, 15, 55 for CONTROL and 65, 59, 35 for TREATED on 14/12/22, 20/2/23 and 24/4/23 respectively. The worm treatment was found to be effective (reduced WEC to 0 in 15 animals) during a 14 day resistance trial before this study commenced, so the similar WEC of the treatments throughout the study is likely to be due to TREATED animals becoming reinfected from grazing in the same paddock as CONTROL animals. The WEC were quite low during the study and worm infestation is likely to have a more severe impact on growth in animals with higher WEC.

## Discussion and conclusions

These results demonstrate the level of growth reduction that worm infestation can cause in cattle with low/moderate WEC, and highlight the way that grazing management needs to be a part of worm management in cattle. Worm treatments are likely to be more effective if cattle are moved to pastures that have low worm burdens (have been spelled) after they have been treated for worms, to reduce re-infestation with worms from the pasture and other animals (as happened in this study).

## References

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# Long term effects of coccidiosis infection and treatment on cattle growth

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## Introduction

Coccidiosis is a disease caused by protozoan parasites (*Eimeria* spp.) that can cause scouring in calves at weaning. Weaning is a stressful time and stress reduces resistance to coccidiosis infection. Weaners are affected by coccidiosis to different degrees, and while most recover and develop immunity, some can be severely effected and suffer damage to their intestinal tract which can compromise long term growth and performance (Parkinson *et al*. 2019). This study examined the effect of different levels of coccidiosis infection and treatment for coccidiosis on subsequent growth.

## Methods

In May 2021 it was observed that many of the weaners that had been transported by road train to the Douglas Daly Research Farm from a site near Katherine, NT, immediately after being weaned, were exhibiting signs of coccidiosis infection. On 24/5/21 the male Brahman weaners were individually assessed in a veterinary crush and drafted into three groups depending on the severity of their symptoms: Not effected (N) (n=33), Mildly effected (M) (n=73), and Severely effected (S) (n=35). The groups were kept in separate similar buffel grass paddocks for 40 days where they received the following treatments: N: Rumevite Boost with Rumensin ™ supplement blocks (Ridley AgriProducts Pty. Ltd.), M: Laucke Beef weaner pellets ™ (Laucke Mills) containing Lasalocid Sodium at 46 mg/kg fed at a rate of 3 kg/head/day. S: Drenched with Baycox ™ (Bayer) containing Toltrazuril 50g/L on 24/5/21 and Laucke Beef weaner pellets fed at a rate of 3 kg/head/day. After 40 days, when the signs of coccidiosis had cleared up, all the animals were put back into one mob and they grazed together until 15/12/22. The liveweight gain of the groups from 24/5/21 until 15/12/22 was compared.

## Results

The mean weight of the S group was lightest ($P<0.05$) when the severity of coccidiosis infection was assessed in 2021 (N= 147 kg, M = 155 kg, S = 136 kg). There were no differences in mean growth between the groups ($P=0.6$) over the period from 24/5/21 to 15/12/22 (N= 154 kg, M = 149 kg, S = 151 kg), despite one S animal having much lower growth (60 kg) than all the others over this period.

## Discussion and conclusions

The S group being lighter initially than the other groups is not surprising, as lighter (younger) weaners are more prone to coccidiosis infection since their immune systems are less developed and they are more likely to be stressed by weaning (which lowers their resistance to coccidiosis). There were no differences between the groups in mean growth over the 17 months following weaning indicating that the treatments for coccidiosis were effective and that there was no long term damage from coccidiosis infection. The much lower growth observed in one S animal compared to all the others may have been a result of intestinal damage from severe coccidiosis infection but there are other possible causes and a post mortem investigation was not conducted to investigate potential causes. These results suggest that short term, treated, coccidiosis infection does not negatively impact long term growth. The effect of longer term, untreated coccidiosis infection was not studied, as all affected animals were treated in this study.

## References

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# The cause of buffalo fly lesions – what have we learned?

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## Introduction

Buffalo fly (BF) lesions, are a significant health issue in north Australian cattle. A filarial nematode, *Stephanofilaria* sp., vectored by BF, has been associated with the development of lesions but has not been detected in all instances and the pathogenesis of lesions remained unclear. Previously, detection of *Stephanofilaria* was by histological examination or saline recovery of nematodes, but sensitivity of these methods was low. Development of qPCR-based techniques for detection (Naseem *et al*. 2021) increased ease and sensitivity of detection and facilitated study of the causes of BF lesions.

## Methods

The surface of skin lesions was swabbed and BF were netted from cattle on 20 beef cattle properties in north, central and southern Queensland. Lesions were tested for the presence of *Stephanofilaria* by qPCR. To investigate a potential role for bacteria in lesion development, bacteria were isolated from the swabs and surface-sterilised flies. Bacteria were identified by MALDI-TOF and strain typing was by rep-PCR and genome sequencing. In addition, Brangus cattle at the UQ Pinjarra Hills Facility were monitored repeatedly over 16 months for BF numbers and the size, location and severity of lesions. Skin response to BF and nematode antigens was measured by intradermal skin testing.

## Results

RESULTS All northern and central Qld properties except for one tested positive for *Stephanofilaria* in lesion swabs or BF, or both. However, none of the 66 swabs or 1220 BF collected from southern Queensland tested positive for *Stephanofilaria* despite the frequent occurrence of lesions in the source herds. Of the 49 bacterial lesion isolates collected, 37 were *Staphylococcus agnetis* and 12 were *S. hyicus.* Half of the BF bacterial isolates had genotype identical to the lesion isolates and genome sequencing indicated presence of exfoliative toxin genes in all instances. Histological comparison of lesions indicated more severe pathology in lesions with *Staphyloccoccus* spp. present than in those without.

In the studies with Brangus cattle, high lesion cattle had stronger skin responses to BF antigens than resistant cattle, though not to nematode antigens, at 1 h, 1, 2 and 3 days after injection.

## Discussion and conclusions

*Stephanofilaria*, although frequently detected, is not essential for development of BF lesions and other factors may contribute to lesion pathogenesis. Our findings suggest the involvement of *Staphyloccoccus* spp*.* bacteria in lesion development and a role for BF in spreading these bacteria amongst cattle. Variability amongst cattle in susceptibility to lesions is primarily a result of differences in immune response to BF antigens rather than due to differences in fly challenge. In addition, lesion score was repeatable suggesting that selection against lesions will lead to reduction in lesion susceptibility. Understanding the pathogenesis of BF lesions will aid the development of optimal lesion treatment and control strategies.

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# Phenotyping cattle for buffalo fly resistance

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## Introduction

There is clear evidence of significant variation between cattle in the number of buffalo flies (BF) they carry and good evidence that susceptibility to BF is heritable (Burrow 2001). However, there have been few attempts to incorporate BF resistance into practical cattle selection programs. Accurately phenotyping cattle for BF numbers is labour intensive and frequently inaccurate and no practically useful indicator characters for resistance to BF have been identified. This project is examining methods of phenotyping cattle for BF resistance, including visual and photographic counts, the use of behavioural response to BF as an indicator of resistance and proteomic markers for resistance.

## Methods

Thirty-five Brangus cattle were characterised for resistance on the basis of visual and photographic paddock counts nine times over two years and in the yards on two occasions. The number of BF-related behaviours (head tosses, tail flicks, ear flicks and foot stamps/kicks) were observed in two-minute periods at each count. Blood samples were taken from all cattle before and after prolonged exposure to BF and proteomic profiles were assessed on the most susceptible and most resistant animals.

## Results

The overall visual and photographic counts of BF were highly correlated (r=0.87). Correlations between paddock counts on individual dates and overall BF count varied from 0.62 to 0.80. Correlations between counts in yards and total counts were lower (0.33 to 0.53) but significantly greater than 0.

Overall frequency of BF avoidance behaviours was correlated with BF counts (0.68) and there were moderate to strong correlations between BF numbers and the individual behaviours assessed (0.62 for head tosses, 0.54 for ear flicks, 0.60 for tail flicks and 0.37 for foots stamps/kicks).

Proteomic comparisons of serum samples from naïve cattle classed as high and low BF carriers on the basis of subsequent BF counts identified 44 significantly differentially abundant (DA) proteins. Prominent amongst these were proteins related to immune response and blood coagulation pathways. In samples collected after BF exposure there were 37 significantly DA proteins with high fly cattle showing differences in anticoagulation mechanisms that may facilitate BF feeding.

## Discussion

The results suggested that even a single paddock count gave a relatively good prediction of overall susceptibility whereas improvement in resistance could also be made by selection using yard counts, but at a slower rate than with paddock counts. Correlations with BF-related behaviours were moderate to high despite that cattle were only observed during two-minute periods on each observation date. We are currently investigating the use of accelerometers or inertial measurement units, potentially in ear tags, to provide ongoing measurement of behaviour over extended periods of time. The use of these tags could provide a more accurate, automated and practically appealing method for estimating BF susceptibility. Further characterisation of proteins related to blood coagulation and immune response pathways may also provide biomarkers for selecting more BF-resistant cattle.

## References

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# The Australian trichomoniasis vaccine

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## Introduction

Trichomoniasis is a venereal disease of cattle which causes delayed conception, pyometra (uterine infections), and abortions. These adverse effects ultimately lead to reduced weaning rates in mobs experiencing outbreaks of this disease. Recently, it has been confirmed that the disease is prevalent throughout North Australian beef herds, with approximately one in ten culled bulls found to be infected with *Tritrichomonas foetus* (Irons *et al*. 2022) by quantitative PCR (McMillen and Lew 2006). A vaccine was developed by CSIRO researchers in the 1980s (Clark *et al*. 1983) but it was not commercialised (unlike vibriosis – VibroVax®) due to a perceived lower prevalence of trichomoniasis, particularly in dairy herds. This Meat and Livestock Australia Donor Company funded study describes the establishment of an Australian *T. foetus* culture collection, the development of laboratory procedures for *T. foetus* culture and storage, and a successful proof-of-concept vaccine challenge trial in 6 bulls.

## Methods

A *T. foetus* culture collection was established by collection of preputial samples from culled tropically adapted bulls with known qPCR positivity from herds located on the Barkly Tableland and in south-west Queensland. Anti-bacterial and anti-fungals were applied to culture pure lines of *T. foetus* for seed vaccine development. Vaccine doses were prepared as described previously (Clark *et al*. 1983) and adjuvated with Montanide ISA 61 VG (Seppic, Australia). Tropically adapted bulls from these positive mobs were provided for this study under UQ Animal Ethics Project 2021/AE000410. Six bulls (4-8years old) were vaccinated with two doses one month apart and 12 bulls (including 6 unvaccinated controls) were challenged with live *T. foetus* parasites 2 weeks after the second vaccination. Tricamper preputial samples were collected fortnightly for 6 months after vaccination for culture and qPCR testing. The immune response to vaccination was determined by assaying sera using an IgG ELISA.

