Accelerating genetic progress in north Australian beef herds



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Executive summary

Northern Australia, perhaps the last frontier yet to be fully tamed by Australian agriculture has a lot to offer still, widely undeveloped with low levels of infrastructure, investment, and population density. Nonetheless, the potential to increase food production in this vast land resource remains immense. "Ultimately adoption and success lies at the producer level, and the ability to change and adapt lies solely with the individual."

The northern Australian beef industry was estimated to be worth \$5.03 billion in 2009-10 (Department of Infrastructure and Regional Development, 2013). Increasing the value of this sector to more than \$10 billion by 2020 was put on the agenda in November 2012 when the Northern Australian Ministerial Forum outlined a joint government and producer organisational approach to benefit from increases in protein consumption from countries in Asia.

When other factors are well managed, herd performance becomes a measure of the genetic value of the herd or the potential the herd has to fully utilise the resources available. Genetic value is cumulative with each generation adding or detracting value in their progeny.

The value of genetic improvement and the economics of using fixed time artificial insemination (FTAI) have recently been quantified under north Australian conditions. A second substantial economic gain of reducing calving intervals and increasing conception rate on first cycle has other economic benefits.

FTAI has the ability to make valuable genetics affordable, en mass. This report provides the commercial breeder with a starting point to accelerate genetic performance and covers some of the pitfalls to a successful program. Not covered in this report is a list of all programs and drugs available for different programs as this will depend on many variables and should be tailored to individual herds, conditions and market access.

This report highlights the need for more skilled technicians and consultants that have the required knowledge of FTAI in extensive beef herds. The benefits of FTAI, and the problems of managing a FTAI program in northern Australian, are not yet widely understood by producers. The current emphasis in Australia is FTAI in heifers, representing only 30% of a breeding herd.

Lactating cows, which are perceived to be more difficult, are an unutilised resource and do provide other benefits having already successfully mothered a calf. More research into FTAI in lactating cows in extensive herds is required, including calf management and the benefits of temporary weaning.

Another required area of research is foetal programming, in particular the effect limiting nutrients have in the first trimester of pregnancy, a common occurrence in the northern Australia, is having on the fertility of progeny.

A best practice guide to assisted reproduction for northern beef breeders should be developed, alongside spreadsheet tools to assist producers analyse the cost/benefit of a FTAI program.

Assisted reproduction technology (such as FTAI) is not only economically viable for the commercial producer, the benefits accrued make it a profitable practice. Ultimately the adoption and success lies at the producer level, and the ability to change and adapt lies solely with the individual.

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Foreword



When I started managing and selecting heifers in my family's cattle herd and culling infertile females in the late 1990s I become interested in why 'some could and others couldn't'. The variability of genetics coming through and 'how to get a lot more of the type of cattle we were striving for' led me to enrol in a short artificial insemination (AI) course. I quickly realised that oestrus detection was not going to be manageable when labour and time were in short supply. Many years later at a Breeding Edge workshop follow-up day, presenter John Bertram highlighted the improvements to Fixed Time Artificial Insemination and 'how easy it was' advising Darcy and myself to try a small mob (30) first. Not one to do anything by halves, our first mob of heifers was about 100, and that same year we inseminated 300 heifers. Insemination is the practice of synchronising the females oestrus cycle through manipulation of hormones so that all females ovulate at the same time, and females can be inseminated at a predetermined time.

In 2012 after listening to and later talking with Dr Gabriel Bo from the Institute of Animal Reproduction Cordoba (IRAC), Argentina, we decided potential benefits were being lost by just

using heifers, so we started to research FTAI in lactating females. At this time I realised how much information was out there for assisted reproduction but was not easily accessible. At the time of applying for a Nuffield scholarship limited research aimed at large-scale extensive herds battling climate and the geographical difficulties of northern Australia was available. Meat and Livestock Australia (MLA) has a clear focus on increasing FTAI in heifers with an aim at improving genetics in Northern Australia, so it was a natural fit for the organisation to invest in this research. As a levy payer, I am pleased that MLA remained engaged in the process and requested feedback on the benefits back to industry. As a Nuffield Scholar, I appreciate their support and their extensive international networks, including an outstanding view of the live export trade in the Middle East, whilst visiting Qatar.

After spending a day ultra-sounding heifers with Dr Sophia Edwards in late 2012, I decided to visit Argentina, in particular Dr Gabriel Bo. I visited South Dakota, USA, and the Blair family, who have been using AI across their herd for over 20 years, and have great practical knowledge on AI. Amanda Blair, who had completed studies linking eating quality of the progeny with nutrition of the mother during pregnancy, started my thoughts on foetal programming and what affect limited nutrition of the cow might have on the fertility of the progeny.

Canada and the intensity of the dairy industry, including a visit to Semex headquarters in Guelph, Ontario, gave an inside view of the potential value of livestock genetics, in particular the under utilization of genetic information in the Australian beef industry.

Surprisingly, sheep research in Uruguay really brought my attention back to the importance of nutrition and body condition in reproduction.

Farmers and researchers as well from Ukraine, India, and France all willingly shared their knowledge to soak up and bring home.

So what does the future hold? A small foray in fixed time embryo transfer (FTET) in 2012-13 has led to the planning of a much larger program in 2014-15. A number of large-scale beef producers have expressed an interest in FTAI and I look forward to giving back to industry by passing on my knowledge to fellow beef producers.

