

Implementing successful controlled mating programs on extensive beef herds

Agri-Science Queensland Innovation Opportunity

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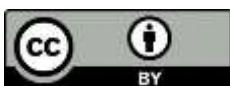


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Summary

This report is for a scoping study examining issues with on property adoption and implementation of controlled mating programs on extensive beef herds in northern Australia.

Controlled mating can have many benefits for a beef business, however the level of benefit depends largely on the individual business. The use of controlled mating is a highly recommended best management practice for beef producers across northern Australia. Significant effort has evolved around research to quantify the benefits of controlled mating. These include the ability to time calving to coincide with peak pasture availability and quality to maximise survival of cow and calf, to avoid lactation during the dry season, to allow for a more efficient supplementation program, and to maintain cow body condition so that she can re-conceive the following year. The practice also enables labour to be condensed into two main rounds for net reproduction rate to be more accurately measured.

This study reviewed current guidelines and implementation processes for controlled mating at a whole property level. The review concludes that insufficient processes are described in detail to facilitate successful beef enterprise adoption of this highly recommended management practice. The complexity of the practice is also described and the need for it to be designed around individual businesses. We conclude that continuing to follow a broad message approach may lead to increased issues with adoption. The review also highlights gaps in research and extension materials available for beef producers, including enterprise case studies that include a full business economic analysis that describe sound and successful, proven adoption strategies.

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Background

The practice of controlled mating (i.e. restricted, seasonal) is defined as the practice where bulls are introduced to the breeding herd for a controlled period of time and then are removed from the female herd. The practice can be an effective tool in breeder management systems with many potential benefits. However, survey information has shown that successful implementation of controlled mating systems on extensive beef operations in northern Australia is low. Many surveys have highlighted that the adoption of controlled mating is low in the Burdekin NRM region and throughout northern Australia (O'Rourke et al 1992 and McCosker et al 2011). However, independent practice change surveys completed for the Burdekin Grazing BMP and Extension Support project since 2013 have shown a high occurrence of producers changing the mating system used on their herd for only a short period of time before transitioning back to traditional practices (Moravek et al 2003). Producers within these surveys discuss the method used and the complications encountered, often demonstrating a breakdown in the implementation process. Northern Australia's vast, variable landscape can also make the practice of controlled mating challenging due to the level of feral bulls, extreme wet seasons affecting infrastructure, and variable seasonal conditions causing cows to slip from the optimum calving window.

When successful, controlled mating can be an effective tool in breeder management systems with many benefits in regards to herd management (Meat and Livestock Australia, (MLA), 2006). Controlled mating can be used to manage herd nutrition and body condition; apply pressure to the herd's reproductive performance to be at its most efficient level without occurring significant costs through tightening the calving period; to incorporate best management weaning practices; to manage bull and replacement heifer performance and cull cows on reproductive performance.

There is currently a gap in extension materials that describes proven and successful implementation strategies for producers when considering transitioning to controlled mating. The majority of literature available, describes the mating system and its benefits but fails to give any detail of where to start, the critical steps and the potential setbacks that may be encountered.

This project aims to better understand controlled mating adoption impediments through a review of current research, extension materials and implementation guidelines. In addition it also involved consultation with specialist public and private service providers who assessed a case study and recommended strategies. A producer interview was also conducted to gain their insights into the processes they used.

Project Objectives

This project investigated the issues associated with the adoption of controlled mating on extensive beef herds in northern Australia. The project, aimed to determine and therefore propose strategies to develop improved guidelines for beef producers.

Project objectives:

- Identify issues limiting successful adoption and implementation of controlled mating.
- Identify potential collaborators for whole of business case studies demonstrating where successful implementation of controlled mating has occurred and the economic benefit.
- Establish a plan for the development of an industry publication and other extension material.

Methodology

Table 1 Project activities and milestones

Activity	Description	Who	Scheduled Start	Scheduled Finish
1. Literature Review	Literature review on the research, implementation and current extension guidelines of controlled mating	Alice Bambling Mellissa Holzwart Lauren Williams Holly Reid Brigid Nelson	16/10/2017	30/01/2018
2. Consultation	Consultation involving industry to determine issues with successful implementation and identify gaps in current implementation strategy guidelines of controlled mating in extensive beef herds in northern Australia	Alice Bambling Mellissa Holzwart Brigid Nelson	1/02/2018	5/03/2018
3. Identification of potential collaborators for whole of business case studies	Project meeting to identify and nominate potential collaborators for whole of business case studies. Identify businesses that represent Northern Australia (Queensland, Northern Territory and possibly Western Australia).	Alice Bambling Mellissa Holzwart Lauren Williams Holly Reid Brigid Nelson	6/03/2018	13/04/2018
4. Establish a plan for the development of an industry publication and other extension materials	Using information obtained from project activities 1 and 2, develop a plan for future project direction, highlighting key areas requiring development.	Alice Bambling Mellissa Holzwart Brigid Nelson	6/03/2018	1/06/2018
5. Scoping study report (Final Report)	Scoping study report detailing recommendations for future project direction, focused on increasing adoption and filling gaps in current extension guidelines and materials.	Alice Bambling Mellissa Holzwart Brigid Nelson	8/03/2018	27/07/2018

- Literature review

Review of available scientific papers, workshop and course materials, factsheets, brochures, news articles and published producer case studies.

