final report

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Industry initiatives to improve young breeder performance in the Northern Territory.

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Abstract

This project was undertaken to assess and improve heifer performance in the Northern Territory (NT) cattle industry. This was done through performance recording, research and demonstration of different heifer management practices on commercial properties and surveying cattle managers. The performance recording found that pregnancy rates were generally adequate in maiden heifers (>75%) but were often very low (< 20%) in first calf heifers due to low liveweights between calving and weaning. However, where first calf heifers were in good condition at this time high pregnancy rates (> 70%) were achieved. Calf loss in first calf heifers was often high (> 30%) and averaged 23%. The surveys showed that managers tend to over-estimate first calf heifer fertility and under-estimate calf loss. Also they are mostly aware of the main issues affecting heifer fertility and are open to changing their management practices to improve heifer performance.

This project showed that not only is there considerable room for improvement of first calf heifer fertility on NT properties, but also that improvement is achievable. Economic analysis showed that a 30% increase in first calf heifer re-conception rates would likely result in an increased annual gross margin of $10.95 million for the NT pastoral industry.

Terminology

Throughout this document, the term heifer is used to refer to replacement breeders up until the time that they have weaned their first calf and should therefore be pregnant with their second. In most parts of northern Australia, heifers are mated for the first time when they are 2 years old, calve first as 3 year olds and wean their first calf at 3.5 years. Where heifers are mated as yearlings, similar principles apply. To avoid confusion the following terms are used:

Maiden heifers - Heifers being mated for the first time.
First calf heifers – Heifers from the time they are pregnant with their first calf until it is weaned.
Second calf cow – Females from the time they are pregnant with their 2nd calf until it is weaned.
Yearling mating – heifers mated in the first wet season after weaning.

The age group of heifers is denoted by the use of the symbol for number (#) and the year that they were weaned in. Therefore heifers weaned in 2004 are referred to as #4 heifers etc.

A number of abbreviations are used in this report. These are:
NT = Northern Territory
NT DoR = Northern Territory Department of Resources (note - the name of the department changed several times during the course of this project, however the current name is used in this report to refer to the department).

WR1 = Weaning round 1
WR2 = Weaning round 2
PJ Wt = Pre joining weight
PC Wt = Pre calving weight
VRD = Victoria River district

Executive Summary

This project had a number of objectives but ultimately the aim was to better understand and improve heifer fertility on NT cattle properties and to increase the adoption of practical and successful management strategies. This was to be done by determining the current state of heifer fertility and existing heifer management strategies on thirteen NT properties. Techniques and recommendations for improved heifer management across the whole of northern Australia were assessed and a suite of selected management strategies were demonstrated and studied on two co-operating properties. These demonstration sites along with well attended regional field days were instrumental in achieving practice change throughout the NT

The project has been successful in achieving its objectives in that it;

- Has measured and documented actual heifer performance on a significant number of stations across the NT.
- Has surveyed cattle managers (both before and after the project) in regards to the management practices they use as well as their knowledge of and attitudes towards different practices that affect heifer fertility.
- Has researched and demonstrated different heifer management practices on large heifer demonstration sites on commercial properties in the Katherine and Alice Springs districts.
- Will result in the production of a best practice manual on heifer management.

More specifically the main findings and conclusions in relation to each of the objectives were;

1. Demonstration sites on commercial properties

Heifer research and demonstration sites were established on commercial properties in the Katherine, Tennant Creek and Alice Springs regions. The work at the Tennant Creek site had to be abandoned due to drought but the other two sites were very successful in raising the profile of heifer fertility and management in the districts, and in researching and demonstrating different heifer management practices. Successful field days were held at both sites.

A brief summary of the main findings of work at the Katherine (Newry station) and Alice Springs (Tieyon station) demonstration sites is as follows;

Newry: Pregnancy and calf loss rates were measured in maiden and first calf Brahman heifers and in second calf cows. Pregnancy rates were low in all classes due to low liveweights during mating periods. This occurred largely due to unintentionally high stocking rates as many extra animals entered the trial paddocks during the wet seasons. The poor paddock security prevented planned research into controlled mating. Calf loss rates were high in first calf heifers (24% and 34%). Successfully raising a calf to weaning reduced the chances of calf loss in the next pregnancy.

Research was conducted into several diseases that affect heifer fertility. Vaccination against vibriosis prior to mating increased conception rates in maiden heifers by 11%. Pestivirus (BVDV) was found to be prevalent in the herd. A single injection of a Vitamin A supplement during pregnancy did not affect calf loss rates.

Tieyon: The work at Tieyon was completed despite drought conditions persisting throughout most of the study. Growth throughout the drought was surprisingly high (the average annual growth of maiden Angus heifers was 117kg). Growth was much higher in the one good season experienced during the study (ie. 0.73 kg/day in summer 2008/09) than in the preceding season (growth of 0.05 kg/day) after several consecutive drought years had taken their toll.

Mating was continuous but more heifers became pregnant during summer than winter. The intended study of controlled mating had to be abandoned due to the drought conditions, but a desktop study found that the best 3 month period for mating was in Jan-Mar. The average estimated weight at first conception was 284 kg but there was a large range in the weight at which heifers first conceived. Pregnancy rates in maiden heifers (at April musters) averaged 83% if heifers >300 kg at the end of mating were considered to be maidens.

Calf loss averaged 12% in first calf heifers and 9% in second calf cows. These rates are low for extensive situations. First calf heifer re-conception rate averaged 18% at first round musters in drought years but was 46% in April 2009 after a good season. Weaning had a large effect on re-conception rates (heifers whose calves were not weaned took significantly longer to re-conceive).

Research to test the benefit of vaccination against pestivirus (BVDV) was not possible as most heifers had already been exposed to the disease before they could be vaccinated against it. Results from a trial to test the benefits of vaccination against vibriosis were inconclusive but suggested that vibriosis was not a major problem in the herd.

2. Heifer performance recording on NT commercial properties.

The heifer performance recording on eleven commercial properties found that pregnancy rates in maiden heifers (all breeds) were generally adequate (>75%) to produce sufficient numbers of replacement heifers where heifers were first mated as two year olds. Low rates were recorded where poor seasonal conditions were experienced, over stocking occurred or yearling mating was practiced.

A wide range of pregnancy rates were recorded in first lactation heifers although most were quite low. Re-conception rates of less than 10% were found on more than a third of properties. Re-conception rates were less than 25% on 73% of properties and were only found to be greater than 50% on 2 of the 11 properties. One of the major findings of the performance recording work was that the fertility of first calf heifers on many properties was much lower than expected. This is demonstrated by the fact that on average first calf heifer re-conception rates were estimated by property managers to be 63% in the start of project (2004) survey, however performance recording in this project showed that the actual figure is likely to be much lower.

There was a very strong relationship between the weight of heifers at the time their calves were weaned and the proportion that had re-conceived. Re-conception rates were low where heifers had low body weights during the joining period. A wide range (4% to 39%) of calf loss rates were recorded in first calf heifers although they were generally high (the average was 23%).

3. Best Practice Manual

The Best Practice Manual will be published during 2010.

4 & 5. Start and end of project surveys.

Surveys of managers were conducted at the start (2004) and end (2009) of the project. The 2004 survey was more extensive as it aimed to get a detailed understanding of how heifers are managed on NT cattle properties, what managers thought their current heifer performance levels were and their attitudes towards different management practices. The purpose of the 2009 study was to assess how heifer performance and manager's knowledge, attitudes and practices had changed over the duration of the project.

The surveys showed that awareness of the problem of low re-conception rates in first calf heifers increased over the course of the project. The average of the managers' estimates of branding

rates from first calf heifers was 21% lower (fell from 63% to 42%) in the second survey than the first, while estimates of branding rates from breeders and maiden heifers remained the same.

The surveys measured the proportions of managers using different management practices and their knowledge of the factors affecting heifer fertility. The attitudes of managers towards change were also surveyed and it was found that NT cattle mangers are generally open to changing their management practices for the purpose of improving heifer performance.

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- The managers of Newry (the heifer demonstration site in the Katherine region) during the time of this project, firstly Rod McColm and then Joe Atkins, and their families and staff for their hospitality, assistance and co-operation. Also thanks to the management of Consolidated Pastoral Company especially Ken and Geoff Warriner for their support of the work at Newry.
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- The owners of Tieyon (the heifer demonstration site in the Alice Springs region), the Smith family and especially the manager Paul Smith and his family and staff for their hospitality, assistance and co-operation. The fact that the work could be completed through such an extended period of drought was only possible because of their commitment. As a result this research has provided some very valuable information that is also very rare, since the breeding performance of cattle on a commercial station in Central Australia has not previously been recorded through such a period of extended drought.
- The staff of NT DoR (formally NT DPIFR) who assisted in data collection at various times, especially Kieren McCosker, Trisha Cowley, Trudi Oxley, Whitney Dollemore, Megan Hoskins, Ash Cooper, Sarah Streeter, Harmony James, Andy Bubb, Bryan Gill, Sally Leigo and Darryl Kantawarra. Also Neil MacDonald for his assistance in the planning of the project and proof reading, and Mark Hearnden for his assistance with statistical analysis.
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Contents

1 Background

It has been widely documented that the fertility of cattle is lower in northern Australia than in temperate southern Australia (McClure 1973, Rudder *et al*. 1976 and Holroyd *et al*. 1979). This is the result of a number of environmental and genetic factors, but the predominant reason is the stressful environmental conditions in northern Australia where seasonal under-nutrition (due to poor pasture quality and quantity during the dry season), heat, humidity, parasites and large distances between water and pasture all impact on cattle performance (Entwistle 1983).

These factors have an even bigger impact on the fertility of heifers than mature cows. In northern Australia most heifers are mated for the first time a year later than in southern Australia (Entwistle 1983) and Fordyce (1996) states that pregnancy rates of maiden two year old heifers in the dry tropics are often below 50%. Also re-conception rates in heifers during their first lactation are often very low eg. less than 25% (Sullivan *et al*. 1997; Schatz and Hearnden 2008) and the problem of the low conception rates in lactating first calf heifers is recognised as the biggest area of inefficiency in Northern Australian breeding herds (McLure 1973 and Entwistle 1983).

While there have been many reports of low reproductive performance of heifers in northern Australia, there have also been some reports of very good performance as well with conception rates exceeding 90% in both maiden (Holroyd *et al*. 1988 and Doogan *et al*. 1991) and first calf heifers (Savage *et al*. 2004). This shows that there is potential for large improvements in heifer performance in northern Australia.