Acknowledgements

Nuffield Australia is an extraordinary organisation that I am proud to be a part of, an extended family of fellow agriculturalists, a melting pot of ideas, innovation and positive outlook. It is always refreshing to talk with a fellow scholar who shares the passion for producing food and who challenges your ideals, your existence and your contribution to society.

Meat and Livestock Australia has provided an invaluable network and resource. As a levy payer it is reassuring to see MLA pursue with rigor a return to industry for their investment in me. While I started this journey intending to find the 'silver bullet' for progressing genetic progression, I returned with a global outlook on agriculture, an understanding of how Australian agriculture needs to progress into the future to maintain a place on the world stage, and a confidence to share my ideas and passion to influence change. I look forward to giving back to industry the investment that has been made in me.

I would like to acknowledge Australian researcher Dr Sophia Edwards. Many of her reports on FTAI form much of the basis of my own understanding on the subject. Sophia continues to research FTAI in the northern Australian beef herd; her knowledge and experience is invaluable to the industry.

The decision to do a Nuffield Scholarship and be away for sixteen weeks of international travel, for a busy working mother doesn't come easily, unless of course you know you have the support of your family, friends and community.

Thank you to my sons Tom and Jack. What independent and knowledgeable young men you are, and for just 'making do' your future partners may thank me one day.

The extended Knudsen and Vander Have families and the Hawkwood community at large; behind every good person, there are always many working in the background.

Darcy Knudsen for performing quite literally a 'juggling act' between running our business, fulfilling many of my community obligations and fatherhood - attending to all manner of requests during my absence. The day I flew to India on the first leg of the Global Focus Program (GFP) Darcy was entrenched at the local *Bush Spirit* festival, slaving over an open fire and cooking up a storm of Billy Tea and Damper for 500, with two small boys in tow. Thank you for embracing the Nuffield family and becoming a part of something extraordinary.

Abbreviations

- AI Artificial Insemination
 BBSE Bull Breeding Soundness Evaluation
 EBV Estimated Breeding Value
 ET Embryo Transfer (non-surgical)
 DIY Do It Yourself
 DNA Deoxyribonucleic Acid
 FTAI Fixed Time Artificial Insemination
 FTET Fixed Time Embryo Transfer (Non-surgical)
 GFP Global Focus Program
 IETS International Embryo Transfer Society
 IRAC Institute of Animal Reproduction, Cordoba, Argentina
 IVF In Vitro Fertilization
- MLA Meat and Livestock Australia
- MSD Mating Start Date
- NHIA National Herd Improvement Association
- SNP Single-Nucleotide Polymorphism

Objectives

This report aims to:

- Clearly outline the economic benefits of assisted reproduction technology in the context of northern Australia.
- Define best practice management of the breeding herd for success in assisted reproduction.
- Recommend steps that industry could take to increase the uptake of technology such as AI and ET.
- Identify further research and extension required to improve genetic progression in north Australia.
- Identify the potential for Australian genetics to be exported globally.

1. Introduction

There are five factors that influence the rate with which populations can be changed; generation interval, heritability, selection differential, genetic correlation, and the number of traits which are selected for. Reducing generation interval (the average age of the parents when their progeny is born), has been shown to significantly increase genetic gain, and if coupled with genomic selection can double the genetic gain made in each generation. An observation of the Canadian dairy industry proved a good example of the genetic gains that can be made when genomics, Expected Progeny Difference (EPD) (the equivalent of Estimated Breeding Values in Australian beef cattle) and assisted reproduction methods are all combined.

In northern Australia the application of genomics is relatively new, but will become increasingly more available due to a number of research projects nearing completion. Genomics coupled with Estimated Breeding Values (EBV) provide for accuracy of genetic trait measures at a much younger age and this will help to reduce the generation interval considerably. Heritability, selection differential and genetic correlations between traits dictate how much progress can be achieved in a particular trait in one generation change. The more traits that are selected for generally slows progress in any one trait, although it is widely accepted that selecting for single traits leads to compromising other traits and is not recommended. Some traits such as colour, or polled/horned are often controlled by a singular gene, and can be easier to select for. Other traits such as tenderness and feed efficiency are polygenic, that is they are influenced by more than one pair of genes. Once superior genetics are identified it is important for commercial breeders to be able to access them quickly.

Fixed time artificial insemination was developed in order to reduce the need for oestrus detection. FTAI has been performed, with successfully repeatable results, since the 1980s and adjustments in the last ten years have enabled FTAI to be used in extensive *Bos Indicus* herds, such as those of northern Australia. Even so only a small number of females are artificially inseminated each year in Australia.

Embryo transfer (ET) and fixed time embryo transfer (FTET) is another technology that allows both parents to be selected at the time of implant, ET allows herd genetics to completely change in one generation. FTET is becoming increasingly successful, and therefore commercially viable for transferring very valuable genetics. It has the potential to allow calves to be born into the environment that they are going to live in, and this enables better adaption to harsh climates as opposed to purchasing grown bulls that often take a year to adapt.

FTAI and ET enables the breeder to change genetics quickly, decreasing the time taken to disseminate superior genetics to the breeder, and to change market specifications, increase production and fertility. This results in the exchange of genetic material in large numbers and essentially accelerates the genetic progress of the herd.