- Consultation

The project aimed to engage industry when examining possible issues associated with the adoption of controlled mating and the likely problems faced by beef producers. To engage industry, a producer based scenario was developed. Key specialists in the field of animal production and beef breeding were identified representing both private and public service providers. The specialists were divided into two groups, based on area of expertise; group one had more experience with smaller more intensive herds in southern and central Queensland, and group two was made up of those with more experience with larger more extensive herds in northern Queensland, the Northern Territory and northern Western Australia. A relevant scenario was provided to each group and each individual was asked to respond to the ‘mock producer based enquiry’. Information sought related to key first steps for the producers to follow when implementing controlled mating for the first time, recommended processes, possible issues and barriers the producers may encounter when adopting the practice and tactics to overcome these issues as well as resources and tools recommended.

The information provided from the specialists was collated and summarised.

A producer survey was designed to gain understanding behind why producers implement controlled mating systems, the processes and resources they used, benefits observed and issues faced and overcome during the process.

- Identification of potential collaborators for whole of business case studies

The project team in consultation with Departmental staff across other regions, identified and collated a list of four potential collaborators for possible future whole of business case studies.

- Establish a plan for the development of an industry publication and other extension materials

The project team assessed the information gathered in project activities 1 and 2 (see Table 1). The key learnings from each of these project components were analysed and key areas for future development highlighted.

- Scoping study final report

This document, the third project activity, analysed the results from both the literature review and consultation activities. This report summarises recommendations for possible future project directions, including strategies for the development of an extension document on controlled mating.

Results

Controlled mating is a highly recommended best management practice in the beef industry. However, there has been limited research completed on the practice, with most of the research relying on simulated modelled outputs with limited field based experiments, particularly commercial scale, completed across northern Australia.

In this project, due to the importance and emphasis that is placed on this management practice for beef producers, significant time and effort was taken to examine all components of the practice relating to both recommendations described by research and practical information for on-property adoption.

There is adequate information available to beef producers on the topic of controlled mating, the benefits to productivity, relationships between time of calving and breeder body condition and nutritional requirements. However, information on the important factors such as the economic benefits, and successful implementation of the practice at the whole of property level was found to be limited.

Review of current research and extension literature

A literature review examining current research and extension documentation relating to the implementation of controlled mating was completed (Appendix 1). A small number of scientific papers and reviews on the topic have been completed and documented prior to this project. The review completed during this project differed from those completed previously as it aimed to match the results and guidelines described by scientific literature with documented extension materials for beef producers.

The review considered in detail the benefits of controlled mating as described by research as well as current extension implementation guidelines. The review also identified gaps in the available research and implementation guidelines available for beef producers. The gaps identified, particularly in the availability of extension implementation guidelines, assisted this project when recommending strategies for future project direction. Conclusions from the review are:

- Adoption of controlled mating is currently low across northern Australian beef herds.
- There are various recommendations on the ideal length of joining. They vary depending on location, fertility of the land, timing and amount of annual rainfall.
- There is a gap in extension materials that describes proven, successful implementation strategies for producers to use when considering transitioning to a controlled mating system
- Known economic benefits of controlled mating is limited to a few model based scenarios.
- Literature relating to the topic of controlled mating is reasonably diverse however only a few examples are specific to northern Australia.
- No data was found for field based experiments examining controlled mating across northern Australia. Most guidelines developed from literature are based on modelled outputs.
- Bull control and management, infrastructure, variable climates, low fertility land types, and producers overall commitment to change has been identified as the main issues influencing the adoption of control mating in northern Australia.

Considerable workshops, courses, information and tools are available to beef producers on the topic of controlled mating. However information, relating to implementation of controlled mating strategies across the whole of property, is found to be brief and refers to further planning and advice needed.

Consultation activity

The methodology differed slightly from the initial project proposal. Initially workshops were planned to engage both research and extension officers as well as industry. A closer examination of budget lead to a change in the methodology for this component of the project. The scenario based responses proved to be an equally effective method in gaining very detailed and specific insights from beef production specialists. The responses from two mock producer based scenario from 10 beef production specialists were analysed. The results were summarised with the following outcomes determined.

- Extensive one to one support is currently recommended in order for producers to successfully implement controlled mating.
- A detailed property map including infrastructure and carrying capacity is an important tool required when planning to implement controlled mating.
- Allocate a secure paddock for bulls that can be spelled, spilt paddocks if necessary. Discuss issues around paddock security and the economics for new infrastructure (fences).
- Important to work out property's green date to determine ideal time for lactation and weaning so that cows are lactating when pasture is at its best quality. Then work out the pasture growth curve to determine ideal mating period.
- Beneficial to have a good data recording system, preferably with individual ID, in place to keep track of production.
- Controlled mating is not a practice that can be implemented without changing other management practices, such as attitude to disease, vaccinations, VBBSE on bulls and grazing land management practices for it to be successful.
- Use of segregation through foetal aging as a stepping stone is highly recommended especially for large scale properties in the north.
- Segregate and treat heifers separately from main breeder mob. This group of breeders can be controlled mated for the ideal period from the first year of implementation.
- Implement the practice over a number of years, so that no significant drop in calving percentage is experienced and out of season pregnant breeders can be used for cash flow.
- Implementation of a controlled mating system can only be determined on the basis of a particular business, property and herd situation.
- Challenges posed to producers:
 - Increase labour in particular times of year with condensed branding and weaning rounds.
 - Having a positive attitude to change to controlled mating systems need 100% commitment from the producer for it to be successful. Holidays and time away from the property needs to be planned around critical dates such as bulls in and bulls out.
 - The majority of income will come at once with controlled mating rather than trickle in through the year.
 - Having sufficient infrastructure to control bulls, the ability to spilt breeders up and yarding facilities to handle larger mobs of weaners.
- Sufficient courses / workshops are available and highly recommended to producers by specialists in these areas. These can also be used to help the producer establish themselves within a group of like-minded people that can be used as support throughout the process.