Improvements in heifer performance have the potential to bring about large gains in profitability for northern Australian properties since heifers require about a third of the grazing area available for grazing females on a property (Fordyce 1996). Ridley (1994) calculated that while heifers comprise one third of the animal equivalents of a commercial breeding herd (in the Victoria River District), they only yield an average of 17% of the total calf crop, and that a 40% improvement in heifer productivity would therefore result in a 7% lift in the production of the whole breeding herd. With weaning rates in the adult herd now averaging in excess of 80% in some areas, there do not appear to be many other ways of achieving such a considerable lift in overall productivity.

It is generally accepted that there have been large improvements in cattle performance on NT cattle properties in recent times (Savage *et al*. 2004) and there are many anecdotal reports of high heifer fertility. However, due to the large size of most NT properties and the fact that mustering efficiency and paddock security (especially during the wet season) are often poor, most anecdotal reports of reproductive rates in the NT are just a guess (where animals have not been individually identified and their performance recorded). As a result the aim of one part of this project was to establish the current levels of heifer fertility on NT properties and determine the extent to which low heifer fertility remains a problem.

Another aspect of the project was to demonstrate management strategies to improve heifer fertility on commercial properties and also attempt to determine why such strategies are not more widely adopted. Low heifer fertility has been identified by researchers as a major problem on northern Australian properties for a long time (Entwistle 1983). A meeting in Darwin on 15 July 2002 confirmed that relevant representatives from Qld, NT and WA government agencies, plus representatives from some of the major pastoral companies, believed that these problems are still prevalent over much of the northern industry, even on stations recording near optimal adult breeding performance. There are a number of possibilities for why this may be the case;
- Many producers may not be aware of the extent of the problem on their property
- Various heifer management strategies to improve fertility lack cost benefit information and are not being widely adopted

- The heifer strategies that have been adopted are not very effective.

2 Project Objectives

The objectives of this project were: - that by December 2009, the Research Organisation will have:

1. Identified (in consultation with industry), evaluated and demonstrated practical management strategies to improve the performance of heifers and young breeding females on one commercial property in each of the Katherine, Barkly and Alice Springs regions (total 3 sites).

2. Recorded the reproduction performance of heifers and young breeders on 9 representative stations in the N.T. and established benchmarks for young breeder reproductive traits on each of those stations.

3. Produced a Best Practice Manual for heifer management in the N.T. and northern W.A (in conjunction with WA DAF).

4. Surveyed N.T beef producer heifer management practices at the start of the project to identify barriers (real and perceived) to implementation of other known practices.

5. Surveyed N.T beef producer heifer management practices at the end of the project to document changes during the life of the project.

3 Methodology

The methodology is described for each objective separately here (where it assists with continuity and makes the report easier to read, the methodology is only briefly outlined here and then covered in more detail at the start of the "results and discussion" section for that objective).

Demonstration sites on commercial properties. - Initially three demonstration sites were established at Newry in the Katherine region, Helen Springs in the Barkly region and Tieyon in the Alice Springs region. The Regional Beef Research Committee (RBRC) in each region was engaged as a steering committee for the work in its region. However due largely to drought conditions (Helen Springs only received 2 inches of rain over the 2004/5 wet season and 2005 was a very poor season on the Barkly) the management of Helen Springs decided that they could not continue with the work and the demonstration site was abandoned (in fact conditions were so bad that many of the stock on Helen Springs were sold or sent to other properties). This was clearly communicated to MLA at the time and was done with their agreement.

Only a general methodology of the demonstration site work will be given here and the specific methodology of the research at each of the Newry and Tieyon demonstration sites will be described in more detail in the reports of results in section 4.

The way the properties on which the research was conducted were selected was that the RBRCs in each region were consulted and asked to recommend properties that they thought might be good sites for the work. Then the managers of these properties were contacted, the nature of the work was clearly explained to them and they were asked if they would be willing to host the work. Once a manager had agreed to consider being involved, a tour of the property was conducted to see if the paddocks, yard facilities etc. would be suitable. In all cases it was only after the property had been visited and the work-plan explained that the manager committed to being involved.

On each of the properties the research aimed to compare different heifer management techniques to the way heifers were currently managed on the property. Some of the management techniques studied were controlled mating, supplementation, weaning management, vaccination against vibriosis, vaccination against pestivirus, and injection with Vitamin A during mid-late pregnancy.

Not only were the effects of the heifer management techniques analysed scientifically but the work acted as a demonstration of how to implement the techniques in that location and allowed producers from the district to assess how relevant they would be to their situation.

3.1 Heifer performance recording on NT commercial properties.

Only a brief outline of the research is given here. The methodology is described in more detail at the start of the results and discussion section (4.2).

Initially the aim of this part of the project was to record the performance of heifers for two years on three properties in each of the three regions (VRD, Barkly and Alice Springs) i.e. a total of 9 properties. However the work evolved as it went along and extra properties were added and some dropped off after one year. Performance was recorded on a total of 14 properties (see appendix 9.6)

The performance recording found that current fertility levels in first calf heifers were much lower than expected on many properties (in fact after several years all recorded re-conception rates were lower than 20%). This resulted in actively seeking properties to participate where it was known that re-conception rates would be higher so that the work was representative of the whole NT industry.

3.2 Best practice manual.

A best practice manual for heifer management in Northern Australia is in the process of being produced in collaboration with the WA DAF collaborative heifer research project. The best practice manual will be completed and published in 2010.

3.3 Survey - Start of the project.

A survey of producers was conducted in 2004 to determine current management practices, producer attitudes and estimated production statistics in relation to heifers.

The survey was developed and fortunately the timing coincided with a major Pastoral Industry Survey being done at the time by the NT DoR (the department was known as DPIFM at that time). This allowed the heifer survey to be added to the Pastoral Industry Survey. DoR staff conducted face to face interviews right across the NT. As a result a large number (169) of property managers were surveyed.

The results of the survey were collated and are presented in section 4.3.

3.4 Survey - End of the project.

The aim of the end of project (2009) survey was to determine if producer's knowledge, attitudes and management practices had changed over the duration of the project. The sample size was not as high as for the start of project survey (2004) as the 2009 survey did not coincide with a Pastoral Industry Survey, nevertheless it is believed that the results were significant. The survey asked many of the same questions as the 2004 survey and was emailed out to all NT properties that NT DOR had an email address for (about 200 properties). After 2 weeks a reminder email was sent out to encourage more people to complete the survey. Following this many properties were contacted by telephone and asked to do the survey over the phone. Attempts were made to ring as properties as possible that a phone number could be found for, however not all properties could be contacted and on some properties a suitable person to complete the survey could not be found during the time limits available. The end result of these attempts to survey NT property managers resulted in the completion of 53 surveys. The results of these surveys are presented in section 4.3.

4 Results and Discussion

The results and discussion for each of the project objectives are presented in a separate section.

4.1 Demonstration sites on commercial properties.

A major report on the research at each of the demonstration sites is presented in sections 4.1.1 and 4.1.2.

4.1.1 Heifer demonstration site in the Katherine region – Newry.

4.1.1.1 Introduction

Newry is located about 440 km west of Katherine, just east of the Northern Territory/Western Australia border (i.e. 16^{o} 00' S, 129^{o} 25' E). It has been owned by the Consolidated Pastoral Company (CPC) since in 1992 as a part of their aggregate of stations across northern Australia. The property is 2,348 km^{2} in area and usually carries around 15,000 head of cattle on its black soil, forest and stony ridge country. It turns off about 4,000 head a year, of mostly young steers and spayed heifers for the South East Asian live export market.

The climate is tropical with a distinct wet and dry season and almost all of the approximately 800 mm of annual rainfall falls between November and April. The temperature and humidity are high during the wet season months, pasture quality deteriorates in the dry season. Both cattle tick and buffalo flies are endemic in the region. As a result most cattle are high grade Brahman.

The cattle graze native pasture on Newry and the major desirable species are Curly Bluegrass (*Dicanthium fecundum*), Golden beard grass (*Chrysopogon fallax*) and a small amount of Flinders grass (*Iseilema spp*.). Less desirable species such as White grass (*Sehima nervosum*), Feathertop (Aristida latifolia), Black spear grass (*Heteropogon contortus*) and Annual sorghum (*Sorghum intrans*) are present in abundance especially on the ridges and hilly country. There is not as much Mitchell and Flinders grass (desirable pasture species) present on Newry as there is on properties further south in the Victoria River District (VRD). The table in Appendix 9.1 contains a summary of the most common pasture species found in the paddocks that were used in this research.

Most of the land in the research paddocks can be described as basalt plains. The land units are shown in more detail in the land unit maps in Appendix 9.2.

The cattle involved in this research grazed in several paddocks around Glenarra Yards. Maiden heifers were joined for the first time in the "Electric paddocks", and then they were allocated to either "Transit" or "Matilda" paddock where they had their first calves. After a year in either "Transit" or "Matilda" they were transferred to "Steer" paddock where they remained for the rest of the study. It was intended that the heifers would be run at a stocking rate of 8.5 head per km^2, however the paddock security was poor with many flood fences washing down during the wet season and as a result the paddocks were over stocked at times with many cattle from other paddocks moving in.

Brief outline of the research

The traditional way that heifers have been managed at Newry is that they are put in a heifer paddock at weaning, and kept there (separate from bulls) until they are ready for their first joining (usually at around two years of age). Then they are put into the main breeder herd. This is quite a quite a common management system in the region. Supplementation is only considered in "bad" years.

Several different treatments were studied as part of the heifer research at Newry. The traditional management system was compared to one which involved a limited joining period (Nov-April) and supplementation of heifers from the dry season prior to their first calf until their second joining. Within these treatments the effectiveness of a single vibriosis vaccination prior to the first joining was tested and effects of a Vitamin ADE injection on calf loss were also studied.

4.1.1.2 Methodology

The research involved studying the performance of two year groups of heifers. The first year group of maiden heifers was mated over the 2004/05 wet season (starting in late November 2004) and the next group in the year following. Each year 700 heifers were individually identified, weighed and preg-tested prior to their first joining, and 300 of these heifers were also given a single vaccination against vibriosis at that time. This pre-joining weight was recorded on 31/10/04 for the first year group of heifers and 11/9/05 for the second year group. The pregnancy rates in maiden heifers were determined from pregnancy testing at the first weaning round in the following year (on 8/4/05 for the first year group and 13/5/06 for the second year group).