2. Back to basics

Before engaging in assisted reproductive techniques it is important to note that there are many factors that contribute to fertility and performance of the breeding herd in northern Australia. It is imperative to eliminate or manage as many of these factors as possible before investing heavily in assisted reproduction.

Although not covered in the scope of this report in great detail, as there are many other sources which cover each of these in much greater depth, it is essential that the producer is aware of, and has, where possible, managed the following factors. These factors could impede on the success of reproduction, whether it be assisted or natural.

2.1 Disease

There are a number of reproductive diseases that can affect reproduction in the northern Australian beef herd. It is relatively inexpensive to have a herd tested for these diseases, and local veterinarians are a good source of information. Some diseases such as *Leptospirosis* and *pestivirus*, also known as *Bovine viral diarrhea virus* (BVDV) can be managed with vaccination programs. Other diseases such as *Neosporosis* and *Trichonomiasis* may require different onfarm management techniques and are not as easily controlled. Nonetheless awareness of the existence and prevalence of disease in the breeding herd is the first step to managing or preventing disease. Controlling diseases that affect reproduction helps reduce rates of early embryonic loss and foetal abortion.

2.2 Selection pressure

Often breeders are reluctant to cull non-performing females (females that do not wean a calf annually) because they struggle to maintain numbers. The ability to cull more females and apply tighter selection criteria is enhanced when weaning rates are improved and cow mortalities are reduced, both of which generally have a positive effect on business performance in the northern beef herd. With larger numbers of females available, breeders can cull females that are identified with less than optimal performance. Traits such as pregnancy status, temperament and resistance to parasites can be taken into account. Selecting for traits that have a high heritability (the likelihood of a trait being passed onto progeny), and traits that have a wide selection differential (the difference in a trait between the lowest and the highest animal), will increase the rate of genetic change for each generation. It is important to establish minimum and maximum criteria for each trait.

2.3 Measured reproductive performance

It is an advantage before starting an assisted reproductive program to know how the herd is performing currently, even if it is approximated from existing records. Honest evaluation of herd performance, including strengths and weaknesses, lays the groundwork for future direction.

Questions for the breeder to answer are:

- What is the true weaning rate of the herd, which is defined as the numbers of weaners divided by total herd mated in a 12 month period.
- The average weight of weaners.
- When are most calves born.
- How long is the calving period.
- How long is the mating.
- When is the Mating Start Date (MSD).
- What body condition is the breeding herd.
- What is the breed of the parents.
- Are the progeny meeting market specifications?

A thorough analysis of the current position is paramount to forming a plan to improve genetics. *Study the past if you would define the future (*Confucius). Once the breeder has constructed a clear view of the present herd, it is important to ascertain genetically where the breeding herd needs to be to optimise production levels.

Considerations include:

- Markets
- Geographic location
- Climate and climate variability
- Land and pasture type

- Matching nutritional requirements with the nutrition available from pasture
- Level of maintenance required
- Parasites and disease.

Prioritise traits that have a high heritability and which will have the largest affect on profitability. Given the poor reproductive rates found in northern Australia, traits that improve fertility would generally be a high priority. Once the breeding goals are identified the breeder must then identify potential genetics that meet the requirements of the herd moving forward.

2.4 Estimated Breeding Values (EBVs) and genomics

There are a number of tools that can help the breeder in appraising new genetics for the commercial herd. Purchasing genetics can be a considerable expense, particularly if the genetics do not perform as intended, so it is important to accurately assess genetics using robust programs such as EBV's. This gives the breeder an excellent evaluation of the differences between sires for example and what positive and negative traits they might introduce to the genetic value of their progeny. Phenotypic assessment of the potential genetic value is no longer the only option breeders have to assess genetics. While structural soundness is still an integral part of assessing breeding potential, using a phenotypic assessment alone gives the breeder only a small segment of the potential data that can be gained. Successful use of genomics was observed in the Canadian dairy industry where genomic testing was being done on bull calves at birth. At *Semex* headquarters in Guelph, Ontario, Canada, bull calves with high genomic value had orders for semen that they could not produce in a lifetime, well before they had even reached puberty.

EBVs coupled with other technologies, such as polled gene testing for beef breeds, is a very good predictor of future performance. EBVs and other reliable genetic measures based on rigorous testing have not been widely adopted in northern Australia particularly in *Bos indicus*, or tropically adapted breeds, even though other beef breeds such as Angus have clearly lifted performance levels by using EBV's and genomics. Single-nucleotide polymorphism (SNP) testing is providing genomic testing with a high accuracy, at a fraction of the cost of full DNA sequencing.

2.5 Bull Breeding Soundness Evaluation (BBSE)

BBSE measures scrotal size, sheath score and structural soundness, sperm motility and morphology. For the breeder looking to purchase sires, particularly for an assisted reproduction programme a BBSE, including a morphology test is essential. BBSE is a very good indicator of the quality of the semen and can identify whether the bull's semen is viable to freeze, as semen has to meet a minimum standard in order to be able to freeze it successfully. Semen can be adversely affected by sickness and injury, body condition, nutrition, and environmental conditions (such as extremes in temperature). The quality of a bull's semen can recover; however, some morphological conditions of semen are genetic and can affect fertilisation rates and early embryonic loss. Early embryonic loss means the female can have a further prolonged calving interval. Again BBSE is not widely adopted in the north Australian beef herd.