Identification of potential collaborators for whole of business case studies

Four potential collaborators were identified based on knowledge that their business has successfully adopted controlled mating or are in the process of implementation. The collaborators identified are all of a commercial scale and represent the northern beef industry. The collaborators were not approached in this project however will be part of the extension plan.

Establish a plan for the development of an industry publication and other extension materials

The results of both the literature review and consultation project components were analysed by project staff. It was determined that whilst many guidelines and principles for the implementation of controlled mating are consistent across literature there is not a simple, standalone extension package or product available to beef producers. The project team has established a plan to produce a document that beef producers can follow to design their controlled mating system. However, emphasis will still be put on getting extensive one to one consultant and/or extension support to help with the process due to the complexities in matching a system to an individual business. The plan includes:

- Using information gathered from this project, develop a full range of key steps and processes for beef producers to follow when implementing a controlled mating system.
- Test the proposed steps and processes at the producer level to determine practicality and transparency of messages.
- Utilise the list of potential collaborators for whole of business case studies to identify four to six willing participants.
- Develop publicly available case studies on successful implementation of controlled mating at the whole of property level, including an entire businesses economic analysis.

Conclusions/Significance/Recommendations

Conclusions

This topic requires further investigation to make definitive conclusions on the usefulness and value of an extension publication for producers. There is a limited range of scientific literature that has examined the topic of controlled mating and results are largely based on modelled outputs that do not consider economics, specific to northern Australia beef enterprises.

On the other hand, there is considerable published extension materials on the topic of controlled mating as a whole. Within most of these materials, controlled mating is highlighted as a key management practice. However, this study found that similar to the research, the majority was designed around southern Australian mating systems. It also found that detailed information relating the full range of steps and processes for successful implementation of controlled mating does not currently exist. The project found that there are no published case studies that describe sound and successful strategies for implementing controlled mating in extensive beef operations, including economics.

Information collected to date indicate there is value in controlled mating and a number of consistent approaches used by industry that could be explored further.

Significance

This study investigated the topic of controlled mating with an aim to better understand issues associated with adoption and to therefore propose strategies to develop better guidelines for beef producers. The development of improved guidelines and recommendations will assist not only beef producers to increase the skills and knowledge required to implement this practice, but also assist

extension staff working with producers to achieve adoption of grazing best management practices such as controlled mating.

Recommendations

This study recommends that further project work be undertaken to address the issue of available extension materials describing the full range of steps and processes required for the successful adoption of controlled mating. This project through the review of current literature and extension materials has highlighted some key guidelines, steps, processes and tools required. However, further investigation is required to test these guidelines at the beef producer level.

Key Messages

Controlled mating in order to prevent breeders lactating in the dry season is a highly recommended best practice across northern Australia.

Issues exist with the successful adoption of controlled mating across many extensive northern beef enterprises.

It is difficult to develop a blanket strategy for the implementation of controlled mating as every business is unique and therefore has different limitations and objectives.

Controlled mating is one out of many management tools in beef production and requires certain levels of management to already be in place before it is implemented.

It is recommended that producers should first contact a trusted advisor in the field of beef production, in particular beef breeding, to gain extensive one to one support before trying to implement a controlled mating system. This could be a consultant, veterinarian, or a beef extension officer.

Recommended that the producer attends some form of training to assist with planning to ensure other necessary practices are in place first. This also provides the opportunity to develop a like-minded support group.

Where to next

The Grazing BMP and Extension Support project plans to continue to examine this topic including the possibility of investigating and acting on each of the recommendations as highlighted in this report.

We plan to conduct further producer interviews to gain a better understanding of the drivers and limitations behind the implementation of controlled mating and produce case studies, following their process of implementation from start to finish, including entire business economic analysis. It is planned that a formal publication, documenting the findings, will be produced.

Budget Summary

Budget Summary

The project was underspent on budget.

Budget

- \$5000

Expenses

- Spent \$4400 (incl. GST)

Four private industry consultants chosen as specialists in the field of animal production and beef breeding systems were engaged to assist with project activity 2 – Consultation. Refer to Methodology.

References

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- McCosker K, Fordyce G, Smith D, Burns B, Jephcott S, McGowan M (2011a) Survey of selected northern Australian breed breeding herds: 1. Management. In Proceedings of the Northern Beef Research Update Conference, Darwin, August, p.120. North Australia Beed Research Council, Brisbane.
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Appendix 1 - Literature review of controlled mating

Implementation of successful controlled mating programs on extensive beef herds in northern Australia

A review of literature

Alice Bambling, Department of Agriculture and Fisheries, Animal Science, 4720

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Executive summary

Improving productivity and reproductive performance is a high priority for the northern Australian beef industry. Controlled mating is a commonly promoted breeding system that can result in many benefits. Information gathered has shown that the implementation of successful controlled mating systems on extensive beef operations is poor. Feedback from producers has shown that the implementation of these systems is difficult to manage, often due to breakdown in the implementation process. There is currently a gap in extension materials that describes sound and proven successful implementation strategies for producers to use when considering transitioning to this beneficial and recommended best management practice.

This literature review highlights the difficulties in sourcing detailed process of implementation of controlled mating in beef herds in northern Australia that is accessible to producers that are considering making a practice change on their property. The review also highlights that limited studies into the economic impact control mating has on individual properties have been conducted. There is only a small number of detailed studies that have collected data on controlled mating, none of these include a full economic analysis of the practice.