At the 1st round muster (in April) after their first joining the heifers were allocated to one of two paddocks. "Transit" paddock was the control paddock where heifers were managed in the traditional way. Bulls always remained in "Transit" but they were removed from the "Matilda" paddock at the April muster and not returned until late November (so that the heifers in "Matilda" were control mated). The heifers in "Matilda" were also supplemented with Uramol^{TM} lick blocks (20% Urea, 2.7% Phosphorus, 9% Calcium, 35% salt and other trace elements) in the dry season prior to calving for the first time (July to November) and with Phosrite^{TM} blocks (28% DCP, 15% Urea, 10% cottonseed meal, 7% Magnesium oxide plus molasses) over the wet season when they were lactating for the first time. The heifers that had calved down in "Transit" and "Matilda" were moved to "Steer" paddock at the first round weaning muster and replaced with heifers from the next year group being studied.

Once heifers were moved to "Steer" paddock they remained there for the duration of the project (until mid 2009) and their performance was recorded at biannual musters in April/May (1st round = WR1) and September/October (2nd round = WR2). At each muster they were weighed, preg tested, and their lactation status (wet/dry) and condition score were recorded. Any calves that were big enough were weaned at these musters.

Paddock security proved to be a major problem in the course of the research. There were a number of flood fences that were washed down in the wet season and even in the dry season bulls seemed to go where ever they pleased. As a result it was not possible to implement the control mating treatment and although there were fewer bulls in “Transit” paddock, effectively both paddocks were mated continuously. Also many extra cows from other paddocks entered the trial paddocks over the wet seasons and were mustered with them. This compromised the supplementation experiments and meant that it was not possible to identify which calves came from heifers in the trial paddocks. Therefore it was not possible to compare the weaners from the different paddocks.

The methodology of several smaller experiments (eg. the effect of vibriosis vaccination) is described where those experiments are covered within the results and discussion section.

4.1.1.3 Results and discussion.

Maiden heifer fertility

The major factor affecting pregnancy rates in maiden heifers is joining weight assuming there are no major disease problems (Entwistle 1983), and figure *4.1.1*-1 shows how pregnancy rates confirmed on (dates?) increased as joining weights increased in both year groups of maiden heifers at Newry.

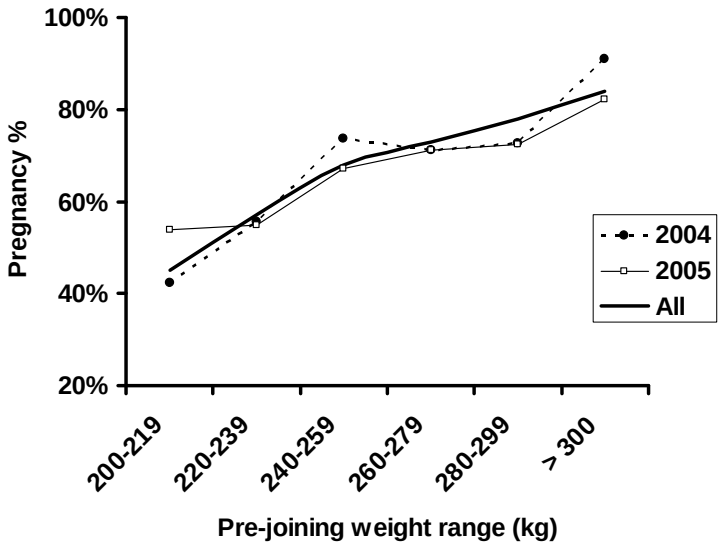

Figure *4.1.1*-1. Effect of joining weight on the fertility of Newry maiden heifers.

Joining weight also effected the time it took heifers to conceive for the first time with heavier heifers conceiving earlier in the joining period (figure *4.1.1*-2).

Figure *4.1.1*-2. Effect of maiden joining weight on the average number of days taken from the start of mating (SOM) to first conception.

Some of the benefits of early conceptions are that the calves born are older and therefore heavier at weaning. Calving earlier also gives heifers more time to re-conceive before pasture conditions deteriorate after calving and so earlier calving heifers should have higher chances of re-conceiving. This did not occur with the heifers in this study where maiden joining weight had no significant longer term effects on fertility (table *4.1.1*-1). It is likely that the reason no long term benefits of heavier maiden joining weight were seen was because most heifers were in too poor condition to re-conceive regardless of when they calved and required several months on green feed following weaning before they resumed cycling. Ongoing benefits from high maiden joining weights and earlier calving are more likely to be seen when heifers are in better condition between calving and weaning.

Table *4.1.1*-1. Effects of maiden joining weight on subsequent re-conception rate, time taken to re-conceive and calf loss.

Maiden joining weight range (kg)	% heifers that re-conceived before weaning	Avg days from calving to re-conception	Calf loss (1st calf)
200-219	6%	313	23%
220-239	3%	319	30%
240-259	5%	312	33%
260-279	7%	316	21%
280-299	6%	298	24%
> 300	11%	290	16%

Overall the pregnancy rates in maiden heifers at Newry in the 2 years of this study were quite low and this was due to the low average joining weights of the groups (Schatz and Hearnden 2008). Table *4.1.1*-2 summarises the performance of both year groups of maiden heifers that were studied at Newry. The pregnancy rates are what would be expected from the corresponding average joining weights. The main reasons why average joining weights and pregnancy rates are slightly lower than could otherwise be achieved are that the heifers were not supplemented prior to first joining, and the stocking rate was often higher than intended (there are several flood fence crossings in the heifer paddocks and many extra animals entered the paddocks).

Table *4.1.1*-2. The performance of each year group of maiden heifers.

1st joining period	Avg joining weight	Pregnancy rate	Number	Avg growth over joining period
Nov '04 – Apr '05	236 kg	59%	675	86 kg
Nov '05 – Apr '06	264 kg	65%	466	86 kg

As bulls were always present (even in the paddock that was intended to be control mated) heifers continued to conceive continually in the months following the intended end of mating in April. Figure *4.1.1*-3 shows that while most heifers conceived within 9 months after the start of mating, some heifers took much longer (eg. > 18 months).

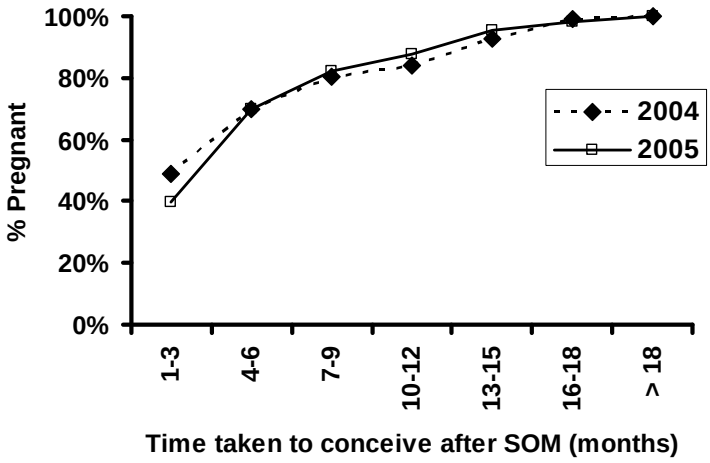

Figure *4.1.1*-3. The length of time (in months) taken for maiden heifers to conceive after the start of mating (SOM).

In both year groups approximately;

- 64% of heifers had a calf weaned on schedule at the first weaning round muster in the year after joining.
- 12% had their calves weaned at the 2nd round muster that year
- 20% had their calves weaned at the WR1 muster the following year.
- 4% took even longer than that.
- Note - this takes into account those heifers that lost a calf and re-conceived as well as those that just took a long time to conceive for the first time.
- There were only 3 heifers (out of 1244) that never conceived i.e. were barren.

In summary, management of young heifers should focus on getting them to their first joining at weights that are conducive to good fertility. A pre-joining target weight of around 270 kg is required for high conception rates (eg. 80%) in maiden heifers (Doogan *et al.* 1991). Strategies to increase joining weights include running heifers in better paddocks, using lower stocking rates and supplementary feeding). Most management practices that are implemented to increase the joining weight of heifers will require them to be segregated.

First calf heifer fertility

The fertility of beef cows is generally at its lowest during their first lactation (Entwistle 1983). This is due to the large nutritional requirements that are required for lactation and maternal growth to occur at the same time (i.e. first calf heifers are still trying to grow themselves while feeding their calf and this requires a lot of energy). The problem is exacerbated in northern Australia where poor pasture quality during the dry season and environmental stresses such as ticks, heat, and

buffalo flies often result in first lactation heifers being in poor condition and hence low re-conception rates.

Body weight/condition is one of the major factors affecting re-conception rates and the time it takes heifers to resume cycling after calving (the post partum anoestrus interval) (Dunn and Kaltenbach 1980; Short *et al.* 1990b). Lactation and poor body condition both increase the length of time it takes for heifers to resume cycling (Randel 1990). Lactation has a negative feedback on the resumption of cycling and when the body stores of fat in a heifer are inadequate the hormones required to initiate cycling are not secreted, and as a result the time it takes for heifers to resume cycling is extended. When this is common in a herd the re-conception rates are low. Figure *4.1.1*-4 (from Schatz and Hearnden 2008) summarises data collected on commercial properties in the NT as part of this project and shows that there is a strong relationship between body weight and re-conception rates, with re-conception rates increasing as weight increases.

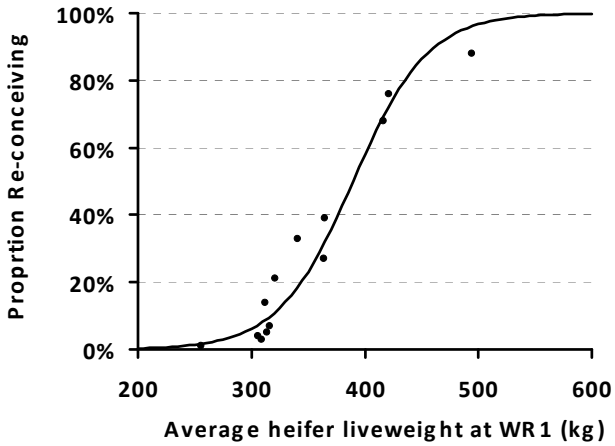

Figure *4.1.1*-4. The effect of weight on re-conception rates in lactating 1st calf heifers on commercial cattle properties in the NT.

Re-conception rates were low (5% overall) in lactating first calf heifers at Newry during the period of the study (see tables *4.1.1*-3 and *4.1.1*-4).

Table *4.1.1*-3. Overall re-conception rates in Newry lactating 1st calf heifers at WR1.