2.6 Body condition

It is a reality of northern Australia, and the changing nutritional requirements of females over their breeding life, that managing body condition is very difficult. Climatic conditions of northern Australia, the wet and dry season, means body condition is never static, and can quickly go from an increasing plane of nutrition to decreasing. A good indication of whether body condition and nutrition is sufficient for FTAI is to observe females in the herd cycling naturally.

Dr Gabriel Bo (2013) identified body condition of the female as being the most important factor in the success of reproduction, whether it be natural mating, assisted using AI or ET and regardless of using FTAI or oestrus detection methods. Body condition at the time of insemination is the most important, however a rising plane of nutrition, or approximately a daily weight gain of 0.3kg, six weeks prior to insemination and six weeks after insemination is equally important. It was observed that many breeders pay less attention to body condition and nutrition after insemination, but continuing to manage nutrition afterwards improves embryo survival rates. Body condition is also important for reducing lactation anoestrous, and therefore reducing the time taken to get back in calf after calving. The quality of the ovum produced by the female are also affected by body condition, to the point where body

condition up to nine months previous affected the quality of eggs presented for fertilisation. This affectively means that body condition needs to be managed throughout the female's life, not just at mating periods.

Dr Gabriel Bo (2013), indicated an **average** body condition score of three is optimal. A score three, allows the body to change from survival mode, to reproduction mode, natural reproductive hormones are produced and this makes it easier to manipulate the reproductive cycle for FTAI.

3. Benefits of FTAI

Artificial insemination is used to gain access to otherwise inaccessible genetics that may be from overseas or from sires that are unobtainable or unaffordable. Use of AI can increase the diversity of bloodlines without purchasing a bull, allow the use of younger bulls, or the use of a bull that was injured or died, provided the semen was taken beforehand.

Al using the traditional method of using oestrus detection has been used successfully in the stud industry. The disadvantages particularly for large scale commercial breeders can be: oestrus detection can be more difficult to manage in large numbers

- inadequate facilities may make it difficult
- the need for skilled labour to accurately detect standing heat
- Al can be more difficult in *Bos Indicus* cattle that often have less obvious heats
- allowing for time to assess females twice daily and inseminate.

FTAI came into fruition to try and manage these disadvantages. FTAI allows for:

- larger numbers, sometimes up to 250 per day, to be inseminated, depending on facilities
- better time management of AI programs
- lack of skills required for oestrus detection
- a technician is only required on site for a few hours instead of days or multiple trips to a property
- lower cost per calf.

These developments allow all breeders (regardless of size and skill) to access a growing range of available genetics and to use superior genetics on a large percentage of the breeding herd. There are other benefits to synchronising cows' reproductive cycles. Synchronising cows can decrease days to calving intervals, resulting in more breeders in calf earlier and heavier weights at weaning. For every oestrus cycle not in calf see Figure 1. Figure 1. Earlier calves are heavier.



Assumption for calculations – Age at weaning 210 days, ADG pre-weaning .5kg, 37kg birth weight.

Adapted from <u>www.bayeradvisor.com.au/bosynch</u> to reflect Northern Australian weight gains.

Synchronising can also assist in managing lactation anoestrous, therefore decreasing the interval between calvings; even a modest reduction in calving interval can improve overall herd performance by reducing costs and increasing weaning weight.

A recent report on the potential economic return from the use of FTAI in a genetic improvement programme investigated the potential genetic profit over three years, from three breeding programs. Natural mating with no genetic improvement (NATM-G), Natural Mating with Genetic Improvement (NATM + G) and Fixed Time AI with Genetic Improvement (FTAI + G), a Japanese ox index, using breedplan for the Brahman breed was used. In the third year bulls from the first year were used (Edwards, 2014).

Figure 2 shows that using FTAI for three years and using EBV's to select genetically superior sires, was eight times as profitable as using natural mating with the same sires. This research was done under northern Australian conditions and uses an AI conception rate of 30%, which is achievable.

There are a number of synchronising programs; the type of program the breeder uses depends on the age, lactation status, body condition of the cows and availability and cost of drugs.



Figure 2 The potential economic return from the use of FTAI in a genetic improvement programme.

Source (Edwards et al, 2014). See Appendix 2 for full report.

4. Heifers or cows

There are advantages to using heifers or lactating cows in an FTAI program in northern Australia. Heifers as a group are easy to manage, respond well to feeding regimes in order to stimulate follicular activity. In a well managed *Bos indicus* herd, pregnancy rates of 40% for FTAI are achievable. Synchronisation can also induce a greater percentage of peri-pubertal heifers to start cycling, thus getting in calf earlier.

However heifers only represent about 20-30% of the breeding herd. Lactating cows, which make up a larger portion of the herd, are often perceived as being more difficult to manage. The additional complication of calf management during FTAI means that cows are often not considered as candidates for FTAI. Lactating cows can also be in anoestrus for long periods; this is particularly apparent in *Bos indicus* herds and body condition is also harder to manage in lactating cows. However lactating cows can achieve higher rates of pregnancy, with rates exceeding 50% to FTAI in *Bos indicus* herds. Cows have a proven record for mothering ability and calving ease, so more calves are weaned. Synchronising cows can also reduce lactation anoestrus, resulting in shorter calving intervals. In the harsh environment of northern Australia, managing calves throughout the process of FTAI is of high importance.