The review describes the benefits of control mating in beef herds and the three main documented approaches used to implement the mating strategy on property. Bull control and management, infrastructure, variable climates, low fertility land types and producers overall commitment to change has been identified as the main issues influencing the adoption of control mating in northern Australia. Management strategies for minimising their potential to adversely impact calving and weaning percentages are also explored.

The main conclusions are that further investigation is justified to obtain better recommendations for implementing controlled mating in a northern Australian beef herd through a detailed step by step approach on how to implement a range of different control mating processes for different circumstances. It is also recommended that solutions for all possible issues producers may encounter throughout the transition process are incorporated into the literature. Further effort is also recommended to obtain a better understanding of the economic impact controlled mating has on individual businesses, this may be in the form of comprehensive producer case studies.

1.0 Background

The practice of controlled mating (i.e. restricted, seasonal) is defined as the practice where bulls are introduced to the breeding herd for a controlled period of time and then are removed from the herd (MLA, 2006). There are various recommendations on the length of controlled mating. MLA (2013) recommends to achieve ideal calving distribution bulls are run with the cows for a minimum of 45 days and a maximum of 60 days. Holroyd & Fordyce (2001) state that in the dry tropics, controlled mating commences from November to January onwards for five to seven months. Finally, MLA (2017) reports that controlled mating can refer to a period of joining from three to seven months in duration.

A number of sources have identified controlled mating as an important practice in breeder cattle management across northern Australia including Queensland, the Northern Territory, Pilbara, and Kimberley regions of Western Australia (McGowan et al 2014). However, feedback from producers has shown that the implementation of successful controlled mating systems on extensive beef operations is difficult to manage.

Controlled mating is often used in more favoured areas with more reliable seasonal conditions and 100% bull control (MLA, 2006). The further north, north/west you move in Australia, the less

businesses you will find who operate within a controlled mating system. This is primarily due to northern Australia's rangelands occurring mainly on low fertility soils and native pastures growing mostly in the summer period (November to April). Under these conditions grazing animals commonly suffer protein and energy deficiencies in the dry season (April to November) and mineral deficiencies, particularly phosphorus throughout the year. Annual productivity of cattle is constrained by variable rainfall, short pasture growing seasons and extremes of temperature. There are a number of distinct native pasture communities in northern Australia and there is a large variation in annual performance both between and within each of these communities. Cattle production in the far north is characterised by large properties, low stocking rates, low management costs, and low productivity compared with many southern production systems (Holroyd & Fordyce 2001). Northern Australia's vast, variable landscape can make the practice of controlled mating challenging due to the level of feral bulls, extreme wet seasons affecting infrastructure, and variable seasonal conditions causing cows to slip from the optimum calving window (Braithwaite & de Witte 1999).

However, when successful, controlled mating can be an effective tool in breeder management systems with many benefits in regards to herd management (MLA, 2006). The adoption of controlled mating can be used to manage herd nutrition and body condition, apply pressure to the herd's reproductive performance to be at its most efficient level without occurring significant costs through tightening the calving period, incorporate best management weaning practices, manage bull and replacement heifer performance and cull cows on reproductive performance. Unfortunately, to date, there has been limited research conducted on controlled mating and its economic advantages to producers in northern Australia.

This review provides a summary of the scientific and extension literature on adoption and implementation of controlled mating programs in beef herds across northern Australia and identifies issues limiting successful adoption and implementation of controlled mating. The relative benefits of controlled mating and the economic benefit to its successful implementation are discussed. The review also includes a targeted review of potential issues limiting successful adoption and implementation of the system to help identify future development options.

This information will be used by industry to identify gaps in current implementation strategy guidelines. The project will provide a base to plan for the development of extension packages to provide practical guidelines for producers to transition to a successful controlled mating program and to adopt grazing best management practices.

2.0 Current adoption

In a survey of northern Australian beef producers, O'Rourke et al (1992) reported that a high percentage of respondents left bulls in the herd all year round and those producers who did control mate still used relatively long joining periods, averaging 6.7 months. Similarly a survey of beef producers in the Burdekin and Suttor catchments, Moravek et al (2013) found that 64% of producers still used a continuous mating program. Furthermore, McCosker et al (2011) found that only 27% of properties in the more extensive areas of the Northern Territory and northern Western Australia used a controlled mating system. These reports demonstrate low adoption rates of controlled mating across northern Australia

Williams (2008) discovered a comparable result through a research study based through James Cook University and CSIRO, where she explored the influence of resource dependency and targeted media on graziers' decisions to practice controlled mating in the Upper Burdekin region, North Queensland. A group of 26 producers were surveyed as part of the project. Of this group of producers 14 (54%)

practised controlled mating in their cattle herds and 12 (46%) did not. The length of joining varied amongst the producers. Seven, eight and nine months were the most frequent separation periods. Williams (2008) also found that only seven producers in the sample practiced controlled mating for financial reasons, other reasons included better herd management, to improve financial control and expectations and to improve calving rate and herd fertility. Results from Williams (2008) study suggested that the graziers who do not practice controlled mating have the perception that it is too much hard work, or would not work on their property due to their particular geographical restraints.

In addition, Williams' (2008) study reported approximately half of the participants who practiced controlled mating felt there was a financial need as opposed to their peers who did not controlled mate because they felt that there was no financial need. This study demonstrates that controlled mating is being adopted by those who identify the practice as a financial necessity and are more willing to try new management strategies. Even the graziers who implemented controlled mating and who had no financial need to do so felt that they benefited financially from this practice.