Year 1st joined	Total number of heifers recorded	Avg weight of wet heifers at WR1	% that re-conceived while lactating
2004	611	306 kg	5%
2005	484	314 kg	5%

Re-conception rates 1st calf heifers have been shown to be strongly effected by weight during the joining period (Schatz and Hearnden 2008). The reason that re-conception rates were low in 1st calvers at Newry is that their weight/condition during their 2nd joining period (between calving and weaning) was low (see table *4.1.1*-3). The main reason why their weights were low was overstocking (un-intentional) of the heifer paddocks. Prior to calving the stocking rates were set at 8.5 heifers per km^2, however there are many flood fences that go down during the wet season in the heifer paddocks and many extra cattle entered the paddocks. In fact at the first round muster in 2007 about 3 times as many animals were mustered from the heifer paddocks than were put in there prior to the wet season.

Stocking first calf heifers at lighter stocking rates, running them in better paddocks and supplementing them are some of the simplest and most effective ways of increasing heifer weights during the joining period (between calving and weaning). Early weaning is recommended to preserve body condition to increase the chances of re-conception in subsequent years, but it

does not have any effect on first calf heifer re-conception rates, as re-conception needs to occur within 3 months after calving (i.e. before weaning) for a heifer to have another calf within 12 months.

Effect of the weaning round at which calves were weaned on heifer re-conception rates.

No first calf heifers re-conceived when they were wet (lactating) at the 2nd round musters (i.e. while lactating through the dry season - table *4.1.1*-4). Re-conception rates were higher in heifers weaning their first calf in 2008 than in previous years, but it must be noted that these heifers were at least a year older than the first calvers in the other years i.e. these were heifers that should have already had their first calf in a previous year but either lost their first calf or did not conceive during their 1st joining season.

Table *4.1.1*-4. Effect of time of weaning on re-conception rates and weights in 1st calf heifers.

Time 1st calf weaned	Re-conception rate	Number re-conceived	Avg weight of wet heifers	Avg weight of heifers that re-conceived
May '06	4%	21 of 404	306 kg	345 kg
Oct '06	0%	0 of 89	298 kg	
Apr '07	5%	18 of 356	325 kg	349 kg
Sep '07	0%	0 of 85	320 kg	
Apr '08	16%	17 of 383	334 kg	355 kg

Table *4.1.1*-4 emphasises the effect of weight on re-conception rates as it shows that at any of the musters, that the average weight of those heifers that did re-conceive was heavier than the average weight of all the lactating first calf heifers at that muster.

While re-conception rates were lower in heifers whose calves were weaned at the second round, the average time that they took to re-conceive was actually less than for heifers whose calves were weaned at the first round (table *4.1.1*-5).

Table *4.1.1*-5. Average number of days from calving to re-conception for heifers whose calves were weaned at different rounds.

Time when calves were weaned	Number of heifers	Avg calving date	Avg re-conc. date	Avg number of days from calving to re-conception
WR1 06	404	30/10/2005	1/10/2006	335
WR2 06	89	28/05/2006	20/1/2007	236
WR1 07	356	15/10/2006	4/9/2007	324
WR2 07	85	24/2/2007	2/12/2007	281

Figure *4.1.1*-5 illustrates how this occurred. Most heifers were too poor to re-conceive before their calves were weaned and they required several months grazing good pasture during the wet season before their condition picked up enough for them to resume cycling and re-conceive. The reason that heifers whose calves were weaned at 2nd round musters had shorter average times from calving to re-conception is that they had less time to wait from weaning until the next wet season when their condition picked up and they resumed cycling (figure *4.1.1*-5).

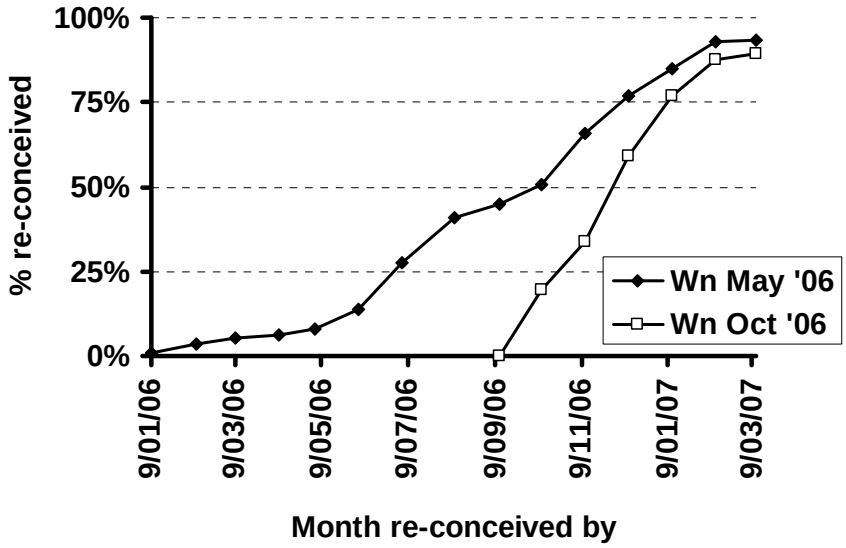

Figure *4.1.1*-5. Time taken to re-conceive for heifers (1st year group) whose calves were weaned at either the 1st or 2nd round muster.

In figure *4.1.1*-5 estimates of the date that heifers re-conceived on (from preg testing data) were used to graph the patterns of re-conception for the first year group of heifers whose calves were either weaned at the 1st or 2nd round musters in 2006. It shows that while re-conception rates were initially higher in heifers whose calves were weaned at WR1, and then about another 30% of them then re-conceived in the dry season months after weaning, that by the end of the next wet season the proportion of heifers that had reconceived was fairly similar for both groups of heifers (i.e. the average time taken to re-conceive was shorter for heifers whose calves were weaned at WR2).

It should be noted that while the expected benefits of early calving (i.e. so that calves can be weaned at WR1) were not seen in terms of re-conception rate or length of time taken to re-conceive, there are other benefits associated with early calving. For example the average weight of weaners weaned from earlier calving heifers is heavier than from later calving heifers (as their calves are older at weaning).

Effect of supplementation on re-conception rates in first calf heifers.

There have been many reports of supplementation causing increased re-conception rates in first calf heifers through the effect of heavier weight/better condition (McSweeny *et al.* 1993, Marston *et al.* 1995, Dixon 1996b; Monteil and Ahuja 2005). It was intended to examine the benefits of supplementation with lick blocks at Newry as it has been normal practice there not to supplement heifers, however the problem of many extra animals entering the trial paddocks made a proper comparison impossible.

Both year groups of heifers were split into two even groups after the maiden joining and one group was supplemented with Uramol blocks from July to November and then with Phosrite blocks over the wet season when they were calving for the first time. The other group received no supplementation.

In both years in which the supplementation treatments were implemented, many extra animals entered the treatment paddocks and some animals switched between treatment paddocks. As a result it was not possible to accurately assess the effect of supplementation. However when the extra animals and those that switched paddocks were disregarded, the lactating heifers that were

in the paddock that was supplemented weighed 12 kg more than the un-supplemented lactating heifers in the first year and the re-conception rate was 8% compared to 1% in the unsupplemented paddock. While there was some difference between treatment groups the effect of overstocking is likely to have diminished the benefits that may have occurred from supplementation.

In the second year even more non-trial animals entered the trial paddocks making a comparison between the supplemented and un-supplemented paddocks impossible (in fact 3 times as many animals were mustered from the paddock after the wet season as were put in there the previous year).

While it was disappointing to not be able to properly examine the benefits of supplementation in this work, the generous sponsorship of LNT should be acknowledged.

Subsequent second calf cow fertility

Re-conception rates are usually higher in heifers after their second calf than after their first as re-conception rates in cattle are usually lowest after the first calving (Entwistle 1983). In this study re-conception rates at the first weaning round muster were about 15% higher in lactating heifers after their second calf than after their first (Table *4.1.1*-6).

Table *4.1.1*-6. Re-conception rates in lactating 1st calf heifers and 2nd calf cows at WR1.

Year 1st joined	1st calf heifer Re-conc. rate	1st calf heifer Avg. weight	2nd calf cow Re-conc. rate	2nd calf cow Avg. weight
2004	5%	306 kg	21%	349 kg
2005	5%	314 kg	20%	367 kg

Figure *4.1.1*-6 shows that more heifers re-conceived sooner after their second calving than after their first i.e. re-conception rates were higher in second calf cows at any time after calving.

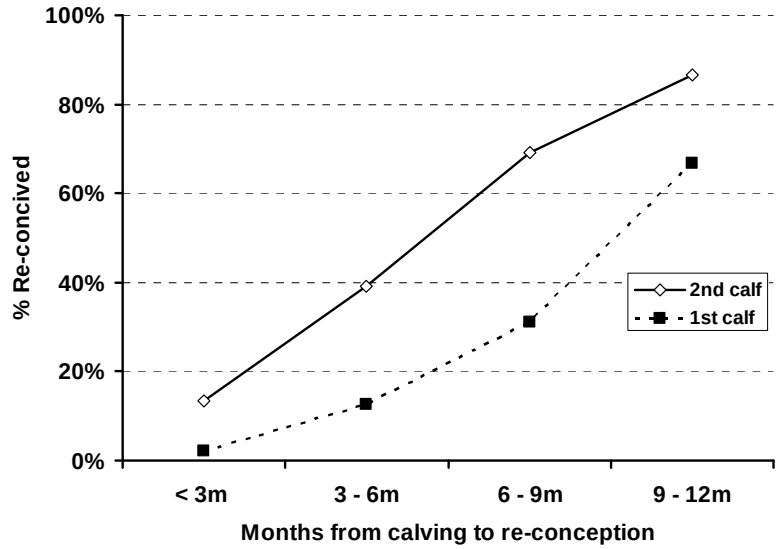

Figure *4.1.1*-6. The time taken to re-conceive after calving for first calf heifers and second calf cows.

Even though re-conception rates were higher in second calf cows than in first calvers, the rates were still quite low (21% and 20%). Again this was largely due to the low heifer weights during the re-conception period (between calving and weaning) as a result of un-intentional overstocking of the paddocks (a result of extra animals entering the trial paddock). Efforts to increase re-conception rates will involve strategies that increase the weight of heifers during the

re-conception period. Examples of such strategies are; moderate stocking rates, supplementation, and timely weaning of the previous calf.

There is a school of thought among some cattle managers in northern Australia that re-conception rates are not very important in first calf heifers as they think that heifers that do re-conceive as first calvers will then miss a calf the following year, while those that did not re-conceive will then have a calf and so all heifers will have had 2 calves in the first 3 years after first joining.

The research at Newry found that 85% of heifers (that did not lose their first calf) had 2 calves in the 3 years after first joining (table *4.1.1*-7). The fact that re-conception rates in first calf heifers were so low meant that very few actually had the chance to have 3 calves in the 3 years.