## Results

Four of the six vaccinated bulls did not become persistently infected after challenge. However, two vaccinated bulls became persistently infected. All except one bull had a significant increase in IgG ELISA value after the second vaccination.

## Discussion and conclusion

This research isolated, purified and developed *in vitro* methods for the laboratory propagation of Australian *T. foetus* isolates. A successful proof-of-concept Australian trichomoniasis vaccine trial was conducted using bulls from *T. foetus* positive mobs. Future research is planned to undertake a large vaccination trial involving *T. foetus* naïve 2 year old bulls to demonstrate efficacy in protecting replacement bulls from becoming infected.

## References

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# Animal welfare and ethics principles for managing dingo-cattle conflicts

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## Introduction

Cattle producers are often subjected to accusations that they are somehow violating animal rights or moral duties, or causing unacceptable harm to animals. These claims can be most intense for managing wildlife-livestock conflicts, such as the lethal control of dingoes and other wild dogs (Allen and Hampton 2020). Animal interventions can be justifiable under several ethical frameworks, but it is the articulation of these justifications which can be difficult without an understanding of key animal ethics and welfare principles. These principles are described here for dingo-cattle management practices, but may be equally applied to other on-farm practices including early weaning, dehorning, vaccinations, branding or management of slaughter to final product. Awareness of these principles will help producers defend the industry against unjustified ethical accusations about animal management practices.

## Key principles

1. Animal ethics and animal welfare are two very different things. Animal welfare is an objective science primarily concerned with quantifying pain and suffering, or 'how' animals are harmed or killed. Animal ethics is subjective philosophy, primarily concerned with 'why' animals are harmed or killed, or the motivation(s) for harm and killing.
2. 'Good ethics' and 'good welfare' are often inversely related, and maximising one typically minimises the other.
3. Multiple different ethical philosophies or frameworks might be used to determine the permissibility of animal harm and killing, and the most common of these philosophies are known as (A) natural law or deontology (i.e. 'animal rights'), (B) virtue ethics (e.g. so called 'compassionate conservation'), (C) consequentialism (i.e. consequences matter most, 'net benefits'), (D) divine command theory or religious ethics (i.e. if deity says its ok, then its ok), (E) care ethics, and (F) ethical particularism (i.e. everyone has a different and valid view).
4. Debates about the permissibility of animal management practices often arise because people are arguing from one philosophical position without recognising that others are arguing from a completely different position. Regardless, practices resulting in lethal dingo control can be ethically justifiable under each of these different frameworks.
5. For example, perceived disagreement between views on the permissibility of dingo control primarily concerns the effectiveness of various management practices at minimizing animal welfare issues, and not the underlying ethics, motivations or morality of those practices.

## Conclusion

Managing livestock and other animals for productive outcomes is a ubiquitous human endeavour, and is a necessary component of maintaining human society. Dingo control, as an example, can be justified on ethical and welfare grounds whenever a risk to cattle welfare exists and the mitigation tool(s) used are capable of minimising that risk. Those concerned about the lives of dingoes, cattle and other animals should focus more on animal welfare and less on animal ethics.

## References

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# Objectively monitoring animal welfare across contexts

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## Introduction

When animal welfare is compromised, their resilience to changes in their environment is reflected by changes in the underlying structure of their behaviour, including bout lengths, and frequency of transitions between activities (Mandel et al., 2017). This decrease in welfare may be due to health, heat, hunger, handling/husbandry, bullying/animal to animal and other causes. A common behavioral diversity metric for animal welfare may provide a method to compare and contrast between and within contexts.

## Methods

Cattle behavioural diversity, the range of behaviours exhibited, was determined from data generated by accelerometer ear tags from three experiments: 1) separation stress: separation of calves from cows at weaning for cows (n = 30 animals; 14 days) and calves (n = 31 animals; 14 days); 2) thermal stress: core body temperature (CBT) of cattle (n = 19 animals; 4 days); and 3) surgical procedure pain stress: dehorning (n = 367 animals; 12 days); castration (n = 22 animals; 12 days); and de-horning + castration (n = 271 animals; 12 days).

For each of these separate experiments, Allflex ear tags were attached to each animal, with animals classified into one of the following six states for every minute (resting; medium activity; high activity; rumination; eating / grazing, walking and panting). The following classification of 'no stress' vs 'stress' was applied to each of these records: Separation stress: 'No stress' = 7 days prior to separation, 'Stress' = 7 days after separation. Thermal stress: 'No stress' = CBT < 39°C; 'Stress' = CBT ≥ 39°C. Surgical procedures stress: 'No stress' = 6 days prior to surgery, 'Stress' = 5 days after surgery.

For each animal, the proportion of minutes in each hour an animal was classified as undertaking a particular behaviour i was calculated, say pi, i = 1, 2, …, s where s is the number of behaviour states (s= 7 here). These proportions were then used to calculate the Shannon-Wiener diversity index (Miller et al., 2020) (H) for each animal at each hour of its respective study. The index H increases with the number of behaviour states exhibited and how evenly distributed they are. The maximum H is loges ≈ 1.95 (s = 7 here), with minimum H of zero when only one behaviour state is exhibited over the 1-hr interval. Next all the diversity H values were analysed using a linear mixed model with fixed effects for stress level ('No Stress' vs 'Stress'), trait (calf separation; cow separation; thermal stress; and the three surgical stresses); as well as a stress level × trait interaction. A random effect was included for each animal (nested within a trait) to allow for repeated measures on the same animal. The mixed model was fitted using the lme4 package in R, model-base means obtained and pairwise comparison from the emmeans package, and graphic output using the ggplot2 package in R.

## Results

There was a highly significant stress level × trait interaction ($P < 0.00001$) indicating different effects of stress for each trait. However, behavioural diversity (H) was greater in stress vs 'no stress' contexts.

## Discussion and Conclusion

Periods of stress were associated with greater behavioural diversity across contexts. Further validation of this approach is required but despite this, H appears to be a suitable animal welfare monitoring metric.

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# Cattle behaviour and weight gain following dehorning and castration with and without pain mitigation

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## Introduction

Pain resulting from dehorning and castration of cattle poses a threat to animal welfare and production. There have been many studies examining acute responses to pain in livestock undergoing husbandry procedures and the effect of pain relief. However, there are fewer studies that have examined welfare and production metrics over a longer duration following husbandry procedures, especially for large numbers of animals. This study aimed to fill some of the gaps in knowledge regarding the impact of dehorning and castration procedures and pain relief in cattle.

## Methods

762 mixed breed weaner calves (155 ± 18kg) due to undergo routine castration and dehorning were used. All polled female and polled stud male cattle were allocated to: (1) positive control group (no castration or dehorning) (n = 98). All other calves were blocked by sex and breed and randomly allocated to one of four treatment groups: (2) negative control group (castration and/or dehorning with no pain mitigation) (n = 97), (3) castration and/or dehorning with pre-operative meloxicam (n = 155); (4) castration and/or dehorning with intra-operative topical anaesthetic (n = 258), and (5) castration and/or dehorning with pre-operative meloxicam and intra-operative topical anaesthetic (n = 154). All polled male cattle were castrated only and all female cattle were dehorned only. All calves were weighed at the following time-points: 7 days before treatment, immediately before treatment, 7 days post treatment and 35 days post treatment. Percent change in body weight was calculated for each animal at each time-point. Ear tag sensors were fitted 7 days before treatment and remained fitted for the duration of the experiment to monitor behaviour.

## Results

There was a significant effect of treatment on percent change in body weight from baseline (immediately before marking on day 0) to day 7 ($P < 0.001$) and to day 35 ($P < 0.001$). There was also a significant effect of procedure (castration, dehorning, castration and dehorning) on percent change from baseline to day 7 ($P < 0.001$) and to day 35 ($P < 0.001$). All weaners, including those in the positive control group, lost weight over the first 7 days following treatment. The positive control group lost the least weight over days 0 to 7, and gained the most weight over days 0 to 35. There was no difference in percent change in body weight between any of the pain mitigation treatments or the negative control group. Dehorned animals lost the greatest amount of weight over days 0 to 7, and gained the least amount of weight over days 0 to 35. There was a marked effect of dehorning on rumination, eating and heavy breathing behaviour, with unmarked controls and castrated animals spending more time ruminating and eating, and less time heavy breathing across the study. In contrast to the effect of marking procedure, there was no apparent effect of pain mitigation treatment on average daily rumination, eating or heavy breathing across the 35 days of the study within either marking category.

## Discussion and conclusions

The results demonstrate that irrespective of pain mitigation, dehorning significantly impacted animal behaviour out to at least 35 days following the procedure.

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# Investigation of novel analgesic therapies for improved and longer lasting pain relief for cattle undergoing dehorning and castration.

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## Introduction

Necessary husbandry practices performed in livestock production systems such as dehorning and castration of cattle are invasive surgical procedures that impact animal welfare and productivity over an extended period (Van der Saag, et al., 2018). Current commercially available analgesic products may be limited by their duration of action in their ability to address the full extent of the pain response following certain husbandry procedures. Therefore, novel analgesic therapies for sustained duration of action are being investigated. This study aimed to compare the effect of several existing analgesic therapies, including a medicated pellet feed ration for calves undergoing castration and dehorning.

## Methods

Four hundred and sixty three calves averaging 135kg were split into 5 treatment groups; (1) no dehorning or castration (98 animals), (2) castration and/or dehorning with topical anaesthetic Tri-solfen® (TA) administered immediately following procedures (90 animals), (3) castration and/or dehorning with subcutaneous meloxicam administered at 0.5mg/kg body weight (BW) (90 animals), (4) castration and/or dehorning with subcutaneous meloxicam administered at 1mg/kg BW (92 animals), and (5) castration and/or dehorning with meloxicam administered daily for 2 days prior to and 7 days following procedures through medicated pellets at an approximate average dose rate of 1mg/kg BW (93 animals). All animals were weighed at day 0, day 7 and 30 days, to calculate average daily gain (ADG).

## Results

By 30 days following treatment, there was no significant difference in ADG between control animals and animals that were castrated only. However, animals that had been dehorned had a lower ADG than control animals and animals that were castrated only. Seven days after the procedure, the animals that received TA had the lowest average daily gain, whilst the animals that received the medicated pellet had the greatest average daily gain, excluding the positive control group.

## Discussion and conclusions

There is a significant long-term impact of dehorning on weight gain regardless of the pain mitigation strategies used in this study. There was no significant difference in ADG as a result of doubling the dose of meloxicam for castration and/or dehorning. Administering medicated pellets daily over a period of 2 days pre-procedure and 7 days post-procedure had a positive impact on ADG when compared with delivering a single Metacam injection subcutaneously or using TA 7 days after castration and/or dehorning. This highlights the potential of this delivery method as an option for sustained analgesia in cattle and other species. However, more research is required to explore the toxicity effects of administration of analgesic treatments long-term.