In a report to Meat and Livestock Australia, Freer et al (2003), used an extension group to focus on a National Beef Genetics Foresight plan for the current and future beef industry. The team reported on barriers to adoption of breeding and genetic practices in the beef industry and methods for overcoming these barriers. Four major barriers were identified which included lack of 'proof of profit', lack of assistance with adoption after initial exposure to awareness programs, extension in a diverse and fragmented industry and the decline of traditional extension resources. Further, in Williams (2008) study, the majority of producers in the sample stated that they received far too much generic information aimed at primary producers in general, not cattle properties, and that it was time consuming to sift through the information to find anything relevant. The most common way of hearing about controlled mating was from friends (54%) and extension officers (27%). No producer had heard about it from either reading books or the television, but a few had heard of the practice from Landcare meetings. Seventy seven per cent felt the information was relevant to them and 65% felt the information was easy to access. According to this study, producers appear to be mostly influenced by the local Queensland Department of Agriculture and Fisheries representative, financial circumstances and informal networks. The most effective way to achieve adoption appears to be through showcasing producers with different experiences of using a new practice (such as controlled mating). This strategy has inspired other graziers to efficiently disseminate relevant information to them and identifying leaders in the area to informally promote the benefits of practices such as controlled mating.

Finally, Williams (2008) found statistically significant differences between those that practice controlled mating and those that do not. Producers who were using controlled mating were more proactive in their business strategy and herd management techniques and were less likely to be risk averse. Interestingly they were not striving to achieve maximum yield from their herd either. Associated with this second objective is the key learning that the practice of controlled mating has an increased likelihood of adoption if the financial benefits are clearly outlined at the beginning.

3.0 Documented strategies of implementation

There are three main documented processes of implementing a controlled mating system on property. These processes may differ slightly between studies, but promote the same principles. This is not to say, these are the only ways controlled mating can be initiated in a beef herd.

The first strategy, promoted by Meat and Livestock Australia (2013) 'More beef from pastures', recommends segregating breeders that are falling pregnant by the end of their second oestrous cycle.

The remaining breeders are placed into a realignment program that fall pregnant by the third oestrous cycle and bring forward their mating period no more than three weeks each year. Cull any that do not fall pregnant within three cycles. They further recommend to take corrective action when more than 20% of the breeders conceive in the third oestrous cycle, by realigning the reproductive capacity and age structure of the herd over several years to avoid economic penalties for the enterprise. With this method, producers are expected to experience a large decline in calf numbers. It may be more economical to leave mature cows in a continuous mated system and only reduce joining period for heifers. Gradually sell mature cows as new heifers are added to the breeder herd. The recommended minimum and maximum number of mating days is based on the assumption that more than 80% of cows conceived by the second oestrous cycle in the previous year's mating. When more than 20% are conceiving in the third oestrous cycle, the mating period may need to be extended beyond the recommended maximum limit to ensure satisfactory throughput in the short term. This method is supported by Chudleigh et al (2016), whose study states that moving from continuous to controlled mating, may also include an intermediate step of herd segregation and moving from that step to controlled mating will depend upon the rebreed rates of the mature breeding herd. Chudleigh et al (2016) also added that high rebreed rates would appear to reduce the need to segregate cattle and support controlled mating, while lower rebreed rates would suggest it would be difficult to prove that moving from a continuously mated herd to a controlled mated herd, would be economically worthwhile.

The second strategy is to have a joining period of three to seven months in areas where rainfall is somewhat reliable and leave the joining period at seven months in unreliable and less fertile country. Hamlyn-Hill (2016) recommends that before removing the bulls for any length of time that the optimum joining time should be determined. Calving should commence approximately six weeks prior to the property's green date. A green date is the beginning of the growing season and occurs when there is a high probability that all key environmental conditions such as soil moisture, temperature, day length and nutrients are favourable for pasture growth. This is why determining the ideal joining period becomes problematic in areas of low rainfall and high rainfall variability. Peak lactation and peak requirements for the majority of cows should coincide with the production point which occurs four weeks after the green date. This ensures cows have the best plain of nutrition available to them when they have the highest nutritional requirements to prevent loss in body condition. Once the joining time is determined, heifers can be segregated and controlled mated from year one. Meat and Livestock Australia (2006) and Hamlyn-Hill (2016) recommend mating heifers for two to three months if they are all in good condition, and culling those that don't fall pregnant. This will put pressure on reproductive performance of the future herd as heifers that calve late initially will always calve late or will miss out on getting back in calf. Therefore, by having a shorter initial calving period, these animals will be able to be easily identified before joining the main herd. It is also recommended that when commencing controlled mating for the first time, it should be implemented slowly with mature breeders. In the first year, start by taking the bulls out of the herd for the four driest months of the year, then reduce the joining period by one month each year until the desired joining period is reached (Alan Laing 2017, pers. comm., 17 August). This will ensure that the business will not suffer a large decrease in calves within the first few years after implementing the practice.