Table *4.1.1*-7. The proportion of heifers that had either 0, 1, 2, or 3 calves in the three years after their first joining (during the 2004/05 wet season).

	Description of heifers				
Number of calves produced in 3 yrs	**Wet at R1 06**	**Weaned a calf at R2 06**	**Lost first calf**	**Didn't conceive as a maiden**	**All heifers joined '04/5**
0			9%	6%	2%
1	8%	31%	59%	64%	23%
2	85%	69%	33%	30%	70%
3	8%				5%
Total no. heifers	N = 293	N = 52	N = 58	N = 50	N = 453

Those first calf heifers that did re-conceive had higher subsequent fertility (as 2nd calf cows) with a 67% re-conceiving again the following year compared to 20% re-conception in all 2nd calf cows. This resulted in more calves being produced per heifer over the 3 years from heifers that re-conceived as first calf heifers than from those that didn't (Table *4.1.1*-8). Note - these numbers should be treated with caution due to the low number of observations (there were only 9 heifers that re-conceived at WR1 06 and that have long term records).

Over all, for all heifers mated over the 2004/05 wet season (including those that lost their first calf, did not conceive as a maiden, or weaned a calf at the 2nd round muster) 1.78 calves were produced per heifer in the 3 years after first joining. The corresponding figures were 2.00 calves in 3 years for heifers that had a calf weaned on schedule at the first weaning round but did not re-conceive (i.e. were "empty/wet" at WR1 2006) and 2.67 calves in 3 years for heifers that weaned a calf and did re-conceive at this time (Table *4.1.1*-8). From this it is evident that having higher re-conception rates in first calf heifers does increase overall calf production.

Table *4.1.1*-8. The effect of first calf heifer re-conception on the proportion of heifers that had either 0, 1, 2, or 3 calves in the three years after having their first calf weaned in 2006. (Note that these figures do not include heifers that lost their 1st calf i.e. did not wean a calf in 2006).

	Heifers that did not re-conceive at WR1 '06	**Heifers that re-conceived at WR1 06**	**All heifers joined '04/5**
Had no calves in 3 yrs			2%
Had 1 calf in 3 yrs	8%		23%
Had 2 calves in 3 yrs	87%	33%	70%
Had 3 calves in 3 yrs	6%*	67%	5%
Total no. of heifers	N = 284	N = 9	N = 453
Number of calves per heifer in 3 yrs	2.00	2.67	1.78

*a small number of heifers that were preg tested empty at R1 06 actually had a calf the following year but it was a late calf i.e. born just before or after WR1 2007 and so was weaned at WR2 2007.

Table *4.1.1*-8 shows the proportion of heifers that either had 1, 2, or 3 calves in the 3 years after first joining. These proportions were used to calculate how many calves would be produced per heifer that either did or did not re-conceive at WR1 06. Table *4.1.1*-8 shows that over 3 years, heifers which re-conceived while wet at WR1 2006 produced 2.67 calves (or 267 calves per 100 heifers) compared to 2.00 calves over 3 years from heifers that did not re-conceive. Heifers that calved between WR1 and WR2 in 2006 only produced 1.69 calves per heifer over 3 years.

Heifers that did re-conceive as first calf heifers may be inherently more fertile and it may not necessarily follow that if overall re-conception rates were increased through increasing the body condition of all heifers (eg. through lower stocking rates and supplementation) that all heifers that then re-conceived would also have the same higher level of subsequent fertility. However if it is assumed that they do, then these figures can be used to calculate the number of calves produced per heifer at different first calf heifer re-conception rates (figure *4.1.1*-7).

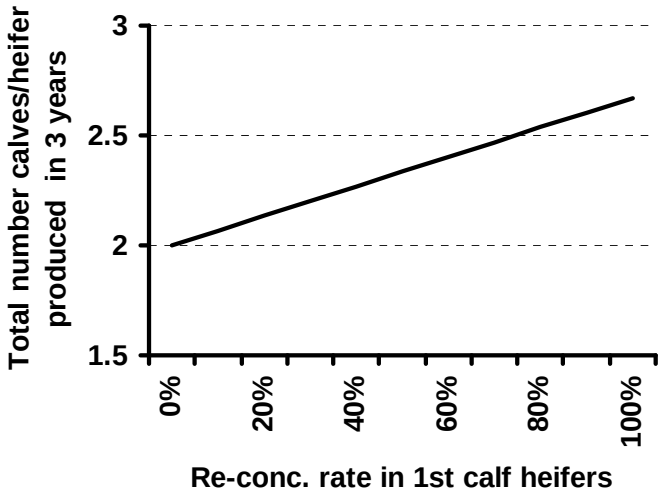

Figure *4.1.1*-7. The effect of first calf heifer re-conception rate on the number of calves produced per heifer in the 3 years after first joining. (For heifers that did not lose their first calf. This was calculated using the figures in table *4.1.1-8* for the proportion of heifers that have 1, 2, or 3 calves in their first 3 years after maiden joining).

Figure *4.1.1*-7 shows that the number of calves produced over 3 years' increases as first calf heifer re-conception rate increases. From this figure the number of calves produced per heifer are;
- 2.067 at a re-conception rate of 10% and
- 2.335 at a re-conception rate of 50%.

This equates to an extra 268 calves per 1000 heifers over 3 years. Also it is likely that the increase in the number of calves produced that occurs when first calf heifer re-conception rates are increased would be even greater than this, as the increase in first calf heifer re-conception rates would be the result of the heifers being in better condition (heavier) and this would also have flow-on effects with heavier weights during the next mating period likely to result in higher 2nd calf re-conception rates.

Calf loss in first calf heifers

In extensive NT cattle herds it is very difficult to accurately assess the extent of calf losses. The paddocks and herd sizes are large, the security is often poor and very few dead calves are actually seen. Indirect methods such as pregnancy diagnosis and lactation scoring of individual breeders at the subsequent weaning muster is the only way to get accurate data on the size of the problem.

In this project a heifer was considered to have lost her calf if she was preg tested in calf at one muster and then was not lactating at the next muster. Calf loss rates in first calf heifers were;

- 24% for heifers due to calve over the 2005/06 wet season
- 34% for heifers due to calve over the 2006/07 wet season

These figures are high but not unusual for extensively managed first calf heifers in the NT (Schatz and Hearnden 2008). Research conducted during this project on 11 commercial properties right across the NT the average calf loss in first calf heifers was 23%. The highest calf loss rate measured was 39% on a Barkly Tableland property and calf loss rates were greater than 30% on 5 of the 11 properties where data was recorded (see appendix 9.6).

Even on properties where calf losses were very high (>30%) the people managing the heifers often did not realise that the losses were that high as very few calf carcasses are seen and poor weaning rates are often attributed to failure to conceive where pregnancy diagnosis is not performed. It is usually not until individual records are kept and foetal aging is routinely practiced, that the scale of calf loss becomes apparent. This is because at a 1st round muster of first calf heifers, most are either “empty & wet” or “pregnant & dry”. Since very few heifers are “empty & dry” this seems acceptable but if records are kept they will reveal that most of the “pregnant & dry” heifers should be wet but have lost a calf and have re-conceived. (If only pregnant maiden heifers were put in a paddock and no other animals entered the paddock then it would be possible to work out the calf loss from the proportion of “dry “ heifers at weaning the following year, however this rarely happens as paddock security is not good on most extensive properties in the NT).

Calf loss is usually higher in first calf heifers than older breeders (Norman 2006) and the performance recording on commercial properties conducted during this project showed that it tends to be higher when heifers are run in larger paddocks.

When estimated calving dates were calculated from foetal aging data it was found that calf losses were highest in heifers that were due to calve in the period between October and December (Table *4.1.1*-9). These are generally the hottest months (average daily maximum temperatures at (nearby) Timber Creek in 2007 were Oct = 39.1, Nov = 39.9, Dec = 37.6) and also the months when the pasture conditions and nutrition were at their worst. (the wet season did not start until December in the years of this study). Poor nutrition affects both the quantity of milk produced and the quality of the colostrum available.

Table *4.1.1*-9. Effect of time of calving on calf loss in first calf heifers (data from all years combined).

Calving period	Number	% Calf Loss	Avg daily maximum temperatures per month at Timber Creek (^{o}C)
Jan-Mar	206	19%	Jan 35.9, Feb 35.1, Mar 35.5
Apr-Jun	37	8%	Apr 35.3, May 33.0, Jun 30.4
Jul-Sep	308	20%	Jul 30.5, Aug 32.9, Sep 36.4
Oct-Dec	636	35%	Oct 38.3, Nov 38.5, Dec 37.2

The fact that calf losses seem to be highest between Oct-Dec may prompt cattle managers to consider delaying the start of joining until March so that calves are born after Christmas, however in reality bull control is very difficult in this country and the time of peak conceptions will generally be set by the seasons. Puberty in heifers is affected by day length (Schillio *et al.* 1992) and many maiden heifers in northern Australia reach puberty (and then get pregnant) when the day length starts to increase after the dry season in September and October (Fordyce 2006).

Also delaying the start of joining until March would mean that more calves would be born later in the year and so would not be ready for weaning until later. This means that a greater proportion of heifers would be lactating for longer into the dry season which will reduce their body reserves (condition). Also the growth of calves is lower over the dry season than over the wet season (0.65 kg/day compared to 0.8 kg/day) and so the average weight of weaners weaned would be lower.

Calf loss in subsequent pregnancies

Calf loss is usually higher in heifers having their first calf than in older breeders that have experienced raising a calf (Norman 2006). This was proved to be true in the research at Newry;

Overall 26% of heifers lost their first calf (N=1244).
If a heifer successfully reared its first calf, then calf loss of the 2nd pregnancy was 17%. However if a heifer lost her first calf, then calf loss with the next pregnancy was 29%.

The effect of Vitamin A on calf Loss

Investigations into large calf losses (eg. 50%) in drought years in western Qld and on the Barkly Tableland found that Vitamin A deficiency was causing deformed brain development in calves and as a result the calves were dying within the first couple of days after calving (Hill *et al.* 2009).

It was hypothesised that pasture in northern parts of the NT may also be deficient in Vitamin A in the late dry season in the same way that it is during droughts in western Qld, although unlike stock in western Qld the heifers at Newry had access to top feed (trees and shrubs) which is a potential source of vitamin A. As a result it was decided to investigate whether Vitamin A deficiency may be contributing to calf losses in heifers that are pregnant through the late dry season.

Method
At the second round muster in September 2007, heifers were preg tested and any that were found to be more than 4 months pregnant were allocated to either a Vitamin A treatment group or a control group.