## References

Van der Saag et al. (2018) Animals 8(35)

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# Novel wound treatment strategies for dehorning

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## Introduction

Dehorning is a routine animal husbandry procedure performed to remove horns of cattle for reduced risk of injury to handlers, other animals, and the animal itself. The removal of horns reduces carcass bruising, estimated to cost the Australian cattle industry millions of dollars annually. Amputation dehorning induces a significant amount of pain evident through behavioural and physiological abnormalities, as well as haemorrhage, infection, and myiasis, leading to morbidity and mortality (Mainau, Temple & Manteca, 2012). Calf mortality directly resulting from dehorning has not been quantified, however, a mortality rate of 2.1% was observed in recently dehorned calves (Bunter *et al*, 2013). Post-operative haemorrhage and infection have been suggested as the main factors causing mortality in dehorned calves (Fordyce, McMillan & McGrath, 2018). Treatments available for dehorning include local anaesthetics (LAs) and non-steroidal anti-inflammatory drugs (NSAIDs) which address short-term pain but are limited in their ability to address longer-term pain and other post-operative complications.

## Aim

The aim of the project is to develop a wound dressing to be applied to dehorning wounds that aids in haemostasis, reduces infection, and improves wound healing. Together with UNSW and Weiss Labs, we have developed a novel wound dressing made of the bioactive polymer, polycaprolactone (PCL). PCL is a synthetic biopolymer that is non-toxic, biodegradable, highly elastic, and producible as a dressing which mimics the scaffold of the extracellular matrix, facilitating adhesion, aiding haemostasis (Ghimire *et al,* 2021). It's critical that the dressing has firm adhesion, is quick to apply, is cost effective, absorbs exudate, and doesn't cause further wound trauma.

## Progress

Prototypes of the novel wound treatment (NWT) are being developed and finalised. A protocol has been developed to test this NWT in late 2023. Focus groups with members of Regional Beef Research Committees (RBRC's) members under the Northern Australian Beef Research Council (NABRC) will be conducted in the coming months to introduce the project and design. We plan to use these focus groups to actively address issues and implement changes that will enhance the usability and efficacy of the dressings.

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# Delivery of meloxicam in molasses lick block to surgically castrated calves

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## Introduction

Livestock husbandry procedures such as surgical castration inflict long-term pain and inflammation, highlighting the animal welfare and production concerns. Pain relief products available to producers including topical anaesthetics (TA) and non-steroidal anti-inflammatory drugs (NSAIDs) are limited to peri or post-operative administration, failing to address procedural pain, and lasting only 24-72 hours.

## Methods

Oral meloxicam delivered via a medicated lick block was evaluated against conventional subcutaneous meloxicam in surgically castrated *Bos taurus* calves. Inflammation, percentage of change in weight (PCW), behaviour and plasma meloxicam concentration (PMC; meloxicam medicated calves only) were compared between various treatment groups. Calves were randomly allocated to treatment groups: meloxicam lick block (ML), subcutaneous meloxicam (M), no meloxicam (NC), or sham castration (PC). Prior to castration/sham castration, all calves received a sub-sedative dose of xylazine. Castrated calves received pre-operative lignocaine injected in the scrotum and spermatic cord, then 3ml topical anaesthetic (TA) in the scrotum post-operative. ML calves had 19 hours of access to the medicated lick blocks prior to castration. M calves were administered 0.5mg/kg of meloxicam subcutaneously immediately prior to castration. Blood samples were collected from ML and M calves via jugular venepuncture on days 0 (ML calves only), 1, 2, 3, 6, 9 and 13 for PMC analysis. Digital and infrared photographs were taken for comparison of healing and estimation of inflammation, respectively. Scrotal diameter was measured at the widest part of the scrotum using digital callipers. Behaviour was monitored by the same 3 observers blinded to treatment. Behaviour was recorded according to a customised ethogram adapted from the literature, via instantaneous sampling at 30 second intervals.

## Results

The combination of oral meloxicam and topical anaesthetic reduced weight loss and increased locomotion and eating. On all days except the first day post-castration, PMC was greatest in ML calves ($P \leq 0.001$). The PCW was minimised in ML calves compared to M and NC calves ($P=0.044$). Eating increased in ML calves immediately after castration and was reduced when the medicated block was removed ($P \leq 0.001$). Locomotion was greatest in ML calves ($P=0.018$). There was a trend for scrotal diameter to be less in ML calves compared to M ($P=0.069$).

## Discussion

The administration of meloxicam via medicated lick blocks enabled pre-emptive and long-term analgesia to be established, improving animal welfare by reducing inflammation and ameliorating pain responses of surgically castrated calves. With further research into the toxicity effects of meloxicam, the application of this technology could enable pre-emptive and long-term analgesia for husbandry procedures in various species.

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# Impact of sinus exposure during dehorning on wound healing, infection, and liveweight

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## Introduction

In northern Australia, calves are commonly dehorned by the manual removal of the horn growing tissue, known as amputation dehorning. Removal of the horn can result in a wound which exposes the frontal sinus in some animals, depending on how developed the horn is at the time of removal. This study was conducted to investigate the impact of dehorning on weaner liveweight and wound healing.

## Methods

In May 2019, 143 *Bos indicus* cross weaners (4-7 months old) were dehorned by amputation dehorning at Douglas Daly Research Farm, Northern Territory. At the time of dehorning the horn size was scored according to diameter at the base (small= less than 2.5cm, medium= between 2.5-4cm, large= greater than 4cm or protruding more than 2.5cm from the head), and whether the sinus was exposed (n=31) or non-exposed (n=112) as a result of dehorning was recorded. All animals were weighed prior to dehorning and then on days 7, 11, 30, 59 and 81 following dehorning. At each weighing, dehorning wound sites were inspected and scored scale from 1 (wound fully healed) to 7 (infection evident; purulent wound exudate clearly evident).

## Results

Sinus exposure was directly linked to horn size. Small horns only had 4% exposed sinus, medium horns = 30%, and large horns = 100%. Infection was most evident on the day 11 inspection and was higher ($P<0.001$) for exposed sinus wounds (50%) than for non-exposed wounds (6%). Wound healing was slower ($P<0.05$) in the exposed sinus animals on days 7 and 11, but was not different to the non-exposed group ($P>0.05$) on days 30, 59 and 81 (Fig. 1). Negative impact on liveweight from initial weight was greater in the exposed sinus group compared to the non-exposed group on day 7, 11, 30, 59 and 81 ($P=0.028$, $P=0.029$, $P=0.078$, $P=0.201$ and $P=0.003$ respectively).

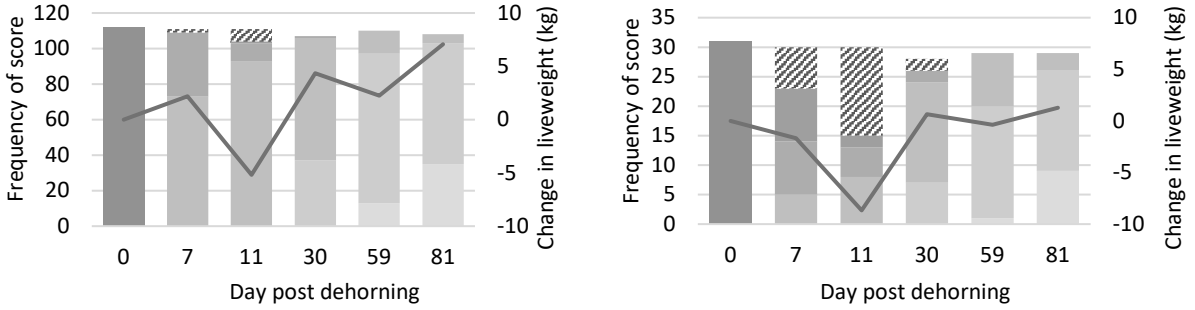


**Fig. 1. Frequency of wound healing score and mean change in liveweight at each observation, for weaners with non-exposed sinuses (left) and exposed sinuses (right).**
Wound score 7 6 5 4 3 2 1 Change from initial weight (kgs)

## Discussion and conclusion

These results demonstrate that exposing the sinus during amputation dehorning negatively impacts wound healing, infection and liveweight, and reinforces the importance of dehorning calves when the horns are as small as possible.

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# Observations on the causes of calf loss in a herd near Katherine, Northern Territory

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## Introduction

The ability to remotely monitor calving would greatly improve research into calf loss under extensive conditions. The CalfWatch project aimed to develop a system to remotely monitor calving, and use it to investigate the causes of calf loss over two calving seasons (Schatz *et al.* 2022).

## Methods

A remote monitoring system using birth sensors (Cowmonitor 2020) and GPS tracking collars (SmartPaddock 2023) was developed and used to monitor calving cows over the 2019 (n=208) and 2020 (n=192) calving seasons in a 22.15 $km^2$ native pasture paddock at Manbulloo station, Northern Territory. The system gave calving alerts and enabled cows to be located when all components worked properly. Calving observations were recorded as soon as possible after calving and calf carcases found within 12 hours of death were sent to the Berrimah Veterinary Laboratory for post mortem investigation. When components of the remote monitoring system failed, calving observations were recorded when cows were seen at the water trough after calving.

## Results

The CalfWatch system was very effective for remotely monitoring calving when all components worked properly. However, the performance of the birth sensors and the GPS collars were variable over the two calving seasons and both systems were only working properly when needed in 43% of cows in 2019 and 42% of cows in 2020. Overall, calf loss rates were 17% in both 2019 and 2020. There were numerous minor (1% or less) causes of calf loss during both calving seasons including early abortion, dystocia, infection and septicaemia via the umbilical cord, pneumonia, deformity and wild dog attack. The major causes of loss were bottle teats (6% in 2019 and 5% in 2020), and "unknown causes" (8% in 2019 and 10% in 2020). The majority of "unknown causes" were in cows with GPS tracking collars that were not working at the time of calving (and so they were not able to be observed) or in cows that appeared to be agitated and so were not observed closely for a few days to minimise stress at this critical time. In both of these situations it is possible that a proportion of losses from unknown causes were due to poor mothering (cows abandoning calves).

## Discussion and conclusions

The technology allowed a greater number of cows to be observed shortly after calving than normally occurs in extensive situations. From these observations, a number of cows were observed to have bottle teats shortly after calving, but several weeks later (after losing their calves) their udders appeared normal and so they would not be identified as having bottle teats at a muster several months later. If this is typical of northern herds then it is likely that bottle teats are a bigger problem than previously thought and cows with bottle teats are remaining undetected in herds and losing multiple calves. Culling of cows that don't raise a calf to weaning could be a worthwhile strategy to reduce losses from bottle teats. The project evaluated a method to remotely monitor calving cows and gained some new insights into the causes of calf loss in extensive north Australian herds.

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# Water restriction impact on the performance of late gestation heifers

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## Introduction

In the extensive rangelands of northern Australia, it is not uncommon for the distance between water points to be 5 km or more. Although cattle can graze long distances from water points, it can limit the drinking frequency and the total volume of water intake, especially when in high ambient temperatures (Schmidt *et al*., 1980). Our objective was to evaluate the effects of a mild water restriction during the prepartum period on cow and calf performance.