The third strategy involves implementing a good heifer management program to align their reproductive cycles up from the beginning to ensure compact calving throughout the rest of their lifetime. Meat and Livestock Australia (2013) has documented in the 'More beef from pastures' program that where it is necessary to move the calving date forward by more than six weeks, it may

be best to leave the current cow herd in its established calving pattern and join the replacement heifers to calve at the desired calving time and period. As the number of young breeders calving at the desired time increases each year, the older, out-of-sequence cows can be culled. After about five years, the herd will be calving at the required time over two heat cycles with minimal risk of low conception rates. Holroyd & Fordyce (2001) elaborate further on the other related issues of heifer management. They reported that under continuous mating, heifers have a high mortality risk as initial lactation of heifers often occurs during the dry season and therefore they generally have a poor chance of re-conceiving whilst lactating. They further suggest that segregation of heifers to provide preferential nutritional management is a cost-effective way of improving fertility. Jayawardhana (1998) and Fordyce (1996) support the practice that heifers should be segregated from cows to allow more efficient supplementation husbandry practices. In addition, Jayawardhana (1998) further recommends mating heifers for three months each year and to transfer heifers back into the cow herd at three and a half years of age and then subject them to mature cow mating practices. The timing of initial mating of heifers is critical so that initial lactation is timed to coincide with the best nutritional conditions. They also recommend that if heifers are mated as two year olds and are not pregnant by the end of the restricted period, they should be culled for low fertility, except in years where very poor nutritional conditions delays in puberty and results in unacceptably low conception rates. Fordyce (1996) recognised that this method enables selection and culling to be more efficient. This enables targeted management of turn-off females for profitable marketing. Furthermore, Fordyce (1996) reported that the method can have additional costs but these costs are offset by extra female sales. Computer simulation models have forecasted that the investment is recovered within two years of commencing the new management practice. As well, the models forecast that profitability of extensive herds will be significantly improved through adoption of improved young female management practices. According to the models, this is estimated to increase gross margins by \$5000/1000 head of cattle.

4.0. Factors influencing the successfulness of adopting control mating

Although there are many sources that have documented the different ways to carry out a controlled mating program, very few have addressed issues that may arise in practice or given practical solutions for producers to overcome them. This is important as some of these issues are responsible for preventing implementation. Williams (2008) found that most producers (73%) took between one and five years to decide whether to control breed or not. There were a variety of reasons cited as being the motivating factor to decide whether to change to this practice or not. The main barriers were 'dry years' and insufficient infrastructure. The main benefit cited was a reduction in the supplement bill. Other barriers experienced by producers are discussed below.

4.1 Bull Removal and control

A number of sources have confirmed that bull removal and control is one of the main issues associated with the success of controlled mating. Meat and Livestock Australia (2006) has identified that restriction of mating, by bull removal, involves many practical difficulties for large extensive herds and in some cases may not be applicable. Meat and Livestock Australia (2017) supports this statement and further states that producers wanting to successfully adopt a controlled mating system need to have the ability to securely manage bulls when they are taken out of breeders to avoid out of season pregnancies. This may require additional infrastructure such as electric fencing. Through a number of producer surveys, the Queensland Department of Primary Industries (1970) have found this to be true. Most herds in the Burdekin region are continuously mated due to the difficulty they have in removing bulls at the end of the mating season and keeping stray bulls out due to insufficient fencing. Both The Queensland Department of Primary Industries (1970) and Meat and Livestock

Australia (2017) agree that getting a clean muster is an important component in having adequate bull control.

Bortolussi et al (2005) also states that bull control is often difficult in northern Australia due to large paddock size, multiple water points and sometimes rugged terrain. Hence, uncontrolled mating is practiced by the large majority of properties in this region. Fordyce (1990) agrees that controlled mating is more appropriate where the level of management is high, close to all cattle can be mustered and cattle can be segregated effectively.

4.2 Infrastructure

Having good paddock security is a prerequisite for successful controlled mating. Producers need to have the ability to securely control bulls when they are removed at the end of their mating period. Additional infrastructure, including standard or electric fencing and waters, need to be considered before implementing a controlled mating program to avoid out of season pregnancy's. This is often a common hurdle that producers face when trying to change their cattle management strategies.

Bortolussi et al (2005) believes that there have been ongoing improvements over the years in most property infrastructure including fencing, water supply and pasture improvement and these have been accompanied by improvements in herd management and mustering efficiency. However the relatively large areas and low stocking rates for northern pastoral land still mean that it is difficult to monitor and control cattle effectively.

The profit margins on a property need to be healthy to allow for improvements in infrastructure and new technologies or practices to be adopted, as most new methods will require some sort of modification or adaptation on the property such as fencing. If the profit margin is not healthy then the producer takes the risk of going further into debt for a practice or technique with no guarantees of success. Williams (2008) found in the sample study that for these reasons graziers prefer to see somebody else trial a practice first before they implement it. Williams found the profit margins on the properties that did not controlled mating were good. Some of the participants still felt that some practices like controlled mating did not offer enough of a significant advantage to them to warrant the additional infrastructure required.

Chudleigh et al (2016) report on 'The impact of changing breeder herd management and reproduction efficiency on beef business performance' states good infrastructure is an important key to profitable beef production in northern Australia. Control of cattle provides better management of nutrition and facilitates herd management activities. It allows producers to decide which stock get to graze what pastures and to implement strategies so that efficiency is maximised. Therefore, there are some exceptions to this according to Williams (2008). This study reported that some properties are not geographically suited to the controlled mating practice that require well maintained infrastructure. Some properties have rivers that run throughout the enterprise, which flood and knock down the majority of fences every year. Some producers believe that the maintenance of repairing these fences is too great, time wise and financially for it to be successful. However, no known economic assessment has been completed for properties in these situations to compare any financial benefits the produces could achieve through the implementation of controlled mating.