The Vitamin A group was given an injection with Vitamec ADE (a 5 ml injection containing 1,470 mg of Vitamin A) while the control group received no injection. Heifers were allocated so that there were even numbers of animals at each stage of pregnancy in each group. When the heifers were mustered again in May 2008 their pregnancy and lactation data was used to determine whether they had lost their calf. 206 animals were allocated to each group in September 2007 but not all were mustered again the following May.

It should be noted that the manufacturer’s instructions recommended that pregnant cows be given 2 injections per year but it was not practical to do this so each animal only received one injection.

Results
Injection with Vitamin A seemed to have no effect on calf loss. While the Vitamin A treatment group had 3% less calf loss in this study (Table *4.1.1*-10) this difference was not significant.

Table *4.1.1*-10. Effect of Vitamin A injection on calf loss.

Treatment	Number of heifers mustered in May 2008	% Calf Loss
Vitamin A	158	20%
Control	147	23%

Vitamin A injection did not have a significant effect on calf loss regardless of stage of pregnancy at the time of injection (Table *4.1.1*-11). Again calf loss seemed slightly higher in the control group but the numbers of heifers in each of these sub groups was too low to prove that the differences were significant.

Table *4.1.1*-11. Effect of Vitamin A injection on calf loss in heifers at different stages of pregnancy at the time of injection.

	Vitamin A			Control		
Months pregnant at Sep '07	No. lost calf	No. Total	% Calf loss	No. lost calf	No. Total	% Calf loss
4 – 5	8	46	17%	10	45	22%
6 – 7	11	50	22%	12	45	27%
8 – 9	12	62	19%	12	57	21%
Total	31	158	20%	34	147	23%

Growth

Weights recorded at musters (following an overnight curfew in the yards) were used to calculate the amount of growth between the pre and post joining musters for maiden heifers. Only heifers that were confirmed to be non pregnant at the pre joining muster were included in these calculations. The post joining weights were not adjusted for stage of pregnancy and so the amount of weight gained includes foetal weight in heifers that became pregnant over their maiden joining period

Both year groups of heifers grew 86 kg on average over the wet season of their maiden joining, however the growth of individual animals over this period varied greatly (min = -2 kg and max = 138 kg). Figure *4.1.1*-8 shows proportion of maiden heifers that grew different amounts over the 2004/5 wet season.

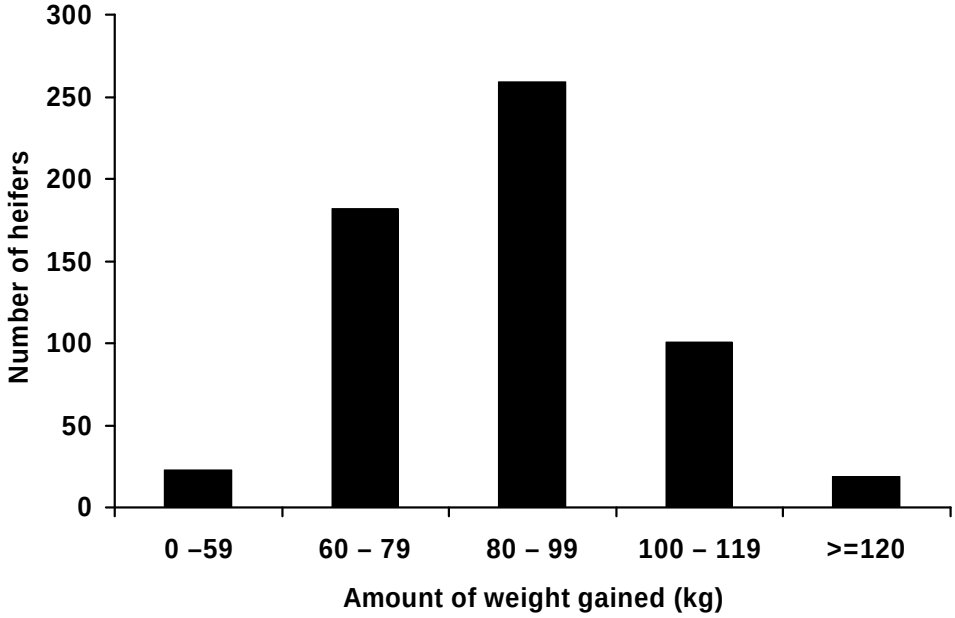

Figure *4.1.1*-8. Range of growth of (dry) maiden heifers over the 2004/5 wet season.

Subsequent analysis of data from herds at other locations has shown that this sort of variation in growth is very common and a major project (the NT Live weight gain project) has been undertaken to try to identify the reasons for this variation in growth. In an attempt to understand why the growth of maiden heifers varied so much at Newry, blood samples were analysed from 3 animals that had not grown much (-2 kg, 12 kg and 42 kg) over a wet season. All 3 had elevated liver enzyme activity indicating that they may have eaten toxic plants, although it is not certain that this was the reason for their lower weight gain.

Figure *4.1.1*-9 provides the growth pattern of heifers that were joined as maidens from Nov ’04. It shows that those that re-conceived as lactating 1st calf heifers were heavier at the first round weaning muster (WR1) than those that did not. Those that did not re-conceive then put on much more weight over the following wet season since they were not lactating over this period. The growth pattern was much the same with the following year group of heifers (1st joined from Nov ‘05) and tables *4.1.1*-13 and *4.1.1*-14 show the amount of growth that occurred between musters for the 2004 and 2005 heifers.

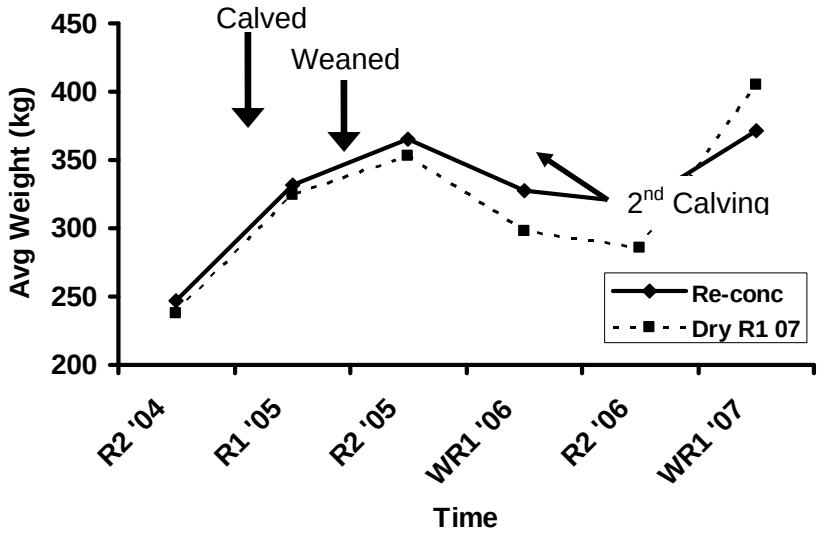

Figure *4.1.1*-9. Weight change of 2004 maiden heifers that weaned a calf at WR1 2006 (weights were not adjusted for stage of pregnancy).
Solid line = those that re-conceived and calved for the 2nd time after R2 06 and were wet at WR1 2007
Dotted line = those that did not re-conceive and so were dry at WR1 2007

Heifers that re-conceived as lactating 1st calvers on average weighed 324 kg at the first round muster when their calves were weaned, and 367 kg (i.e. 43 kg heavier) at the same time the following year when their 2nd calves were weaned. The fact that heifers are so much lighter when their first calf is weaned (and that they are still growing), largely explains why first calf heifers have the lowest re-conception rates of all females in the herd.

On average heifers whose calves were weaned at the first round muster in 2006 and 2007 lost about 5 kg (average of -10, -12, 3, 0) over the following dry season (Tables *4.1.1*-12 & *4.1.1*-13).

Heifers that were wet at these musters but whose calves were not weaned (due to the calves being too small) lost about 46 kg (average of -48 and -45 kg) while they lactated through the dry season (Table *4.1.1*-14).

If heifers calved after the first round muster and then lactated through the dry season on average they lost about 91 kg over that time (Table *4.1.1*-14). However about 50 kg of this weight loss would have occurred at calving (O'Rourke *et al.* 1991a) so the heifers would have lost about 41 kg of their own body weight by lactating through the dry season (Table *4.1.1*-14).

Table *4.1.1*-12. Weight gain between musters of heifers whose 1st calf was weaned at WR1 2006.

2004 Maidens	R2 04 to R1 05	R1 05 to R2 05	R2 05 to R1 06	WR1 06 to W R2 06	WR2 06 to WR1 07	
Re-conc. as 1st calver	85	34	-38	-10	53	← Wet with 2nd calf
Did not re-conc.	86	29	-55	-12	119	← Dry in Apr '07

1st calf born Calf weaned

Table *4.1.1*-13. Weight gain between musters of heifers whose 1st calf was weaned at WR1 2007.

2005 Maidens	R2 05 to R1 06	R1 06 to R2 06	R2 06 to R1 07	WR1 07 to WR2 07	WR2 07 to WR1 08	
Re-conc. as 1st calver	82	3	-33	3	48	← Wet with 2nd calf
Did not re-conc.	87	9	-54	0	102	← Dry in Apr '08

Note - in the tables above;
R = muster round (i.e. R1 = 1st round muster)
WR = Weaning Round muster (i.e. WR1 = 1st weaning round muster)
Dry season = R1 (Apr) to R2 (Oct)
Wet season = R2 (Oct) to R1 (Apr)

Table *4.1.1*-14. Growth of heifers that lactated through the dry season.

Year 1st calved	Timing of calving	Growth from R1 to R2 muster	Number of heifers
2006	Before WR1 2006 (late wet season calf)	-48 kg	31
2006	After WR1 2006 (during dry season)	-92 kg (includes ~50 kg of calf weight)	131
2007	Before R1 2007 (late wet season calf)	-45 kg	45
2007	After R1 2007 (during dry season)	-91 kg (includes ~50 kg of calf weight)	32

The effect of vibriosis vaccination on conception rates in maiden heifers.

Bovine vibriosis (caused by *Campylobacter fetus* subspecies *venerealis*) has been found to be widespread throughout the Northern Territory although the prevalence and impact of the disease is not known. Due to the extensive nature of NT cattle properties, not all bulls get mustered and vaccinated and so there is always a chance that females may contact infected bulls (eg. often some bulls are left behind by helicopter pilots during muster. Also there are scrub bulls and bull from neighbouring paddocks and properties).