## Methods

This trial was conducted at the Dunluce Station, Qld, from September to December 2021. Fifty Droughtmaster heifers were separated into two paddocks 45 days before the estimated calving date. For the water-restricted group, water was available daily only from 10:00 to 14:00. At 14 d before calving, heifers were moved into collective pens and fed *ad libitum* with hay. Water was restricted until 14 days after calving. Heifers were weighed three times during the trial, and liveweight (LW) was adjusted for the products of conception (Silvey and Haydock, 1978). Newborn calves were weighed every other day for 14 days and blood was collected between 24 and 48 hours after calving.

## Results

The initial LW (473 and 475 kg) was not different between treatment groups (P > 0.10). However, water restriction increased LW loss (P = 0.01) during the prepartum period (-24 and – 38 kg of LW loss for control and restricted, respectively). The magnitude of LW loss significantly affected calf performance and transfer of passive immunity. Calves born from cows losing more weight had lower initial growth and lower globulin concentration (Figure 1), suggesting low milk delivery.

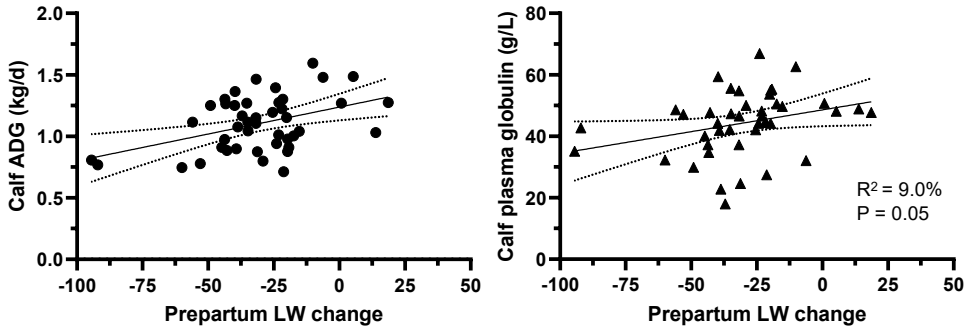


**Figure 1. Effect of prepartum LW change on the initial calf's growth and passive transfer of immunity.**

## Discussion and conclusion

Prepartum cows are already facing serious nutrient restrictions during the end of the dry season, coinciding with the prepartum period. Restricting water availability can exacerbate weight loss. There was a large variation in the magnitude of prepartum weight loss, and the variation in weight loss that affected milk delivery to newborn calves. This trial demonstrates the potential benefits of minimizing weight loss during the prepartum period on milk delivery and transfer of passive immunity.

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# LEGUMES DONE WELL IN A NORTHERN ENVIRONMENT

# Legume production paddocks increase pasture productivity on red earth soils

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## Introduction

Beef cattle production in the seasonally dry zone of north Queensland is based on uncleared native grasslands with significant feed deficits during the 6-8 month dry season (Rolfe *et al*., 2016). Significant areas of red earth soils have historically been cleared providing an opportunity for pasture improvement. Targeting improved dry season nutrition in 'weaner' type paddocks, DAF researchers, with co-funding from Meat and Livestock Australia, tested older and emerging grass and legume cultivars across a range of land-types, including red earth soils (Cox *et al*, 2022).

## Methods

The experiment site was an old pasture on a cleared red earth near Charters Towers (600 mm average annual rainfall, low soil-P, low soil-S) dominated by Wynn cassia, a low yielding legume which drops leaf early in the dry season. The trial was sown February 2020 after cycles of cultivation to reduce Wynn cassia soil seed banks. A replicated (3) factorial grass x legume design was used to allocate small plots. Fertiliser P and S was applied at sowing and the plots grazed each year during the early dry season. The reported yields were estimated on 20 March 2023 (Botanal method).

## Results

Herbage yields 2-3 times those of native pastures in good condition (~2.5 T DM/ha) were achieved by a range of grass x legume combinations (Table 1). Dominant, clumping grasses (Mekong, Massai) out-competed most legumes (including Wynn cassia), but not Seca and Unica stylos. These erect legumes competed well with all grasses. Grasses with a 'creeping' habit (125652B, Jarra and Manzini) combined well with a range of legumes and had moderate suppression of Wynn cassia. Wynn invaded plots with low-yielding legumes (Progardes, Milgarra, 849 gracile) or grasses (ATF714).

**Table 1. Total pasture yield (PY)(T DM/ha), legume content (%) and Wynn cassia yield (shaded).**

| | | Desmanthus | | Butterfly pea | | Gracile | | Atro | | Stylo | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grass group | culitivar | Progardes | | Milgarra | | 849 | | 84989 | | Amiga | | Seca | | Unica | |
| | / line | PY | % | PY | % | PY | % | PY | % | PY | % | PY | % | PY | % |
| Brizantha | Mekong | 6.0 | 0.0 | 5.0 | 0.0 | 5.9 | 0.0 | 6.7 | 10.4 | 5.8 | 6.9 | 5.2 | 46.2 | 5.7 | 36.8 |
| Creeping blue | 125652B | 3.8 | 5.3 | 4.8 | 14.6 | 4.0 | 2.5 | 3.1 | 16.1 | 3.2 | 18.8 | 4.5 | 42.2 | 7.1 | 52.1 |
| Finger | Jarra | 3.3 | 0.0 | 3.1 | 3.2 | 2.8 | 0.0 | 4.2 | 11.9 | 4.6 | 32.6 | 4.4 | 54.5 | 4.8 | 52.1 |
| Panic | ATF714 | 2.9 | 0.0 | 3.2 | 3.1 | 4.1 | 9.8 | 4.6 | 13.0 | 6.2 | 41.9 | 4.9 | 46.9 | 3.7 | 67.6 |
| | Gatton | 4.0 | 2.5 | 5.0 | 16.0 | 4.0 | 0.0 | 5.8 | 20.7 | 5.3 | 37.7 | 5.8 | 62.1 | 7.1 | 43.7 |
| | Massai | 7.0 | 0.0 | 6.2 | 9.7 | 4.8 | 0.0 | 6.6 | 13.6 | 5.6 | 12.5 | 6.5 | 27.7 | 6.6 | 33.3 |
| Sabi | Manzini | 4.3 | 0.0 | 4.9 | 16.3 | 5.5 | 3.6 | 5.1 | 37.3 | 4.9 | 30.6 | 5.1 | 33.3 | 6.2 | 33.9 |
| Ave. std err | | 0.77 | | 0.59 | | 0.96 | | 0.55 | | 0.64 | | 0.44 | | 0.75 | |

Wynn cassia yield (T DM/ha) <0.49 0.5-1.49 >1.5

## Discussion and conclusion

Stylos provide the best option for grass/legume pastures on red earths in north Queensland.

## References

Cox *et al.* (2022) Final Report B.NBP.0812, Meat and Livestock Australia, Sydney.
Rolfe *et al*. (2016) Australian Rangelands Journal 38(3) 261-272.

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# Legume production paddocks increase pasture productivity and suppress invasive grasses on red basalt soils

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## Introduction

Beef cattle production in the seasonally dry zone of north Queensland is based on uncleared native grasslands with significant feed deficits during the 6-8 month dry season (Rolfe *et al*., 2016). Declining land condition and invasion by early flowering grasses further limits enterprise productivity. Targeting improved dry season nutrition in 'weaner' type paddocks, DAF researchers, with co-funding from Meat and Livestock Australia, tested older and emerging grass and legume cultivars across a range of land-types, including fertile red basalt soils, under grazing (Cox *et al*, 2022).

## Methods

The presented data are for an Indian couch and grader grass dominated site on red basalt soil near Mt Surprise (785 mm average annual rainfall, high soil-P, low soil-S) established February 2019 using a replicated (3) factorial grass x legume design for the allocation of small plots. Sulphur fertiliser only was applied at establishment; plots grazed each year during the early dry season and herbage yields measured by quadrat sampling or Botanal methods (here reported for 2 March 2023).

## Results

High herbage yields were maintained 4 years after sowing (up to 16 T DM/ha, pastures in good condition ~3.5 T DM/ha)(Table 1). Plots with Milgarra butterfly pea or Unica stylo had high total yields and these legumes competed well with grasses. Seca stylo and 84989 atro also performed well. Dominant grasses (Mekong, 125652B, Jarra and Manzini) or legumes (Milgarra, Unica) suppressed weed grasses (grader grass + Indian couch), which readily invaded other plots.

**Table 1. Total pasture yield (PY)(T DM/ha), legume content (%) and weedy grass yield (shaded).**

| | | Desmanthus | | Butterfly pea | | Atro | | Stylo | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grass group | culitivar | Progardes | | Milgarra | | 84989 | | Amiga | | Nina | | Seca | | Unica | |
| | / line | PY | % | PY | % | PY | % | PY | % | PY | % | PY | % | PY | % |
| Brizantha | Mekong | 8.5 | 3.5 | 10.1 | 28.7 | 7.8 | 9.0 | 6.9 | 23.2 | 8.4 | 3.6 | 7.8 | 25.6 | 16.2 | 67.3 |
| Creeping blue | 125652B | 4.6 | 19.6 | 12.7 | 26.0 | 7.7 | 22.1 | 7.4 | 20.3 | 6.4 | 18.8 | 9.4 | 33.0 | 14.6 | 51.4 |
| Finger | Jarra | 4.0 | 10.0 | 11.9 | 43.7 | 6.0 | 13.3 | 2.7 | 22.2 | 4.4 | 4.5 | 5.7 | 35.1 | 13.0 | 96.9 |
| Panic | ATF714 | 4.6 | 17.4 | 7.9 | 55.7 | 9.0 | 24.4 | 4.0 | 12.5 | 4.6 | 0.0 | 5.4 | 35.2 | 13.3 | 70.7 |
| | Gatton | 4.7 | 6.4 | 8.3 | 33.7 | 7.5 | 38.7 | 4.9 | 22.4 | 4.2 | 0.0 | 7.0 | 42.9 | 9.8 | 59.2 |
| | NuCal | 4.1 | 2.4 | 10.3 | 29.1 | 5.1 | 9.8 | 5.9 | 16.9 | 5.5 | 1.8 | 7.9 | 36.7 | 16.6 | 69.9 |
| Sabi | Manzini | 5.2 | 3.8 | 12.0 | 47.5 | 11.8 | 39.8 | 4.8 | 12.5 | 5.9 | 3.4 | 7.1 | 56.3 | 15.2 | 89.5 |
| No grass | none | 3.6 | 11.1 | 6.2 | 80.6 | 12.7 | 17.3 | 5.7 | 8.8 | 3.6 | 5.6 | 9.4 | 44.7 | 14.0 | 95.0 |
| Ave. std err | | 1.08 | | 2.50 | | 1.32 | | 0.96 | | 1.19 | | 1.46 | | 1.75 | |

Weed grass yield (T DM/ha) <0.49 | 0.5-1.49 | 1.5-2.99 | >3.0

## Discussion and conclusion

Certain grasses and legumes can increase dry season productivity and suppress invasive grasses.