In an interview with Dr Gabriel Bo (Bo, 2013), he explained a management technique that has been successful for him in Argentina, and that is temporarily weaning the calves from their mothers, for the period between the second and third muster needed for FTAI; his period is about 48 hours. Provided calves had access to plenty of shade, clean water and feed, they were not adversely affected, with almost no mismothering and although there was an initial weight loss there was no difference in weight by weaning. Reuniting with their mother must be as stress-free as possible. This technique offers a solution for northern Australia as taking calves to and from paddocks all the time is laborious and losses are more likely to occur. This technique also induced a positive response in the lactating female, particularly if the female was taken more than 1km away from the calves. It increased the rate of pregnancy from FTAI by almost 20%. When the calf stops suckling temporarily, it changes the messages sent via the mammary nerve to the mammary gland, which in turn stimulates the production of gonadotrophic hormones which influence cycling.

5. Conclusion

5.1 Opportunities in the genetics market

Australia has beef cattle genetics that can compete on the global stage. Northern Australia's climatic conditions are similar to many beef producing nations, including South America, and parts of Africa. Australian cattle would also do well in temperate areas of North America and in Europe in countries such as Turkey. Australian cattle genetics could be exported to many of these regions. The sale of genetics through semen, and embryos both for domestic and export has been largely overlooked by Australian seedstock producers. Embryos in particular, have potential to be exported as embryos are much easier to transport disease free. The genetics market in Australia is fragmented and for the most part seed stock producers are left to fend for themselves in relation to navigating the many pitfalls associated with exporting genetics. The federal Department of Agriculture and Fisheries has very limited resources to help exporters. The sale of genetics is also not a priority for peak bodies such as Meat and Livestock Australia. A concerted effort must be made to gain access to a growing demand for beef genetics by creating overseas demand for Australian genetics and secondly by assisting exporters gain access to these markets.

5.2 Limitations to adoption of FTAI

The majority of Northern beef producers are not economically sustainable as they are not able to fund present and future liabilities (Bush AgriBusiness Pty Ltd, Holmes & Co., 2014). The Northern beef report - 2013 Northern beef situation analysis highlights that superior performance of top 25% producers can be attributed to:

- Higher income through better herd productivity.
- Lower operating expenses, largely through better labour efficiency.

Nearly all productivity differences between herds can be attributed to the better performers achieving:

- Higher reproductive rates.
- Lower mortality rates.
- Heavier sale weights.

There are many factors that influence reproductive rates, mortality and sale weights. However, FTAI used in conjunction with genomic evaluation has the ability to fast track genetic improvement cost effectively and influence reproductive rates, improved growth rates, increase labour efficiency and reduce costs associated with longer periods of calving. Embracing these biotechnologies and adapting the technology to suit individual enterprises will result in improved performance of the herd and ultimately the profitably of the business.

6. Recommendations

6.1 Expertise

Small changes in semen storage and handling, operator technique or farm protocol can improve performance on farm (Dairy Australia, 2014). This statement concurred with anecdotal statements from farmers interviewed that were practising AI in USA, Australia, and Argentina that there can be a wide variation in success rates for artificial insemination between technicians, and following semen handling and storage protocols for best practice. Further evidence of this was the difference in what was thought to be the correct position of semen deposition for AI between technicians and subtle differences in handling techniques of semen straws were also observed between technicians.

In order to lift the standard of technicians in both AI and ET and to protect producers using assisted reproduction, a recognised qualification that requires assessment should be developed. In order that producers can search for a qualified technician and know that there will be a certain level of skill if they have attained accreditation. There are currently few practitioners relative to the numbers of cattle across Australia and even less in northern Australia practicing AI and ET.

The National Herd Improvement Association (NHIA) is currently the only organisation in Australia that has developed an accreditation program for artificial insemination. The organisation also administers an accreditation program for embryo and semen handlers in answer to the recently developed code of practice for embryo and semen handling. Both of these programs have largely been at the request of the Australian dairy industry. Perhaps there is scope to investigate increasing their presence in northern Australia, rather than inventing another organisation, or perhaps there is another organisation already in existence in northern Australia that could administrate.

Greater uptake of subjects such as reproductive technology (University of Queensland), and the further development of career paths that specialise in cattle reproduction would be advantageous. Certainly if the industry is to move forward more skills are needed not just in AI or ET but in sexing semen, sexing or splitting embryos and IVF, all of which are biotechnologies that are commercially available and experiencing a rapid uptake in other beef producing countries.

Currently there are only a few services that offer these more advance techniques and are clustered around major centres. This means that they are out of reach for most producers. As uptake of technology increases it becomes viable for more services to become available in the major beef breeding areas of Australia.

6.2 Cost of semen

Compared to other countries the cost of semen in Australia for *Bos Indicus* and other tropically adapted breeds is expensive, and the availability and diversity of genetics suitable for northern Australia is also small when compared to the genetics industry in other beef producing nations. The cost of producing frozen semen straws is a relatively small component of the overall price of semen straws. Prices of straws are set by the breeder and at this point many stud breeders are pricing themselves out of the market. The cost of semen in Australia must be reduced in order for commercial breeders to fully utilise biotechnologies such as FTAI. Secondly, it makes no sense to purchase overpriced semen that has little genetic data to verify how these genetics may or may not improve the herd.

6.3 Best practice guide

Industry needs to develop a best practice guide for FTAI in northern Australia. As much of the research and many of the results of trials conducted in Australia and globally are not in a format that is easily understood by the commercial breeder, extension is required to increase understanding of FTAI and how to utilise biotechnologies on their own farms. It needs to be targeted at a producer level, and cover the advantages and disadvantages of the main synchronising programs, including suitability of each for different mob types. An understanding of the key elements to a successful program, and also covering correct semen handling and insemination procedures.