4.3 Low fertility and variable conditions

Continuous mating is likely to result in more calves born through the year but the spread of calving is much wider. Under optimal conditions controlled mating can result in long term improvements in herd

performance but under the variable and often harsh conditions of northern Australia there is a risk of poorer performance from controlled mating than continuous mating.

Chudleigh et al (2016) states that any beef business located in a region with highly variable and generally low nutrition in northern Australia that currently has uncontrolled mating faces a significant transition period if it wants to move to a system where “out of season” calves are avoided. Where no reduction in operational costs is achieved and conception rates are not significantly improved, it is considered highly likely that a disruption to mating periods in a region where cows find it very difficult to re-conceive will diminish the economic and financial performance of the beef business. Meat and Livestock Australia (2017) agrees that herds that have poor P4M (pregnant within four months of calving) rates in areas of low nutrition, will find it difficult to shorten the joining period without experiencing a large decrease in calf numbers. Meat and Livestock Australia (2017) further reported that segregated breeder systems are better suited to regions where it is not possible to get the majority of cows to produce a calf every 12 months. In low nutrition environments it may be unachievable because of the number of cows not cycling at the start of joining due to lower body condition following a long dry season. Controlled mating can still be undertaken but some late-pregnant cows may need to be segregated to manage this group strategically and avoid mustering late pregnant cows or cows with calves.

However, this statement is contradicted from the Cash Cow Project (McGowan et al, 2014). A large study of 70 herds across northern Australia found that calving period had a significant influence on the percentage of cows pregnant within four months of calving, with up to 39% difference between the poorest performers (July – September calving period) and the best performers (December-January calving period). This study found that cows that calved “out of season” had a significantly decreased likelihood of reconceiving within four months of calving compared to those that calved at the more “optimum” times of the year. This is supported in a study by Cobiac (2006) that showed females that calved November to January (in the early wet season) had the shortest inter-calving interval, with 80% of these females calving in the same month the following year. In contrast, females that calved March to June (in the late wet season/early dry season) had the longest inter-calving interval of 15 months.

4.4 Perception of the need for change

Williams (2008) found in a study that a small sample of producers who were not control mating believed they have little need to change anything as with little or no debt the property was making a profit so ‘why bother’? Pahl (2015) found in a similar study focusing on encouraging producers to adopt better management practices that if beef producers are unaware of poor performance and/or not interested in improving it, then information on industry benchmarks and best practices will not appeal to them.

Furthermore, the majority of producers (89%) in Williams (2008) study reported that their finances were often the main barrier to implementing change followed by a need (77%), i.e. if there is no need to change then they will not change. When asked whether there was a financial need to controlled mate or not, just over 34% of respondents said there was a financial need to change while 65% said there was not. All the participants who do not practice controlled mating also felt no financial need to do so.

5.0 Known benefits of controlled mating

The cattle industry needs to be continually evolving to respond to constraints by putting more emphasis on more intensive and deliberate management of the herd through practices like controlled mating, greater segregation of animals for mating and feeding, and early weaning (McIvor 2012).

Henderson et al (2013) states that the main objective to controlled mating is to time calving to coincide with peak pasture availability and quality to maximise survival of cow and calf, avoid lactation during the dry season when the cow's nutritional requirements are at their highest and to allow for a more efficient supplementation program. Animal nutritional status has an important effect on fertility through influencing ovarian function, conceptions and pregnancy maintenance as well as lactation. Cows in better body condition are likely to have higher pregnancy and weaning rates than cows in poorer condition. Holroyd & Fordyce (2001) support this claim and continue on to state that strategic management of supplemental feeding can combat body condition issues though maximising benefit from available pasture. In addition, segregating based on nutritional needs ensuring supplementation is provided to only those cows that need it most, and using controlled mating and weaning to manage key events such as early lactation so that they coincide with optimal pasture quality. Further, Chudleigh et al (2016) outlined that one of the main advantages for control mating is that it provides producers with the ability to match nutrition with high demand animals, plus the capacity to target supplements to where they are most needed and to reduce supplement costs by not having out of season breeders. Some case study properties in the Chudleigh et al (2016) study maintained breeder body condition and weight through rigorous control of the mating period, grazing pressure and an efficient weaning system. They believed feeding supplements would not improve the economic efficiency of their beef breeding business and the results of the case study analyses suggest this is correct. Finally, Cottle and Kahn (2014) study states that in northern extensive herds, removing bulls even for two to three months (at the second muster) until December can still make a big difference in tightening up calving spread and reducing out-of-season calving's therefore, reducing the need for excessive supplementation.

McCosker et al (2010) reported that controlled mating is a mandatory first step in the process of being able to accurately measure net reproductive rate. Branding rate is inadequate as an indicator in northern Australia because of the inclusion of 'cleanskins' (unbranded calves from the previous year) in the numbers and uncertainty about the number of breeders contributing to the result. The percentage of female sales relative to total sales has been advocated as a de facto indicator but it can be significantly affected by the position of the herd at the time. For example, in drought recovery or when new waters are being opened, this percentage will fall because of female retention for herd build-up even though the net reproductive rate may be good. The net reproductive rate of the herd and the breeder death rate are at best, approximations.