## References

Cox *et al.* (2022) Final Report B.NBP.0812, Meat and Livestock Australia, Sydney.
Rolfe *et al*. (2016) Australian Rangelands Journal 38(3) 261-272.

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# Adoption of pasture legumes and good agronomy in the Brigalow Belt

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## Introduction

Pasture legumes have been identified as the best long-term option to increase the productivity and returns from grass pastures in Queensland, however successful adoption rates remain low in the Brigalow Belt bioregion (Peck *et al.* 2011). Poor establishment is one of the most common reasons for legumes failing.

## Methods

As part of the 'Legume Best Management Practice in the Brigalow Belt' project (Peck *et al.* 2022), 23 legume establishment and management workshops were held across southern and central Queensland. In early 2022, 104 grazier businesses who attended the workshops were surveyed over the phone about their on-ground practice change: to see if pasture legumes were sown since the workshops, what methods were used and what successes they had.

## Results

The surveys reported 73% of respondents had sown pasture legumes, totalling 19,680 ha across the Brigalow Belt bioregion. Desmanthus was the most frequently selected legume with 30% of participants sowing it into their pastures by 2022. Shrubby stylo and Caatinga stylo were included in 20% and 9% of sown pastures respectively. One third (35%) of surveyed participants used a fallow considered long enough to store moisture for early pasture growth (4 – 12 months) but 45% of respondents used no fallow. One quarter (26%) reported used fertiliser, and one tenth (12%) used rhizobia when sowing.

## Discussion and conclusion

Adoption of better agronomic practices is likely to lead to more reliable legume establishment thereby increasing productivity for an important cattle production region of northern Australia. At the end of the workshops, participants showed high interest in sowing desmanthus and Caatinga stylo, and the survey in 2022 reported that many followed up that idea by sowing paddocks of desmanthus. Desmanthus has been vigorously promoted over the last several years, which is perhaps reflected in these results. By contrast, Caatinga stylo was sown in relatively few paddocks and has had relatively limited promotion. In the workshop, participants are recommended to use six-to-12-month fallows (depending on soil type and rainfall), to fertilise if necessary, and use a rhizobia inoculant to improve the reliability of establishing legumes in the Brigalow Belt bioregion. These practices were used less than what participants had indicated during the workshops suggesting that there are barriers to more widespread adoption. Survey participants reported some of those barriers as access to equipment to prepare a seedbed or apply fertiliser or rhizobia, and not being well-enough informed about management practices. Continued research and development is needed to adapt trial results to commercial scale methods for seedbed preparation, fertiliser application and rhizobia application that are cost effective. Continued extension effort is required to help graziers navigate the options for pasture legume establishment to ensure successful, long-term growth.

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# Redlands Leucaena for increasing beef productivity in north Queensland

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## Introduction

The development and commercialisation of the psyllid tolerant Redlands leucaena has provided the potential for the inclusion of this perennial shrub legume into the grazing systems of tropical and coastal locations across north Australia. The productivity gains resulting from the inclusion of Redlands in north Queensland has now been demonstrated on Goshen Station at Mount Garnet Queensland.

## Method

Throughout the three-year timeframe of the project, three cohorts of Brahman / Brahman cross weaner steers were rotated through two, 32 ha paddocks, planted with Redlands leucaena in twin rows with one metre centres and 10 m row spacings. Inter-row improved pastures included Callide Rhodes grass (*Chloris gayana*), Bissett (*Bothriochloa insculpta*) and Secca Stylo (*Stylosanthes scabra*).

Each cohort was inducted at an average live weight ranging from 133 kg to 176 kg and managed at a stocking rate of 1 AE to 0.6 ha. Two cohorts of similar age and live weight were used as control groups for comparison and managed on native pastures. The first native pasture cohort was supplemented with dry lick at 8% P blocks with the second native pasture cohort supplemented with a grain-based lick. The productivity of the three pastures was highlighted with a comparison of profitability on a per hectare basis.

## Results

The first cohort was inducted on 15 September 2020 at an average liveweight of 133 kg gained an average (ADG) of 0.38 kg per day over the 372 d of the trial. The second cohort was inducted on 21 September 2021 at an average of 170 kg and remained on leucaena for a period of 406 d. This cohort achieved an ADG of 0.53 kg to be turned off at an average weight of 384 kg. The third cohort was inducted on 1 November 2022 and initial weight gains will be available imminently. The weight gain per hectare for each cohort on leucaena was 0.63kg per day and 0.89kg per day per hectare respectively. The control cohorts inducted to the native pasture paddocks demonstrated an average daily weight gain of 0.16kg and 0.34kg. The weight gain per hectare per day for each cohort on native pasture with alternative supplementation was 0.04kg and 0.08kg respectively. The financial returns of the leucaena and native pasture cohorts per hectare on current average price of $3.20/kg live weight indicated a return of $2.02 and $2.85 per hectare for cohort one and two respectively, and $0.13 for the dry lick supplemented native pastures and $1.09 for the grain lick supplemented native pasture.

## Discussion and conclusion

The introduction of Redlands into northern grazing systems has the potential to increase the productivity of the grazing enterprise compared to native pastures with supplementation significantly. This productivity increase is best achieved in cattle at a heavier weight at induction and is highlighted when the average weight gains of the cohorts on the Redlands is calculated on a hectare basis with the subsequent profitability gains. The productivity of the leucaena and improved pasture compared to supplemented uncleared native pastures is further improved by the reduced turnoff period and subsequent increased stocking rates.

This demonstration supported the introduction of the Redlands leucaena variety to appropriate planting areas for improved cattle weight gains, stocking rates, productivity, and financial returns.

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# Adoption, performance and management of leucaena in north Queensland

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## Introduction

Leucaena adoption in north Queensland (above 20°S) has been historically constrained by a lack of cleared land on suitable soil types, producer inexperience, predominance of breeding businesses and losses from leucaena psyllids. The release of the psyllid tolerant cv. Redlands in 2018 increased potential for leucaena in the region. Following release, reliable establishment methods were progressed with producers, under DAF-Meat and Livestock Australia initiatives. Economic analyses have indicated favourable investment criteria for leucaena adoption on suitable land classes in north Queensland (Bowen *et al*. 2019; Lemin *et al*. 2022). Plantings in north Queensland have increased from a pre-2020 area of about 2,300 ha to over 4,300 ha in 2022 (Lemin *et al.* 2022).

## Animal performance

High average daily liveweight gains (ADG) have been measured at a range of leucaena plantings in north Queensland (Table 1). A 5-year replicated grazing trial at Pinnarendi (Mt Garnet) comparing Redlands and cv. Wondergraze showed leucaena productivity was seasonal but dietary quality was high throughout the year (14% CP; 9.0 MJ/kg ME; 59% digestibility).

**Table 1. Liveweight gains measured on leucaena in north Queensland.**

| Location | Soil | Animal class | Period (days) | No. head | Avg. entry wt. (kg) | Stocking (ha/AEA) | ADG (kg) |
|---|---|---|---|---|---|---|---|
| Meadowbank | basalt | feeder steers | 173 (Oct-Mar) | 11 | ~375 | n/a | 0.93 |
| Georgetown | alluvial | weaner steers | 98 (Oct-Dec) | 219 | 222 | n/a | 0.15 |
| Pinnarendi | red-earth | weaner steers | 368 (12 months) | 28 | 229 | 2.5 | 0.67 |
| Pinnarendi | red-earth | feeder steers | 372 (12 months) | 14 | 283 | 2.9 | 0.55 |
| Pinnarendi | red-earth | weaner steers | 367 (annual) | 42 | 264 | 1.7 | 0.61 |
| Pinnarendi | red-earth | heavy steers | 138 (Mar-Jul) | 30 | 511 | 1.7 | 0.77 |
| Goshen | red-earth | weaner steers | 373 (12 months) | 16 | 128 | n/a | 0.39 |
| Goshen | red-earth | weaner steers | 407 (13 months) | 29 | 170 | n/a | 0.52 |

[A]AE=Adult Equivalent (450 kg steer at maintenance)

## Management considerations

Set stocking and cattle preference for grass during the productive monsoonal wet-season, can cause increased weediness and excess leucaena growth. Producers are adopting wider row spacings, wet-season spelling and rotational grazing to address these issues. On light textured, low fertility soils, the response and economics of maintenance fertiliser applications requires investigation. On lightly timbered basalt soils, native trees and rocks are a problem for leucaena management after establishment. On the Atherton Tablelands and Wet Tropical Coast, adoption has been lower in the context of existing, highly productive pastures.

## References

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Bowen *et al*. (2019) Northern Gulf beef production systems, The State of Queensland.

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# Establishing improved pastures on northwest Queensland downs country

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## Introduction

Establishing improved pastures on heavy clay soils in northwest Queensland has the potential to contribute to pasture and beef business resilience in a highly variable rainfall climate prone to drought (Bowen *et al.* 2015). The opportunity to demonstrate the production possibilities of grazing improved perennial grasses and legumes, as alternatives to natural Mitchell grass downs pastures, arose within an on-property irrigated assisted Leucaena production paddock north of Julia Creek, Qld.

## Methods

Inter and intra-row 0-10cm bulk soil samples were collected from a bare 17 ha flood irrigated and vermin-fenced heavy cracking brown clay site to assess nutrient requirements and the suitability of improved pasture species. Selected legume and grass seeds (Table 1) were hand mixed with diammonium phosphate and sulphur (DAP+S) fertiliser and applied at 11 kg/ha and 235 kg/ha respectively. The mix was dispersed between the rows of raised bed Leucaena using a spreader and flood irrigated same day with dam water at 0.1 mL/ha in January 2023. End of wet botanical analysis was conducted in May 2023 with 60 inter-row quadrants recorded over 0.6 ha.

## Results

Additional to the irrigation after seeding, the site received 700.5 ml rainfall from planting (January) to assessment (May). The botanical analysis in May recorded 18 pasture species, yielding a total of 3169 kg DM/ha. Flinders was the dominant species (62% of yield) followed by Rhodes (21%) and non-legume dicots (7%). Bambatsi, desmanthus and Floren each contributed less than 1% of the yield (Table 1). Buffel was seen onsite but not between the rows. No butterfly pea or Caatinga stylo was identified.