6.4 Research

The current trend in Australia has been to increase FTAI in heifers, and much of the research conducted has been using heifers. As heifers only represent 20-30% of the herd and are less

likely to wean a calf, there is merit in investigating the viability of FTAI in lactating cows, provided the calf can be managed successfully a further accelerated rate of genetic progression could be achieved if lactating cows were included as candidates for FTAI.

Research is required to ascertain if there is a link between maternal nutrition, particularly in the first trimester of pregnancy, and the effect on fertility of the progeny. This is particularly relevant to northern Australia as climatic conditions mean that females are often subject to a plane of nutrition less than what is required for normal functions. This is known as foetal programming, and more research is needed to understand how nutrition in pregnancy possibly influences gene expression.

Continuing research into genomics for trait selection in *Bos Indicus* cattle is imperative, and could allow for the industry to select for traits such as parasite or disease resistance, as well as more recognisable traits in reproduction, growth or meat quality.

Appendices

Appendix 1 Body condition score for beef cattle

Score 1 – Poor A very low level of musculature, and no evidence of any fat. Skeletal structure is very pronounced.



Score 2 – Backward Light tissue covering over the skeleton. The backbone remains clearly distinguishable as are the rear ribs.



Score 3 – Moderate The animal has a fair degree of muscling, but with no significant fat. Neither the backbone nor ribs are prominent. The pins are filled out but not mounded. The tubal coxa ('hip') remains prominent.



Score 4 – Forward The animal is evenly- and well-covered in muscle and fat. Skeletal protuberances are all smoothly rounded.



Score 5 – Fat The animal has obvious substantial levels of fat, some of which may be lumpy in appearance, especially around the pins and flanks. Most skeletal definition has been lost.



Source: Kieren McCosker, Beef Cattle Research Officer – Cash Cow Project, Katherine Research Station, Department of Primary Industry and Fisheries and Peter Smith, Development Officer, Department of Agriculture and Food. (http://futurebeef.com.au/topics/breeding-andgenetics/body-condition-score-for-beef-cattle/, 2014)

Appendix 2 POTENTIAL ECONOMIC RETURN FROM USE OF FIXED-TIME ARTIFICIAL INSEMINATION AS PART OF A GENETIC IMPROVEMENT PROGRAMME

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SUMMARY

To investigate the potential return on investment of implementing a genetic improvement program in a self-replacing commercial Brahman breeding herd, three different selection and breeding strategies were evaluated through modelling, 1) Natural mating with no genetic improvement (NATM-G), 2) Natural mating with genetic improvement (NATM+G), and 3) Fixed time AI (FTAI) with genetic improvement (FTAI+G). In each scenario, the Jap Ox Index was used to quantify genetic gain and improvements were made using a Brahman sire with a top 10% Jap Ox Index (\$45).

A sire was selected from the progeny generated in Year 1. This sire was then used in Year 3 for natural mating in a multiplier herd. A partial budget was used to calculate the cost per calf weaned. The costs per calf weaned in Year 1 were calculated to be \$46.83, \$371.42 and \$173.76 for NATM-G, NATM+G and FTAI+G, respectively. The Jap Ox Index for the progeny was calculated to be \$20.00, \$32.50 and \$32.50 for NATM-G, NATM+G and FTAI+G, respectively. However, when progeny from Year 1 were used in Year 3 for breeding, the costs per calf weaned in Year 3 were calculated to be \$46.83, \$10.27 and \$4.35 for NATM-G, NATM+G and FTAI+G, respectively. In Year 3, Total Genetic Profit was calculated to be \$0, \$124.38 and \$1017.00 for NATM-G, NATM+G and FTAI+G, respectively. This model supports the return on investment in genetic improvement in Brahman cattle in northern Australia, and demonstrates the potential value of FTAI in both disseminating improved genetics and improving rate of genetic gain.

INTRODUCTION

A range of local and global factors are impacting on the Australian beef industry contributing to an average return on assets of only 0.3 to 2.0%. Poor reproductive performance in extensively managed tropically adapted herds is one factor contributing to this poor financial performance (McCosker et al. 2010). Genetic improvement to increase herd productivity with a strong emphasis on reproduction has the ability to improve the financial performance of northern breeder herds. The results from recent molecular and quantitative genetic research enable selection of superior tropical breed sires for a range of traits such as age of puberty, postpartum re-conception interval and lifetime productivity (Fortes et al. 2012; Johnston et al. 2009). The large genetic variation in reproduction traits observed in Brahman genotypes provides substantial opportunity for improvement through genetic selection (Johnston et al. 2009). Artificial insemination (AI) provides a practical method of increasing the dissemination of superior genetics in commercial and seed-stock bull breeding herds. The use of AI in northern Australia is currently estimated to be less than 1% of the breeder herd and traditionally considered difficult to implement in extensively managed herds. A strategy to increase the dissemination of superior genetics in northern beef herds is use of fixed-time AI (FTAI), which eliminates the need for oestrus detection. FTAI is often associated with lower labour inputs, and enables insemination of large numbers of females and production of more calves than typical oestrus detection programs (Edwards et al. 2012). The objective of this study was to use modelling to compare the potential return on investment of implementing three different selection and breeding strategies 1) Natural mating with no genetic improvement (NATM-G), 2) Natural mating with genetic improvement (NATM+G), and 3) FTAI with genetic improvement (FTAI+G), in a self-replacing commercial Brahman breeding herd.