A trial was conducted to determine whether there was any economic benefit from giving maiden heifers 1 injection of a vibriosis vaccine (Vibrovax^{TM}) just prior to joining. The vaccine instructions state that heifers that are older than 18 months of age only require 1 injection of the vaccine to gain immunity from vibriosis for 2 years. Since most heifers are joined for the first time at two years of age in the N.T, giving one injection of a vaccine is a practical treatment, whereas a vaccine that requires 2 injections several weeks apart is not practical due to the high mustering costs associated with large paddocks.

The experiment was repeated with two year groups of maiden heifers in 2004/5 and 2005/6 at Newry. Prior to joining, maiden Brahman heifers were weighed and pregnancy tested and every second non-pregnant heifer was given a vibriosis vaccination. The vaccinated group (VIB) and the control group (CON) all grazed together in the same paddock and bulls (mixed ages) were introduced to the heifers in late December and remained with them continuously from that point onwards. Several fences were washed down over the wet season and as a result other bulls gained access to the paddocks and not all heifers were re-mustered. The heifers were weighed and their stage of pregnancy determined at the first round muster (WR1) in April/May and then again at the second round muster (WR2) in September/October.

Conception rates were significantly higher (+11%) in the VIB group at the WR1 muster in both years (table 4.1.1-15). By the WR2 muster the advantage in conception rate of the VIB over the CON groups was reduced (6% in the first year and 9% in the second year), however the higher proportion of late conceptions in the CON groups is not desirable, as these heifers will calve and lactate in the dry season. This is likely to reduce their chances of re-conception and increase the likelihood that they and/or their calf will die. Their progeny are also likely to have lower weaning weights and may take an extra year to reach turn-off weight.

Table *4.1.1*-15. Average weight and fertility of maiden heifers in each treatment group.

Year	Treatment	Pre-joining avg. weight	WR1 % pregnant	WR1 avg. weight		WR2 % pregnant	
2004/5	VIB	238 kg	53[a]	323 kg	(N=252)	78 [a]	(n=276)
2004/5	CON	234 kg	42[b]	322 kg	(N=343)	72 [a]	(n=385)
2005/6	VIB	256 kg	70[a]	333 kg	(N=202)	84 [a]	(n=198)
2005/6	CON	254 kg	59[b]	332 kg	(N=222)	75 [b]	(n=232)

[a,b] Pregnancy rates with different superscript letters in each year are significantly different (P<0.01).

If an extra calf is valued at $300 then (using the most conservative figure) a 6% increase in conception rates from vaccination results in a return on investment in the order of 600%. However the actual benefit is much greater, as there are significant benefits from having an increased proportion of calves conceived early in the joining period.

It should be noted though that where re-conception rates are very low in first calf heifers and there is a long period between calving and re-conception that the benefits of vaccination may diminish over time (see next section).

The longer term effects of Vibrio vaccination

When the longer term effects of vibrio vaccination were studied it was found that the benefits that came from the vaccination (i.e. more conceptions early in the joining period) did not result in higher calf production in the longer term. When the number of calves that heifers had produced over the term of the study was calculated (eg. a heifer that had 2 calves and was 7 months pregnant in May '08 was said to have produced 2.7 calves) it was found that there was no difference in the average number of calves produced by heifers that had received a vibrio vaccination or those in the control group (table *4.1.1*-16).

Table *4.1.1*-16. Effect of single vibrio vaccination prior to maiden joining on the average number of calves produced by May 2008.

Treatment	Heifers 1st joined in Nov '04	Heifers 1st joined in Nov '05
VIB	1.97	1.34
CON	1.98	1.35

Normally it would be expected that more early conceptions would translate into higher re-conception rates, shorter inter calving intervals and greater long term calf production. However the reason that this did not occur in this study was that the condition of most first calf heifers was so low that nearly all heifers did not re-conceive while lactating but it took several months into the wet season (after their calves had been weaned) before their body condition picked up enough to re-conceive. As a result there was little advantage from calving early and the time taken to re-conceive was actually longer for heifers whose calves were weaned at the first round than for those whose calves were weaned at the 2nd round (see figure *4.1.1*-5) simply because they had more time between calving and the next wet season.

The benefits of vibrio vaccination in terms of more early conceptions would have been more likely to have to have translated into higher long term calf production if the condition of first calf heifers had been better and re-conception rates higher.

The other benefit of early conceptions is that calves are older and hence heavier at weaning. It is likely that the average weaning weight of calves from the Vibrio vaccinated heifers was higher than for the calves from the control heifers since they had a higher proportion of early conceptions. However we were not able to confirm this as the heifers were run in the same paddock and there was no way of telling whether weaners came from vaccinated or control heifers (calves were not mothered up).

Pestivirus (BVDV) testing

Pestivirus has been shown to have significant effects on herd reproductive rates and profitability (McGowan 2007) If a cow becomes infected with Pestivirus during early pregnancy they can either abort the pregnancy or produce persistently infected (PI) calves. PI's are usually always "poor doers" (don't grow well) and are constantly spreading the disease to other animals (McGowan 2007).

Blood samples were taken randomly from 30 heifers each year for Pestivirus testing. The results showed that 60% of 3 year old females and 83% of 4 year olds had previously had exposure to Pestivirus.

Controlled mating (restricted joining period)

Originally it was intended to study the effects of controlled mating (i.e. removing the bulls so that joining was for a restricted period). The bulls were put into the heifers in late November and then removed from the paddock intended to be control mated at the muster in the following April. It was hoped to determine whether the benefits of a condensed calving period (and hence no need for a second round weaning muster) and preventing out of season calving would offset the probable lower conception rate that would occur from restricting the joining period. However the paddock security was not good enough to allow this study to take place, as bulls always got back into the paddock that was supposed to be control mated.

It was possible to do a “desktop study” of control mating by comparing the data for heifers that calved during the period that they would have if they had been control mated to the data from all of the heifers.

One of the problems with this approach was that many heifers went missing over the course of the research and it was not possible to determine whether they had died or just wandered to different paddocks. As a result heifer mortality rates could not be determined. As a result the question of whether calving out of season increased heifer or calf mortality rates cannot be answered from this research.

Another problem with this study of controlled mating was that the body condition of all first calf heifers was so low that very few had re-conceived by weaning and nearly all required several months on green feed in the following wet season before re-conception occurred. As a result heifers that calved later in the year actually had a shorter time from calving to re-conception simply because they had less time to wait until the wet season. By the end of the wet season their re-conception rates were almost the same as for heifers which had calved earlier (see figure *4.1.1*-5). As a result there was very little measurable difference in total calf output between heifers calving at different times of year (resulting from early or late conception). Control mating would only have a chance of being more profitable than continuous mating in situations where re-conception rates are higher.

It should be noted that most extensive properties in the NT (especially in the northern parts) have the same problems keeping bulls out of heifer paddocks when trying to implement controlled mating (*pers. obs.* T Schatz). During the performance recording part of this project it was found that all properties (except the stud herd on the Barkly property) had maiden heifers that were already pregnant at the start of joining or heifers that were already lactating at the end of their first (intentional) joining.

Electronic data recording and NLIS (EID) tag loss rates

All data was recorded electronically in this research. The heifers were tagged with EID button ear tags (NLIS tags), and a full length ALEIS EID race reader was fitted to the crush to read the tags. The crush was mounted on top of weigh beams so that heifers could be weighed at the same time as they were being preg tested to enable quicker processing and so that data was only being recorded for one animal at a time. Both the EID reader and the scales were connected (by leads) to a TruTest XR3000 scale indicator and this was used to record weight, pregnancy test result, lactation status (wet or dry), condition score, and any comment that needed to be made.

The equipment worked very well and no problems were experienced with it over the course of the research. Data collection was fast enough that it did not slow down preg testing.

Prior to their maiden mating all heifers were tagged with NLIS button tags. The round Allflex tags were used in the first year group and the triangular or "house shaped" Leader tags were used in the second year group. There was no difference in tag loss rates between the two different brands of tags after 2.5 years.

The NLIS tag loss rates are shown in table *4.1.1*-17. In May 2009 the tags had been in the first year group of heifers for 4.5 years by which time the NLIS tags had fallen out of 14.6% of the heifers remaining in the study and had been replaced with a different NLIS tag. However most tags that had fallen out had been put in an incorrect place (this was evident from the position of the empty hole in the ear). Where tags had been put in the correct place very few fell out (correct placement is in the middle of the ear and between the 2 large cartilages). A large hole in the ear was observed in some animals whose tags that fell out. In these cases the holes seemed to be fairly high in the ear where the ear was thicker and it was speculated that the tag had been too tight. The constant tight contact with the ear in humid conditions may have caused a localised infection and the ear tissue to rot out.

Table *4.1.1*-17. Loss rates of NLIS button tags over time in research heifers at Newry.

Length of time that the EID tags had been in	% lost (cumulative)
1.5 years	0.6%
2.5 years	3.5%
3.5 years	10.9%
4.5 years	14.6%

Field days

Field days were run at Newry on 5/7/06 and 20/8/08 to communicate the findings of the study to the cattle producers in the region. It was intended that attendance at these field days would be restricted to people directly working in the NT and northern WA beef industry, and so invitations were not publicised to the wider public. The reason for this was that it was hoped that the field days would be very interactive with lots of discussion between the people attending and it was felt that public discussion amongst cattle producers is often inhibited at larger gatherings.

Both field days were very successful with about 40 people attending each day with nearly all working directly on properties in the region. There was a lot of interest in the results and they provoked plenty of discussion both during the day and at the BBQ's that followed.

4.1.2 Heifer demonstration site in the Alice Springs region – Tieyon.

4.1.2.1 Introduction

Tieyon station is located about 80 km east of Kulgera (around 370 km south east of Alice Springs). It has been owned by the Smith family since 1919 and is currently managed by Paul Smith. Tieyon is 6,562 km^2 in area and in good years runs about 8000 cattle but during poor years the numbers are reduced and by 2008 cattle numbers were down to about 3800.

Tieyon has a pure black Angus herd and mostly turns off steers to markets in South Australia. The herd is continuously mated (i.e. bulls always remain with the females) and traditionally two musters are performed each year at which calves are "branded" and weaning occurs. Most of the paddocks are quite large (some are over 1,000 km^2) with only a few water points where cattle can drink. Within large paddocks cattle tend to run in herds that graze an area within walking distance around a water point. Apart from shortly after a rainfall event there is almost no surface water on Tieyon and cattle either drink from troughs at bores or from dams. This allows trap yards to be used for much of the mustering.

The major land systems on Tieyon are the Moorilyanna, Breakaway, Tieyon and Pedrika land systems. All the research in this study was done on cattle that grazed in a paddock known as One Tree. There are only two land systems in One Tree paddock and these are the Moorilyanna and Breakaway land systems (appendix 9.3 for a map and descriptions of each land system).