**Table 1. Rates of seed application (January) and dry matter yield assessment post wet (May).**

| Improved pasture type | Seed planted | DM yield (May) | % Total DM yield (May) |
|---|---|---|---|
| Tolgar Rhodes (*Chloris gayana*) | 1.1 kg/ha | 626.79 kg/ha | 21% |
| Bambatsi panic (*Panicum coloratum*) | 2.5 kg/ha | 21.64 kg/ha | 1% |
| Marc desmanthus (*Desmanthus virgatus*) | 1 kg/ha | 7.27 kg/ha | 0% |
| Floren bluegrass (*Dichanthium aristatum*) | 1.7 kg/ha | 2.95 kg/ha | 0% |
| Biloela buffel (*Cenchrus ciliaris*) | 1.7 kg/ha | - | - |
| Butterfly pea (*Clitoria ternatea*) | 2 kg/ha | - | - |
| Caatinga stylo (*Stylosanthes seabrana*) | 1 kg/ha | - | - |

## Discussion and conclusion

Low yields of the sown species after an above average wet season in Julia Creek has highlighted the difficulties in establishing improved perennial pastures on heavy cracking clay soils. Salinity, bed preparation, sowing rates and species competition may have impacted establishment success to date. Liveweights of cattle grazing the site from June 2023 will be recorded to evaluate the production potential of improved pastures in comparison to natural Mitchell grass downs in northwest Qld.

## References

Bowen *et al.* (2015) Feeding Forages in the Fitzroy, State of Queensland, Brisbane.

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# Potential disruptors to early follicular development and embryonic loss in cattle grazing legume species

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## Introduction

Oestrogenic pastures in Australia have been found to affect fertility in cattle especially when pastures have been affected by pest infestations or other stressors such as low rainfall. Phyto-oestrogens are structurally similar to mammalian oestrogens and can produce similar physiologic effects (Mlynarczuk *et al.* 2011). Early embryonic loss may be as high as 24-29% in cattle fed on a legume pasture (Shore *et al.* 1998). Exposure to multiple phyto-oestrogen compounds simultaneously may critically alter the function of the bovine reproductive system and embryo development.

## Methods

A grazing trial was conducted with 20 pluriparous Angus cows on a series of treatments consisting of 7 weeks on ryegrass (control), 3 weeks ryegrass followed by 4 weeks on legumes (L4), 7 weeks on legumes (L7), 7 weeks on legume:ryegrass mix (R7). Cows were subjected to an oestrus synchronisation programme similar to those previously described (Wyse et.al. 2021) using a combination of a 7-day intravaginal progesterone releasing device (CIDR®), oestradiol benzoate, Prostaglandin F2α and gonadotrophin releasing hormone analogue. On day 4 of the synchronisation, cows were superovulated using twice daily injections of FSH (Folltropin V), were artificially inseminated (AI) 2 days after CIDR removal, and had embryos recovered non-surgically seven days post AI. Pasture and blood (plasma) samples were collected every 7 days and stored at -20°C for extraction of phyto-oestrogens using HPLC-MS-QQQ

## Results

Tentatively, 9 phyto-oestrogens were identified in both the pasture and plasma samples. A total of 56 embryos and 8 unfertilised oocytes (UFO) were recovered from the embryo, seven days post ovulation. Embryo quality did not differ between the control and treatment groups, however, embryo stage differed between the control and treatment groups.

## Discussion and conclusion

Plasma concentrations of coumestrol in both the R7 and L7 groups were 2-fold higher compared to the L4 and control group. However, 100% of cattle produced embryos in the L7 group, whilst 0% in R7 group. This study shows that phyto-oestrogens may affect conception and early embryonic development, at concentrations greater than 30 ng/mL. Phyto-oestrogens have been previously observed to suppress follicular development, especially in the early stages (Borzym *et al*. 2008). Total concentrations of phyto-oestrogens, ranging from 2 – 36 ng/mL, had an effect on the embryo stage between the treatment and control cattle.. Whilst this research was conducted on lucerne (*Medicago* sativa) and clover (*Trifolium* pratense) pastures, the results from this trial provides insight into potential effects that phyto-oestrogens may have on bovine reproduction whilst grazing leucaena (*Leucaena leucocephala*) (Romero-Palacios *et al.* 2019).

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Romero-Palacios *et al*. (2019) Physiology & Behavior 211 112683

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# Desmanthus for silage

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## Introduction

Desmanthus is known as a pasture legume where its inclusion can increase animal performance. However, under a cropping scenario desmanthus can produce high yield of good quality forage (Mwangi *et al*. 2022). This study was initiated to determine if desmanthus could be preserved as silage.

## Materials and methods

Progardes desmanthus, cultivars JCU 4, JCU 6 and JCU 9, were established in three irrigated 4 ha blocks in north Queensland (19°35'S 146°54'E) on 21/12/2021. The blocks were slashed and regrowth was mowed after 60 d on 12/4/22. Within 4 hours of mowing, cultivars were round baled and wrapped in 5 to 8 layers of white plastic film wrap. Bales were stored on their ends outside. On 14/9/22 two bales of each cultivar were unwrapped and presented to a group of 15 beef cows for 24 h for monitoring of feeding behaviour. Samples at ensiling and feed-out were analysed by NIR.

## Results

The dry matter (DM) at mowing was similar, but JCU 9 silage was drier than the other silages (Table 1) leading to more extensive moulding. The loss of water-soluble carbohydrate (WSC) in all silages was matched by a reduction in pH and production of fermentation acids. All silages had a restricted heterotactic fermentation typical of round bale silage. Video monitoring revealed that cattle spent more time at cultivars JCU 4 and 6, possibly due to visibly less mounding in these bales.

**Table 1. Composition of cultivars at mowing and of the resulting silages**

| | JCU 4 | | JCU 6 | | JCU 9 | |
|---|---|---|---|---|---|---|
| | Mowing | Silage | Mowing | Silage | Mowing | Silage |
| DM (%) | 36.7 | 54.4 | 38.2 | 54.7 | 30.4 | 64.1 |
| WSC (% DM) | 13.8 | 3.7 | 13.7 | 7.0 | 9.80 | 4.90 |
| ME (MJ/kg DM) | 10.36 | 9.82 | 10.16 | 10.17 | 8.96 | 9.49 |
| CP (% DM) | 19.1 | 20.4 | 23.9 | 27.10 | 17.8 | 23.40 |
| pH | | 4.84 | | 5.23 | | 5.15 |
| Fermentation acids (% DM) | | 5.52 | | 2.85 | | 3.75 |

## Conclusions

This preliminary study demonstrated that desmanthus can be ensiled. All three silages were of good nutritive value and satisfactory fermentation and should support good levels of animal production. The higher apparent presence of moulds in the drier JCU 9 silages suggests ensiling above ~ 50% DM increases moulding and reduces preference for the silage.

## References

Mwangi *et al*. (2022) *Fermentation* **8**, 377

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# Seed production of new cold-tolerant stylos in north Queensland

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## Introduction

Deep-rooted perennial legumes, principally *Stylosanthes,* have increased pasture productivity in the seasonally-dry zone of Queensland but there are few options for frost-prone areas, particularly on light textured soils (Bell *et al.* 2016). Department of Agriculture and Fisheries (Qld DAF) researchers, with co-funding from Meat and Livestock Australia, collected 40 legume ecotypes from old plant evaluation sites in frost-prone areas of southern Queensland and compared these with previously released or short-listed varieties across six trial sites (Peck *et al*., 2021). Five (three *S. seabrana* and two *S. scabra*) were selected for superior yields compared to commercial cultivars. Seed production to support field evaluation and commercial adoption was conducted from 2013 by DAF at Walkamin (17°S, 720 m asl). First yields of pre-commercial scale crops are reported here.

## Methods

A semi-commercial approach to seed production was used to produce true-to-type seed and assess seed production. Seed production was conducted on a slightly acid, fertile free-draining basalt (Ferrosol) soil. Crops were 0.04-0.08 ha and isolated by >50 m. Tested (viability) and scarified seeds were sown mid-January 2021 or 2022 using a cone planter in rows 45 cm apart targeting 50 plants/$m^2$. Weeds were controlled using imazethapyr and bentazone at label rates. Irrigation was applied to supplement rainfall and fertiliser P, K and S applied pre-plant only. Off-types were removed by hand (rogueing) and insect pests (*Nezara viridula*) controlled with dimethoate or methomyl at label rates. The crops were harvested with a conventional combine harvester, dried at 35°C and cleaned using air-screen cleaners before entering long-term storage (10°C, 50%RH).

## Results

All lines produced vigorous seed crops and ratooned to produce a second seed crop (Table 1).

**Table 1. Harvest date and cleaned seed yields (kg/ha) for first pre-commercial crops of new stylos.**

| Species (#) | Name | Harvest 1 (after sowing) | | Harvest 2 (re-growth after harvest) | |
|---|---|---|---|---|---|
| S. scabra (9) | Roxo | Jun. 2022 | 141 | Nov. 2022 | 279 |
| S. scabra (25) | Terra | Sep. 2022 | 125 | Dec. 2022 | 239 |
| S. seabrana (36) | Dura | Jul. 2021 | 137 | Dec. 2021 | 79 |
| S. seabrana (39) | Ultimo | Aug. 2021 | 133 | Jan. 2022 | 83 |
| S. seabrana (40) | Cedo | Jul. 2021 | 98 | Dec. 2021 | 67 |

## Discussion and conclusion

The use of rows to facilitate rogueing and the removal of plants (>200 in most crops) was considered to have reduced seed yields to well below potential (commercial yields ~300 kg/ha). Cool and wet conditions slowed growth of the *S. seabrana* lines during 2021 resulting in seedhead diseases (suspected *Botrytis*, particularly in Cedo) and low ground cover (~50%) by first harvest, but drier conditions favoured growth of the *S. scabra* lines in 2022 (>80%).

## References

Bell *et al.* (2016) Final Report, Project B.NBP.0765, Meat and Livestock Australia, Sydney.
Peck *et al*. (2021) 2021 Agronomy Australia Conference Proceedings. http://agronomyaustraliaproceedings.org/images/sampledata/2022/Pastures/ASApeck_g_522s.pdf

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# G FOR GENETICS IN NORTHERN PRODUCTION SYSTEMS

# Recent advances in cattle genome sequencing

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## Introduction

Recent advancements in genome sequencing have revolutionized the analysis of cattle genomes. The advent of new technologies that enable DNA to be sequenced in long continuous sections, rather than fragmented into smaller pieces, has allowed us to tackle challenges that were previously insurmountable. Currently, two companies stand at the forefront of the 'long-read sequencing' field: Oxford Nanopore Technologies (ONT) and Pacific Biosciences (PacBio). This year, both companies have significantly decreased their prices, thereby expanding the possibilities for studying genetic variations within the Australian cattle population.

## Results and discussion

Several long-read sequencing studies on Australian beef cattle have been published in recent years (Table 1). These studies have explored the application of long-read sequencing in a wide range of areas, including genomic prediction and pathogen detection.

New sequencing technologies have already begun to reshape the landscape of Australian beef cattle genetics research. These advancements enable researchers to examine the cattle genome in a more comprehensive manner and at a population scale. This represents a ground-breaking opportunity for in-depth analysis of a vast number of cattle genomes, leading to a proliferation of genomic possibilities aimed at enhancing the productivity of the Australian beef industry.