MATERIALS AND METHODS

The Brahman Jap Ox index was used to quantify genetic merit of sires (ABRI 2013) used in three different selection and breeding strategies; Strategy 1: NATM using breed average sires with no genetic improvement (NATM-G), Strategy 2: NATM with genetic improvement using a purchased top 10% Jap Ox sire (NATM+G), and Strategy 3: FTAI with genetic improvement using a top 10% Jap Ox sire (FTAI+G) and using NATM+G in Year 3 from selected progeny from Year 1. In each strategy, bulls were produced by NATM or FTAI in Year 1 from the bull breeding herd and used in Year 3 in the multiplier herd. Assumptions for purchase of sire and frozen

semen, pregnancy rate to FTAI and overall weaning rate, and costs of FTAI in a 200 cow breeding herd are presented in Table 1.

The cows mated in each strategy were all assumed to have a breed average Jap Ox Index (\$20). Genetic gain was calculated for each strategy using the following equations: [(Sire Jap Ox Index)

-(\$20)]/2 = Calf Genetic Improvement. In Year 3, when bulls produced from the Year 1 mating are used in the multiplier herd, the genetic gain is calculated as described above.

Table 1. List of assumptions and costs associated with NATM or FTAI

Item Parameters and costs Source

Breed average Brahman sire Purchase price: \$5,000

Top 10% Jap Ox Brahman sire

Purchase price: \$40,000; Semen Price: \$50

Station labour (@ \$200/day) FTAI: 5 personnel x 3 days = 15 units = \$3000

NATM: 2 personnel x 1 days = 2 units = \$400

FTAI costs Drugs to synchronise ovulation: \$3524

AI technician: \$1500

Expected sire working life 4 years (Smith et al. 2011)

Weaning rate (% cows joined) 71 % (Schatz and

Hearnden 2008)

Pregnancy rate to FTAI 35 % (Edwards et al.

2012)

Bull:Cow ratio (NATM) 5 bulls for 200 cows (2.5%) (Smith et al. 2011)

RESULTS AND DISCUSSION

The costs per calf born in Years 1 and 3 of each strategy are presented in Table 2. In the genetic improvement strategies, more genetically superior progeny were produced using FTAI than NATM (63 vs. 28, respectively). In the NATM+G scenario, as the purchase price of a natural mating sire is relatively high, only one sire was used, and thus the number of cows that could be mated to this sire was only 40 (using a 2.5% mating ratio). This strategy limits the production of genetically superior calves compared to that achieved using FTAI, where all cows in the bull breeding herd were AI once, resulting in a higher total number of genetically

superior calves being produced. As a result, in both Years 1 and 3 the cost per genetically superior calf born was lower for the FTAI strategy compared to the NATM-G strategy. Table 2. Cost per calf generated from NATM-G, NATM+G and FTAI+G strategies Year 1 Calculation NATM-G NATM+G FTAI+G Bull breeding herd (n) (A) 200 40a 200 FTAI costsb (B) - - \$ 15,024.00 Cost per sire (Table 1) (C) \$ 5,000.00 \$ 40,000.00 \$ 5,000.00 Sires (n) (Table 1) (D) 5 1 5 Total sire expenses C*D = (E) \$ 25,000 \$ 40,000.00 \$ 25,000 Labour costs (F) \$ 400.00 \$ 400.00 \$ 3,400.00 Mating costs for Yr 1c [B+(E/4)] + F = (G) \$ 6,650.00 \$ 10,400.00 \$ 24,674Progeny by high geneticmerit bulld NATM: (A*0.71) = (H)FTAI: (A*0.35) = (H) - 28 calves 63 calves Progeny by average genetic merit bulls NATM: (A*0.71) = (I)FTAI: (A*0.71)-H = (I) 142 calves - 79 calves Cost per calf G/(H+I) = (K)\$46.83 \$371.42 \$173.76 Year 3 Natural mating using sires generated in Yr 1 Bull breeding herd (n) (L) 200 80b 200 Cost per sire NATM-G: New Sires = (M) NATM+G, FTAI+G: K = (M) \$ 5,000.00 \$ 371.42 \$173.76 Sires (n) (Table 1)e (N) 5 2 5 Total sire expenses N*M= (O) \$ 25,000 \$ 742.84 \$ 868.80 Labour costs (P) \$ 400.00 \$ 400.00 \$ 400.00 Mating costs for Yr 3 (O/4) + P = (Q) \$ 6,650.00 \$ 585.71 \$ 617.20 Progeny from mating $L^{*}0.71 = (R)$ 142 calves 57 calves 142 calves Total cost per calf Q/R = (S)\$ 46.83 \$ 10.27 \$ 4.35 A Due to the relatively high purchase price it is assumed that only 1 purchased sire was used

to breed replacement bulls.

b Insemination expenses include: Drugs to synchronise ovulation and, AI technician and semen costs.

c Mating costs include: Sire expenses and labour costs for mustering and yard handling associated with the mating strategy.

d Genetically improved progeny include: Number of calves born from genetic improvement mating. Weaning rate and pregnancy rates to FTAI are as per Table 1.

e A selection intensity of 16% was applied to sires generated from Year 1. Therefore, only 2 sires were retained to join

80 cows in the NATM+G strategy, however, 5 sires were available to join the entire bull breeding herd in the FTAI+G strategy.