Furthermore, controlled mating allows for targeted weaner management to help maintain breeder body condition. Therefore, empty cows can be marketed earlier in the year to take advantage of better prices, to generate cash flow and to be able to identify and sell unproductive breeders which will increase the herds overall fertility. Pahl (2015) found that through improved cow condition and fertility, the ability to achieve higher calving and weaning percentages will be increased. Meat and Livestock Australia (2017) found that there is evidence from recent research that increases of 5-10% in weaning rates are achievable through improving nutrition and management of reproduction, thus increasing economic returns for producers. A reproductive research trial in the Barkly Region (Collier et al 2011) found this to be true with controlled mating. The trial discovered a significant difference in heifer mortality rate in the three year trial; 2% in the controlled mated herd and 8% in the uncontrolled mated

herd. These results demonstrated the advantages of timing calving with peak nutritional availability. In the controlled mated herd the calves were able to be weaned by mid dry season reducing stress on the cow in the late dry season and consequently cow mortality. Hamlyn-Hill (2016) states that another added benefit to being able to target weaner management is that it gives producers the ability to reduce mustering and labour costs for there would be fewer weaning rounds. Unlike in continuous mating where there is generally a wider spread of calf weights that delay weaning dates until the lightest calves reach target weight, multiple rounds of weaning are required (Meat and Livestock Australia 2013).

6.0 Economics

'The impact of changing breeder herd management and reproduction efficiency on beef business performance' by Chudleigh et al (2016), was the only report found that has conducted an economic analysis on controlled mating using various bull removal time periods.

In this study, a breeding herd with continuous mating in the Victoria River District was modelled as a base file using the Braithwaite Stock Flow Model, with data sourced from the 2010 NT Pastoral Survey, the Cash cow Project and NT DPIF. The base herd was utilising foetal ageing and herd segregation and culled those that didn't re-conceive. Continuous mating on this property resulted in calving being dependent on the first significant rain, varying from year to year with 85% born from October to March. Different bull-out periods were assessed in the model scenarios, September to December, June to September, and June to December. The model was also rebalanced to ensure even grazing pressure in all scenarios. The reproduction rates, weights, mortalities, prices and costs remained the same in the 'with' and 'without' change scenarios.

Removing the bulls from September to December allowed for bulls to be removed with second round weaning, therefore no additional labour costs were added. Over a ten year period, weaner distribution was changed which resulted in 205 fewer calves in total. This resulted in a negative cumulative net cash flow difference of \$89 662.

It was found that by removing the bulls from June to September did not line up with mustering rounds but the change was modelled regardless and no additional labour costs were added. Initially, the lower numbers of weaners is offset by the sale of culls, but in year five, cumulative net cash flow difference becomes negative and in year 10 it was \$21 531.

Removing the bulls from June to December ensured most of the weaners were produced October to December but reduced reproduction efficiency over time. This resulted in a negative cumulative net cash flow difference from year three and by year 10 it was \$60 753.

Therefore, it was concluded that if no improvement in the reproduction rates occurred then a segregated continuous mating system was more profitable than a controlled mating system. The study then decided to look at an improvement in reproduction rates incurred by implementing controlled mating. The re-conception rate to calve within 12 months was increased by 10% for all breeders. Over a 10 year period, controlled mating with better re-conception rates proved to be more profitable with a cumulative net cash flow difference of \$61 100 in year 10. Over the lifetime of the investment, the net present value of the base file was -\$2 411 050 with an internal rate of return of 1.14% and controlled mating with better re-conception rates was -\$2 361 428 with an internal rate of return of 1.22%. Therefore, there was a small improvement employing controlled mating with better re-conception rates.

A number of case studies analysed by Chudleigh et al (2016), identified economic values for controlled mating versus uncontrolled mating or herd segregated versus unsegregated herds. Where maintaining reproduction efficiency was most problematic, it was found that each of the more profitable management systems had pregnancy testing and the performance recording of females as critical components. And yet while there are a number of well-known impacts of out of season calves, many properties in northern Australia have not implemented management practices such as controlled mating to reduce the incidence of out of season calves, or to better manage them. Chudleigh et al (2016) found that uncontrolled mated herds contain cows that generally calve out of season, during the early to middle part of the dry season and are seen to be at risk when seasonal conditions deteriorate. They are identified as a class likely to require additional supplements in most years if an increased rate of mortality was to be prevented and are considered unlikely to conceive again for some time. The usual consequence is for them to become pregnant for an extended time after their current calf was weaned which leads to the production of another calf at an interval of about 15 to 24 months instead of the achievable time of 12 months.

According to Mclean et al (2013), improving the reproductive rate of the herd is one of four practical means to influence business productivity. There is a strong positive relationship between reproductive rate and Kg beef/AE and close analysis with raw data has found that herds with above average reproductive rates also tend to have higher sale weights. Mclean et al (2013) derived an equation to overcome correlations between raw data contributing to Kg beef/AE and used it to predict that if a herd was to increase their reproductive rate by 1% they would see a 1.5kg beef/AE response.

7.0. Conclusions

This review highlights the difficulties in sourcing accurate data to describe the economic benefits of controlled mating to herds in northern Australia and availability of simple and detailed approaches on how to successfully implement the practice and overcome associated problems.

The review describes the benefits of controlled mating and identifies issues that can effect successful implementation of the practice. A number of controlled mating scenarios and options were explored however, there was limited information specific to northern Australia.

Further effort is recommended to obtain better recommendations for implementing controlled mating in a northern Australian beef herd through a detailed step by step approach on how to implement a range of different control mating processes for different circumstances. It is also recommended that solutions for all possible issues producers may encounter throughout the transition process are incorporated into the literature.

There is limited information available that includes an economic assessment of controlled mating. This is believed to be because the production factors of the herd cannot easily be attributed to controlled mating only and it can be difficult to measure the exact change. Further studies are recommended to obtain a better understanding of the economic impact controlled mating has on individual businesses, this may be in the form of comprehensive producer case studies.

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