**Table 1. Recent publications on the use of long read sequencing in Australian beef cattle.**

| Study | Impact |
|---|---|
| Nguyen *et al*. 2023 | Outlines the potential of long-read sequencing to discover structural variants in cattle genomes which may affect important traits |
| Lamb *et al.* 2023 | Uses long-read sequencing for genomic prediction and pathogen detection in cattle |
| Nguyen *et al*. 2023 | Uses long-reads to show how the cattle genome folds within the cell |
| Nguyen *et al*. 2022 | Uses long-reads to understand differences among cattle genes across tissues |
| Ong *et al*. 2022 | Uses long-reads to examine the cattle reproductive tract microbiome |
| Ross *et al*. 2022 | A genome of an Australian Brahman shows evolutionary differences to taurine cattle |
| Hayes *et al*. 2021 | Long-read sequencing data is used to predict cattle age for the first time |
| Lamb *et al.* 2021 | Long-read sequencing is used for genomic prediction for the first time |
| Lamb *et al*. 2020 | Long-read sequencing is first applied to cattle to characterise the Poll mutation |

## References

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# Genomic breeding values to improve fertility and productivity of multi-breed, composite and crossbred tropical beef cattle

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## Introduction

Cow fertility is a major driver of profitability in Northern beef herds. Cow fertility has been difficult to select for, and the availability of genomic breeding values (GBV, based on a DNA profile) would enable more rapid gains to be made. Ideally GBV would be from a multi-breed genomic evaluation, given the wide range of breeds, composites and crossbreds used in Northern Australia.

## Methods

Fifty-four collaborator beef cattle herds from across tropical Australia participated in data collection for the Northern Genomics project. The 29,321 heifers enrolled included crossbred and approximately 8000 purebred heifers from at least 14 breeds. Traits measured included live weight, hip height and body condition score (BCS) at an average of 600 days, and heifer puberty. Heifer puberty trait was cycling or not cycling by an average of 600 days, assessed by presence or absence of corpus luteum using ovarian scanning (Corbet *et al*. 2018). Pregnant or not 4 months after calving (P4M) was also recorded. All heifers were genotyped with the 35K tropBeef SNP array by Neogen, Australasia. Genotypes were imputed up to 709,768 SNP (Bovine HD array) using Fimpute (Sargolzaei, *et al*. 2014). We first estimated breed proportions of each heifer for each of the 14 breeds known to be in the data set. A separate large data set consisting of only purebred cattle was used to estimate SNP effects for breed composition. Then the model fitted to the data was **y**=μ+**cohort+year+het+breedprop+animal+error**, where **y** is a vector of trait records, μ is the population mean, **cohort** is the property+yeardrop+paddock that the heifers were in prior to mustering for trait recording, **year** is the year of recording, **het** is the heterozygosity of each heifer as measured by the proportion of markers that were heterozygous (to capture heterosis effects), **breedprop** is a series of 14 breed proportions as described above, animal is a random effect for each heifer, with (co) variance the genomic relationship matrix among all heifers constructed from the markers (Yang *et al*. 2011). Accuracy of GBV was evaluated by dropping out 10 herds at random, predicting GBV for these heifers, then correlating these GBV with their actual phenotypes.

## Results

The heritability of the traits estimated from the genomic data was moderate (0.22 heifer puberty, 0.22 for body condition score), and higher for weight and hip height (0.32 and 0.43 respectively). These heritabilities were consistent with previous estimates for these traits in tropical beef cattle data sets derived from pedigree (eg Corbet *et al*. 2018). Accuracies of GBV in the 10 validation herds was up to 0.5 for heifer puberty, and above 0.45 for all the other traits.

## Conclusion

GBV are now available for multi-breed, crossbred and composite tropical beef cattle, including for fertility, a key trait driving productivity in northern beef herds. The accuracy of these GBV are moderate, but sufficiently high that gains for fertility and other traits could be made through selection on the GBV.

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# Using genomics to select non-pedigree cattle for bull fertility traits

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## Introduction

Commercial beef cattle breeders have benefited very little from the development of genomically enhanced estimated breeding values (GEBV), especially for fertility traits. The Bull Fertility Update project (Porto-Neto *et al.* 2021) used industry-led Bull Breeding Soundness Examination (BBSE) data and combined them with DNA profiles to apply genomics to non-pedigree tropical cattle.

## Methods

BBSE records of around 8,000 bulls from six tropical breed types were combined with DNA data for analyses. After pre-processing traits and genotypes, the data was analysed using a GBLUP model. To test if the GEBV generated without the individual phenotype translates into on-farm differences between bulls, we first ranked bulls by their GEBV and then compared the performance of top and bottom bulls, grouped by quartiles (Table 1, Q1-Q4).

## Results

The estimates of heritability and the accuracies of GEBV were moderate to high, indicating that we can improve these BBSE traits via selective breeding (Table 1).

**Table 1. The number of records on each trait, descriptive statistics, and genetic analysis.**

| Trait* | Mean | Standard deviation | Heritability | Accuracy | Q1-Q4 |
|---|---|---|---|---|---|
| Scrotal circumference, cm | 30.93 | 4.29 | 0.44 | 0.55 | 2.59 |
| Sheath Score, score | 3.13 | 1.67 | 0.55 | 0.47 | 0.67 |
| Normal Sperm, % | 62.34 | 27.37 | 0.27 | 0.36 | 9.49 |

## Discussion and conclusion

The Q1-Q4 analyses demonstrated that the accuracy of the GEBV from this project translates into applicable trait differences between groups of animals that can inform management decisions. Bulls in the top quartile had better BBSE records than those in Q4.

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# Genomic selection of commercial bulls – "Is my bull worth keeping?"

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## Introduction

Single nucleotide polymorphisms (SNPs) are a widely used tool to identify parentage and develop genomic Breedplan estimated breeding values (EBV's) for seedstock producers. Complex traits such as reproductive performance, feed efficiency and growth traits are expensive and often unpractical to measure in northern Australia. SNP testing potentially allows for early prediction of the genetic merit of an animal including hard to measure traits. Barwick *et al*. (2013), found genomic EBV's to be a useful selection tool once accuracies were >60%. In commercial systems, where parentage is unattainable and measurement of hard to record performance traits is not viable, the use of Breedplan genomic EBV's is an option to allow selection on key performance traits.

The aim of this study was to determine if an accurate genomic EBV developed by Breedplan, can be measured using SNPs on commercially selected tropically adapted sires and to determine whether bull genomic EBV's align with the producers' breeding objectives.

## Methods

Nineteen commercially bred pure Brahman bulls from the North Burnett region, selected for desirable phenotypic traits were used. DNA was taken from these animals via tail hair samples. The tail hair samples were subject to a complete genomic analysis using Neogen Standard Bundle (GGP TROPBEEF). The information on growth traits (200, 400 and 600-day weights), carcass traits (rib fat, rump fat and eye muscle area) and fertility traits (gestation length, days to calving, scrotal size) were recorded directly into Brahman Breedplan. Horn status was assessed visually and measured via SNP.

## Discussion

Across all traits accuracy levels ranged between 25% to 49%, with the growth traits overall having the highest. Although Barwick *et al*. (2013) states that accuracies 60% or above determine that EBV's are a useful tool, the addition of measuring these traits would further increase accuracy. The use of SNPs can assist in identifying superior commercially bred Brahman bulls. For a trait such as carcass weight an EBV can be determined, and animals can then be selected based upon the producers' breeding objectives. In this instance animals with higher carcass weights can be compared against a breed average to select superior animals.

## References

Barwick, S.A, Tier, B, Swan, A.A & Henzell, A.L, 2013, Estimation of accuracies and expected genetic change from selection indexes that use multiple-trait predictions of breeding values, Journal of Animal Breeding and Genetics 130 (50) 341-348

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# Genotype by Environment interaction in tropically adapted beef cattle

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## Introduction

Harsh and variable environmental conditions northern Australia means that to remain productive businesses must be able to breed animals that are robust for production traits, especially fertility. Robust genotypes can maintain productivity despite environmental conditions. The performance of sensitive genotypes varies according to environmental conditions. Accurately identifying robust animals requires investigation of Genotype by Environment interaction (GxE). GxE is the concept that different genotypes respond to environmental variation differently.

## Methods

The Northern Genomics project collected data from 29,321 heifers across 54 commercial herds located in northern Australia. The herds were typical of northern Australia, being large businesses with cross-bred and tropically adapted breeds. Heifers were recorded for three fertility traits across 3 years; puberty at 600 days of age, first pregnancy and second pregnancy as well as liveweight. Tail hair samples were taken from all heifers and genotyped on the 35K TropBeef SNP chip before being imputed up 709,768 SNP on the Bovine HD array (Sargolzaei *et al*., 2014). This study separately used ADWG and temperature/humidity to define two environmental gradients that reflected nutritional availability and heat load respectively. A reaction norm approach where the performance of each genotype is examined along a continuous environmental gradient (i.e. from 'harsh' to 'favourable') was utilized (Hayes *et al*., 2016). The analysis estimated heritability for the trait (intercept) and robustness (slope). A higher heritability of 'slope' was indicative of GxE. This study aimed to investigate whether GxE is a factor for the three fertility traits as well as liveweight.

## Results

The reaction norm analysis found evidence of GxE for weight traits. Evidence of GxE for fertility traits was limited. Reranking was observed for weight at first pregnancy across the ADWG gradient (Fig. 1.). Breeding values for slope were produced and interpreted as EBV for robustness.

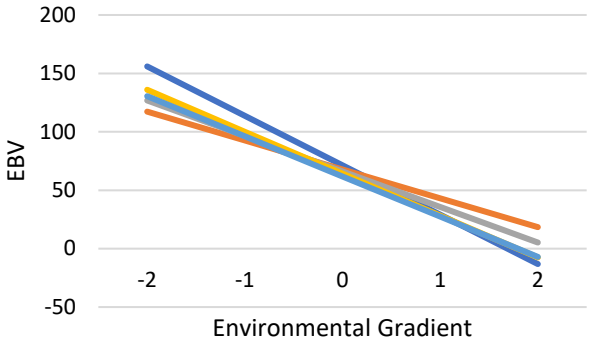


**Fig. 1. Reaction norms for weight at first pregnancy across ADWG environmental gradient.**

## Conclusion

GxE may be a factor for weight traits and EBVs for robustness should be explored. Lack of GxE for fertility traits indicates that selection for fertility traits can be done accurately across the environmental gradient.

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# Stayability trends in a Brahman herd that has been selected for fertility

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## Introduction

Stayability is the probability that a cow will remain in the herd past six years of age whilst weaning a calf every year (Engle *et al.* 2016). When selection for fertility is undertaken, cows are often culled if they do not wean a calf. In these situations, more fertile cows will stay in the herd longer. This study examined whether long-term selection for increased fertility has resulted in greater stayability in a Brahman herd in the Northern Territory (NT).