The lack of adoption of artificial breeding technologies in the northern beef industry could be due to a perceived high cost per calf born. As FTAI+G can generate more high genetic merit calves than natural mating, the total costs of genetic improvement are spread across a greater number of progeny, resulting in a lower cost per calf born than NATM+G. This model assumes that the price of a natural mating sire is correlated with its genetic merit and in turn is correlated with price of semen from this sire. Some assumptions that have not been included in the model,

are: 1) Genetically improved male progeny not retained for use in the herd may be sold for a higher price than average genetic merit progeny, 2) As a high selection pressure is applied to male progeny (only 16% of available progeny selected) the retained sires should have a higher actual

Jap Ox index than calculated in the model, 3) Transport and other associated expenses of purchase of a high genetic merit natural mating sire have not been included, and 4) An increased proportion of females conceiving earlier in the mating period in FTAI may improve weaner values (Spitzer

1986). Total Genetic Profit was calculated to be \$0, \$237.25 and \$1275.00 for NATM-G,

NATM+G and FTAI+G, respectively (Table 3). In this comparison the FTAI+G strategy improved the genetic profit of the calves 5.4 times more than the NATM+G strategy. This is explained by the FTAI+G strategy producing 85 more calves by high genetic merit sires multiplying the effects of the genetic improvement strategy. Table 3. Genetic profit from NATM-G, NATM+G and FTAI+G strategies. Year 1 Calculation NATM-G NATM+G FTAI+G Bull breeding herd (n) (A) 200 40a 200 Jap Ox Index of sires (B) \$ 20 \$ 45 \$ 45 Average Jap Ox Index of cows (C) \$ 20 \$ 20 \$ 20 Genetic gain per calf born (B-C)/2 = (D) \$ 0 \$ 12.50 \$ 12.50Calves by genetic. superior sire (E) 0 28 63 Calves by genetic. average sire (F) 142 - 79 Total genetic gain E*D = (G) \$ 0.00 \$ 350.00 \$ 787.50 Jap Ox Index of progeny (H) \$ 20.00 \$ 32.50 \$ 32.50 Year 3 Natural mating using sires generated in Yr. 1 Bull breeding herd (n) (I) 200 80 200 Jap Ox Index of sire = (H) \$ 20.00 \$ 32.50 \$ 32.50 Calves from mating I*0.71 = (J) 142 57 142 Genetic gain over average cow (H-C)/2 = (K) \$ 0 \$ 6.25 \$ 6.25Genetic gain – calves from replacement cows Yr. 1c (D*0.5)*((E*0.5)*0.71)=(L) \$ 0 \$ 62.13 \$ 142.00 Calves from mating (M) 140 56 140 Yr. 3 genetic gain of progeny M*K = (N) \$ 0 \$ 62.25 \$ 875.00 Total Genetic Profit L + N = (O) \$ 0 \$ 124.38 \$ 1017.00 Due to the relatively high purchase price it is assumed that only 1 purchased sire will be used to breed replacement bulls. A selection intensity of 16% is applied to sires generated from Year 1. Therefore only 2 sires are retained to join 80 cows in the NATM+G Strategy, however, 5 sires are available to join to the entire bull breeding herd in the FTAI+G strategy.

Assume all heifers from Year 1 are retained and bred in Year 3. Assume 50% of the calves born in Year 1 are female and the weaning percentage of these calves is 71%.

CONCLUSION

The results from this modelling support the return on investment in genetic improvement in Brahman cattle in northern Australia and demonstrate the potential value of FTAI in both disseminating improved genetics and improving rate of genetic gain.

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Plain English Compendium Summary

Project Title:	Accelerating genetic progression in the northern Australian beef
Nuffield Australia	herd
Numera Australia	1 1317
Scholar	Kara Knudsen
Organisation:	Nuffield Australia
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Objectives	The aim of this report was to assess the best practices around the
-	world and in Australia which could assist north Australian beef
	producers improve genetics quickly and affordably, and increase
	the uptake of assisted reproduction if it was a viable option.
Background	The author travelled to Argentina, Uruguay, Canada and the USA,
	as well as Australia, visiting researchers, AI and ET technicians, large
	genetics companies and beef producers involved in assisted
	reproduction on a large scale. The latest research and
	management of large numbers of cattle in a program were reviewd
	and an understanding of the elements of success resulted. Other
	countries visited were Qatar, France, Ukraine and Turkey.
Research	A number of obstacles were identified in the course of this
	research. Access to competency skills in assisted reproduction is
	difficult and costly. The availability of tropically adapted semen,
	particularly in comparison to other countries, is coupled with a lack
	of data associated with current genetics available in the <i>Bos indicus</i>
	female when the berds are extensive and the climatic conditions
	of northern Australia, make body condition management a
	constant balancing act.
Outcomes	Producers and industry organisations need to understand the
Outcomes	importance of improving genetics in northern Australia, and that
	FTAI can improve profitability.
Implications	At the time of writing this report many of northern Australian beef
	producers are currently economically unsustainable, and
	reproductive performance has been identified as a key profit driver
	of these businesses. Biotechnologies such and FTAI and FTET
	ultimately the profitably of herds in northern Australia.
Publications	