## Materials and methods

The NT Department of Industry, Tourism and Trade (DITT) has been selecting for fertility in a Brahman herd since 1994. The method of selection and management has been detailed by Schatz *et al.* (2010). Herd records were used to calculate the percentage of cows that stayed in the herd longer than six years of age for each year group of females weaned from 1992 to 2015. These data were used to determine if stayability increased over time. Reasons for culling were: Failing to reconceive; Calf loss; and, Other causes (which includes death and culling for non-fertility related reasons). If a cow could not be matched to a calf through mothering up or DNA parentage testing then it was deemed to have not weaned a calf and was culled, even if it was lactating at a weaning muster. Females that were culled before three years of age were not included in the study.

## Results

**Table 1. Reasons for culling in breeders > or < than six years of age.**

| Age (years) | Fail to conceive | Calf loss | Other |
|---|---|---|---|
| <6 | 70% | 12% | 18% |
| >6 | 55% | 21% | 24% |

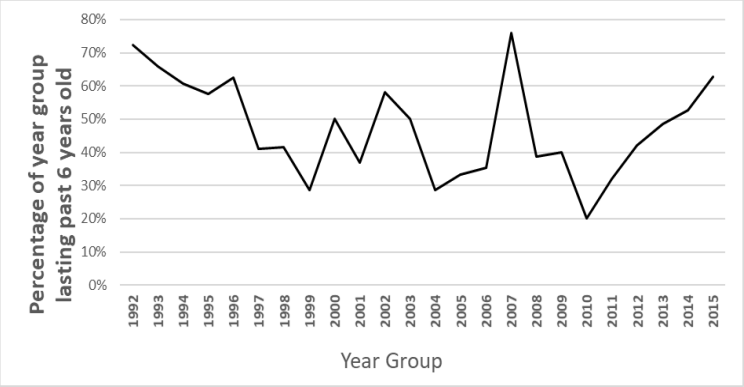


**Fig. 1. Percentage of cows lasting > six years old**

## Discussion and conclusion

Table 1 shows that failure to reconceive was the most common reason for culling both before and after 6 years of age, and that it was proportionally higher in cows <6 years while calf loss was proportionally higher in cows >6 years. the proportion of cows staying in the herd longer than 6 years has not increased over time (Fig. 1). This is somewhat surprising as the fertility trait estimated breeding values for the herd have improved over time (Schatz *et al.* 2010), and so it would be expected that cows would remain in the herd longer since fertility is improving. However, stayabilty of year groups could also be impacted by non-genetic factors such as seasonal conditions.

## References

Engle et al. (2016). Anim. Sci. 94: 142.
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# The Kimberley and Pilbara Beef Breeding Project: Developing modern genetic evaluation tools to identify and breed more profitable cattle for northern WA

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## Learning from Kimberley and Pilbara beef breeders: What's driving profitability?

The Kimberley and Pilbara Beef Breeding Project is a three-year initiative of the WA state government which aims to improve beef profitability in the extensive rangelands of northern WA by applying modern genetic evaluation tools to bull selection.

A critical component of the project is to gather the information required to accurately model productivity and costs for beef breeding enterprises in the north of WA. Building this understanding is based on property visits involving AGBU geneticists and WADPIRD Beef Development Officers, phone or ZOOM discussions and interaction with breeders at regional workshops and forums (BeefUp forums, producer group workshops and breeder-oriented conferences). In the first year of the project AGBU geneticists visited 15 herds in the Kimberley and Pilbara and have introduced the project to an additional 24 enterprises in an effort to better understand on farm productivity and market forces which are driving profitability for commercial beef breeders in the region. This information is being applied in the development of new tools to help WA's northern beef breeders identify breeding animals (particularly bulls) of superior genetic merit for their production systems and markets.

## New tools and advice for Kimberley and Pilbara commercial beef producers

A key contribution information gathered from WA's northern breeders has made is to the development of new BREEDPLAN selection indexes for tropical breeds. Fig. 1 presents an example of the economic weights for BREEDPLAN EBVs for a Droughtmaster index which models a commercial, self-replacing herd producing steers which are finished to a carcass weight of 320kg. This is the first index developed for the breed, and will help Kimberley and Pilbara bull buyers, and those throughout northern Australia, more accurately identify animals which will generate more profitable off-spring.

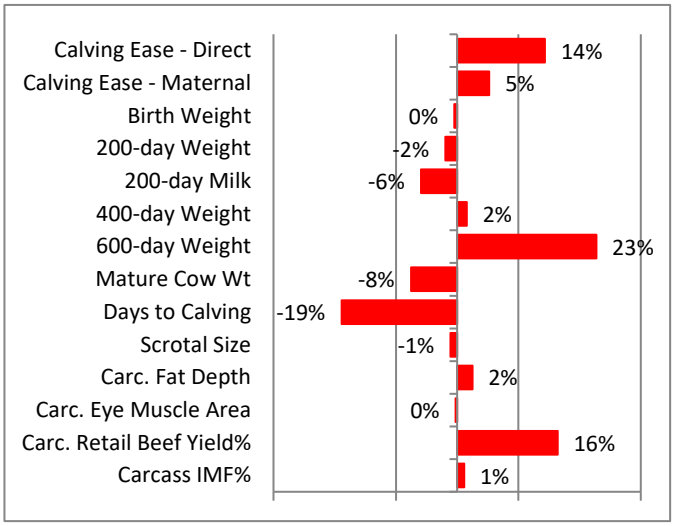


**Fig.1. EBV weightings for the first BREEDPLAN selection index developed for Droughtmaster breeders.**

## The critical role of the stud sector

The degree to which bull buyers will benefit from selection indexes and other tools this project will contribute to will depend on the levels of phenotyping and genotyping in the seedstock sector. Tropical beef breeds have benefited from the intensive recording (particularly for hard to measure, economically important traits) undertaken by the Beef CRC and Repronomics™ projects. There is a need for the northern beef industry to support these projects, and to ensure the breadth of each breeds' genetics and performance are adequately described, if commercial breeders are to obtain maximum benefit from modern breeding tools.

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# Balancing selection for polled in commercial beef herds using digital twin simulations

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## Introduction

To balance progress to a polled herd and genetic gain for breeding objective traits, a digital twin approach was employed to simulate various management strategies, breeding decisions, and resource allocations in cattle breeding programs. Two breeding programs were simulated in the digital twin, a composite herd with an intermediate frequency of the poll locus, and a Wagyu herd with very few polled animals in the base population.

## Methods

A digital twin simulation framework (Villiers *et al*., 2022), was employed to estimate the increase in polledness and genetic merit in commercial herds through alternate breeding programs, utilizing real genotype data (including for the polled mutation), actual production parameters, and various breeding structures. Four breeding management strategies, including multi-sire natural service, artificial insemination (AI), and in vitro fertilization (IVF) with either five or 10 embryos collected per heifer, were analysed. The result of the digital twin simulations was a poll frequency – genetic gain frontier, allowing users to choose where they wanted to be with respect to the trade-off between increased polled frequency, genetic gain and inbreeding.

## Results

The highest rates of genetic gain were delivered by programs that used IVF. Theoretically single trait selection for poll was the quickest way to transition to a 100% homozygous polled (PP) herd and this could be achieved within eight years. A significant increase in PP animals was observed with 40% weight on poll, while only slightly reducing genetic gain in base populations with a 60% frequency of the polled locus. IVF programs allowed for increased selection for poll without affecting genetic gain and expedited the transition to a fully polled herd. Inbreeding was highest with IVF schemes and AI compared to natural service. Due to the high initial frequency of the polled locus in the composites, increasing the weight on poll resulted in reduced inbreeding in later generations as there were more polled sires with high EBVs available for selection.

## Discussion and conclusion

This project leveraged digital twin technology to evaluate the balance between time to poll, inbreeding, and genetic gain. Simulations of a composite herd with an intermediate frequency of polled and a Wagyu herd with a very low starting frequency of polled showed the feasibility of transitioning both herds to nearly 100% PP animals, albeit at a reduction in genetic gain. AI and IVF schemes with high emphasis on poll had higher genetic merit, at the expense of slightly higher inbreeding rates. The digital twin approach may inform breeders on what selection weight to put on polled depending on the polledness of their herd at the start, the desired speed of transition to homozygous polled genotypes and the acceptable trade-off in genetic gain and inbreeding. Notably, the starting frequency of the P allele significantly influenced these outcomes.

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# OUR NORTHERN RECIPE FOR SUCCESS– BRINGING IT ALL TOGETHER

# NABRC. A Producers Journey

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## Introduction

I attended my first South Qld Regional Beef Research Committee meeting in 2008. This started a journey which is best shared here for the benefits and relationships one can extract from being part of NABRC.

I have attended five NBRUC's, the last as organising committee Chair. Now as speaker I have the opportunity to tell my journey, encourage other producers to get involved and share the benefits of being involved with the industry in a different way.

As above, my first SQRBRC meeting was in 2008. At the time my wife and I were running an embryo recipiency business on our properties at Texas in southern Qld. So, the challenges of science and research involved in NABRC definitely piqued my interest. This initial meeting (unbeknown to me at the time) was to lead to a twelve-year involvement with NABRC and Red Meat R&D in general.

I quickly became Regional Committee Chair and began a representative journey. As a Regional committee Chair you get to sit on NABRC and thus begins the process of travel all round northern Australia with fellow Regional Chairs at regular meetings all around the North along with building relationships with MLA staff, Ag Dept "beefies" University Representatives, State Farming group delegates, Researchers and many more people involved in the Red Meat research arena.

My first NABRC meeting was the last for John Cox, Ralph Shannon then took the reigns, followed then by Lee Fitzpatrick. During this time I also began the role of NABRC management committee Chair and my involvement picked up. I was elected Inaugural Chair of MLA's Red Meat Panel, developed for appraisal of MLA's beef producer levy funded R&D program, setting research priorities appraising subsequent project applications and finally funding the appropriate projects. I also began a five-year term on Cattle Council's R&D committee which offered oversight to the MLA program. I was sponsored by MLA/CCA to attend the Australian Institute of Company Directors course.

Outside of NABRC I was engaged by Queensland Investment Council (QIC) to offer expertise on Ag investment and then sat on their Agri Investment Board alongside luminaries such as Don McKay and Susan McDonald as we advised QIC through their purchase of their majority holding in NAPCO.

These and many other experiences have given me a vast understanding of the northern red meat industry creating an enviable group of colleagues with whom I can reach out to for industry guidance. A very privileged asset.

My journey came to an end as we incorporated NABRC and limited producer terms on the committee to two three year terms. In all my journey had lasted 12 years.

## Where to from here?

A Singapore start-up company, animalEYEQ approached me to "open some doors" into the livestock industry here in Australia. animalEYEQ is a camera vision and artificial intelligence business monitoring livestock in intensive situations for count, health feed efficiency and many other relevant applications with works in Australia, the US and Europe. So begins the next part of my journey.

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