Mulga (*Acacia aneura*) dominates the landscape on most of Tieyon, varying in density from sparse open woodland to quite dense scrub. It makes up a considerable part of the cattle's diet (especially during drought). Other species of trees on Tieyon include iron wood (*Acacia estrophiolata*), witchetty bush (*Acacia kempeana*), corkwood (*Hakea ednieana*), waterbush (*Grevillia nematophylla*) and beefwood (*Grevillia striata*). The main pasture species are Woollybutt (Eragrostis *eriopoda*), Oat grasses (*Enneapogon spp*.), Button grass (*Dactyloctenium radulans*), Kerosene grass (*Aristida contorta*), Nerverfail (*Eragrostis setifolia*), Buck Wanderrie (*Eriachne helmsii*), bottlewashers (*Enneapogon spp*.), curly windmill grass (*Enteropogon acicularis*), window mulga grass (*Thyridolepis mitchelliana*), bandicoot grass (*Monocather paradoxa*), Munyeroo (*Portulaca oleracea*) and Parakeelya (*Calandrinia spp*.). Stocking rates tend to be about one cow per km^2 in the southern Alice Springs region. The low stocking rates and large paddock sizes often result in uneven utilisation of paddocks with greater grazing pressure around watering points.

While the rainfall pattern in central Australia is not as seasonal as it is further north, most of the large falls of rain still tend to occur during the summer months. The total monthly rainfall exceeded 30 mm in 18 of the 168 months between January 1995 and December 2008, and 75% of the months in which this occurred were between October and April.

The long term average rainfall is 195 mm but drought conditions were experienced during most of the time that this research was being conducted. The average annual rainfall received over the 4 years since the research began in 2005 was 135 mm (while the average annual rainfall for the preceding 10 years was 270 mm). The annual and monthly rainfall over the trial period is shown in table *4.1.2*-1. The monthly rainfall between January 1995 and December 2008 is shown in figure *4.1.2*-1. From this graph it is evident how little rain fell during the period of the research at Tieyon compared to the preceding years.

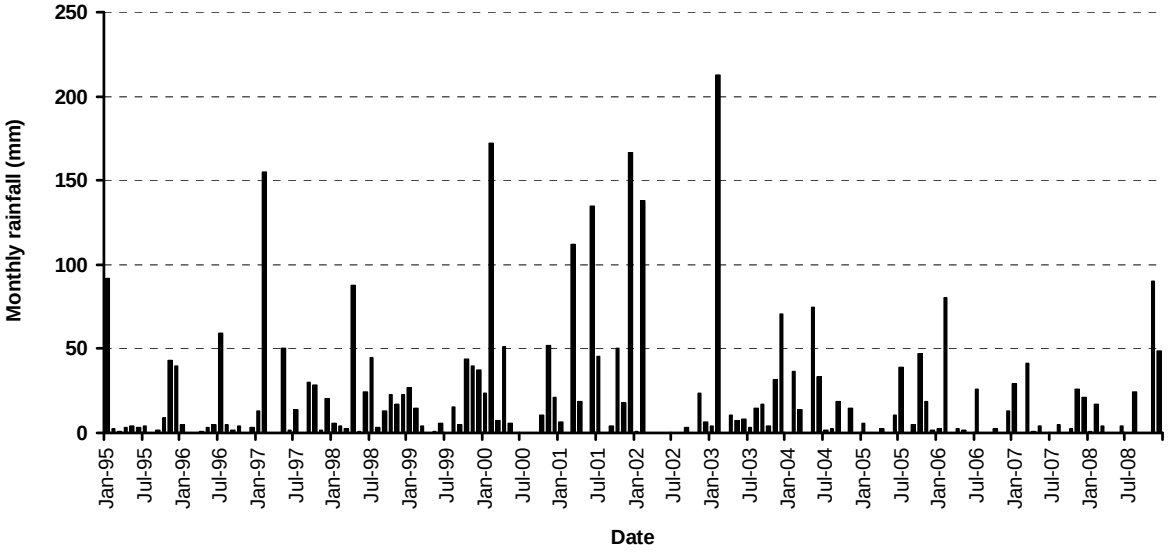

Figure *4.1.2*-1. The total monthly rainfall at Tieyon - 1995 to 2008.

The fact that the research continued through such an extended period of drought was due to the great commitment of the Smiths to the work and as a result this research has provided some very valuable information that is also very rare, since the breeding performance of cattle on a commercial station in Central Australia has not previously been recorded through such a period of extended drought.

There are only a few published reports of the performance of cattle recorded on commercial stations in central Australia but never through such a period of extended drought. Cattle performance was recorded at Mt Riddick from 1991 to 1996 during which time the annual rainfall was only below 300 mm in one year and performance recording was suspended in that year (Coventry 2007). Also CSIRO researchers studied the performance of cattle in Kunoth Paddock (Hamilton Downs) from 1970-1976 and the average annual rainfall during that period was 443 mm (Low 1978; Low and Wood 1979).

Sizable falls of rain fell at Tieyon during November and December 2008 and this resulted in good growing conditions and much higher growth rates and pregnancy rates that at any other time during the research. Unfortunately this has been the only sizeable rainfall event that occurred during the research period so far and so it is intended that the research at Tieyon be continued so that the performance during drought years can be contrasted with that in some better years.

Table *4.1.2*-1. Rainfall at Tieyon during the trial period.

Month	2005	2006	2007	2008	2009
Jan	5.4	2.4	29.2	0.8	0.8
Feb	0	42	0	17.4	0
Mar	0	0	41.6	4.4	2.2
Apr	2.8	2.6	0.6	0	5.0
May	0	1.6	4.2	0	16.0
Jun	10.4	0	0	3.8	
Jul	38.6	25.6	0	0	
Aug	0	0	5.2	24.4	
Sep	4.8	0	0	0	
Oct	47.2	2.6	2.4	0	
Nov	14.4	0	25.8	90.0	
Dec	6.0	13.0	21.2	48.6	
Annual total	129.6	89.8	130.2	189.4	

4.1.2.2 Methodology.

The One Tree paddock in which this research occurred is used as a heifer paddock and typically young heifers are added to it after they have been weaned and are later removed from it after their second calf has been weaned (although this depends on the seasonal conditions and the amount of feed in paddock). After the first two years of the research very few heifers from other paddocks were added to One Tree paddock as it was decided to study the performance of heifers for a longer period of time. The new heifers in the study came from heifer calves born in the paddock that were not weaned but left on their dams to allow a study on the effects of weaning (as male calves were weaned). One Tree paddock is 498 km^2 in area and typically about 500 heifers and their offspring grazed in the paddock during the course of the research. Higher stocking rates can be used in the paddock during better seasons but the research coincided with several years of below average rainfall and drought conditions existed through most of the study.

The research in One Tree paddock started in June 2005 when maiden and first calf heifers (heifers lactating with their first calf) that had been accumulated in the paddock were individually identified with NLIS tags (Electronic Identification Devices) and numbered ear tags, and their weight, condition score, pregnancy status and lactation status was recorded. These measurements were then recorded twice a year, usually in April and October). At the biannual musters any male calves that were big enough were weaned while heifer calves remained unweaned. This allowed the effects of weaning to be studied since approximately half the calves were weaned (males) and half were not (females). When young (unweaned) heifers reached around 200 kg they were tagged and added to the herd of females whose performance was being recorded. Some young heifers were also added to the herd from other paddocks. Over time older females were removed from the paddock to maintain stock numbers at a sustainable level.

This methodology allowed many aspects of heifer fertility to be studied including weight at first conception, conception rates in maiden and first calf heifers and second calf cows, calf loss rates, the effects of weaning and liveweight on the time taken to re-conceive, and length of inter-calving interval. Also an attempt was made to study the effects of vaccination against vibriosis and pestivirus (BVDV). It was intended at the start of the project to also study the effects of heifer segregation and a restricted first joining period (control mating) but the drought conditions experienced since then prevented the implementation these treatments.

The methodology of several smaller experiments (eg. the effect of vibriosis vaccination) is described where those experiments are covered within the results and discussion section.

4.1.2.3 Results and discussion.

Growth

The growth of heifers varied throughout the study period depending on the amount of rain received in each period (see figure *4.1.2*-2 and Table *4.1.2*-2). There was a large difference in growth between seasons with drought conditions and the season where good rainfall occurred. Average growth ranged from 0.047 kg/day (or 7.5 kg in 160 days) during winter 2008 to 0.731 kg/day (or 142.5 kg in 195 days) during summer 2008/09.

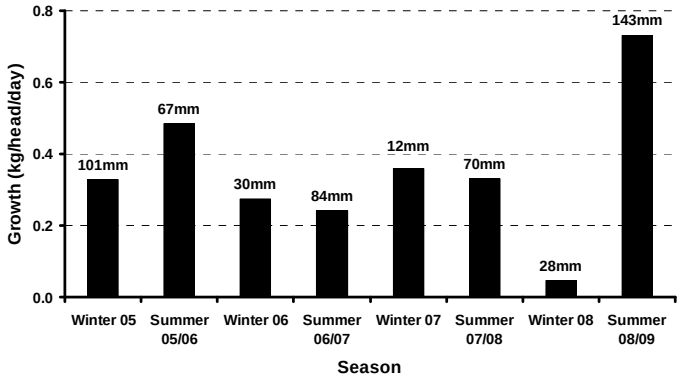

Figure *4.1.2*-2. Average growth of maiden heifers during each season (the rainfall received during each period is shown above the column on the graph). (Note that this is the growth of the heifers that were classified as maiden heifers during each time period and not of the same group of heifers over the years).

Obviously the growth rates that occur in a season are greatly influenced by the amount of rain received in that season, although there was some carry over effect in Winter 2007 and Summer 2005/06 from rain received late in the previous time periods.

Despite the extended drought conditions that were experienced in most seasons during this research, growth was surprisingly high during these periods except for in the winter of 2008 when the cumulative effects of the drought resulted in very low growth. The average annual weight gain in maiden heifers over 3 consecutive drought years (in the 2005/06, 2006/07 and 2007/08 financial years) was 117 kg. This is actually a fairly high annual weight gain in comparison to most areas in the NT during average years (however it must be kept in mind that stocking rates in the Alice Springs district are very low in comparison). During most of this time mulga was a considerable part of the diet of the cattle, and by April 2008 most of the grass had been eaten and a distinct browse line was visible in the mulga trees (see Photo 1).

Photo 1. Tieyon during drought in October 2008. **Photo 2**. Tieyon in August 2009.

In 2008 about 140mm of rain fell in late November and early December and this resulted in very high growth rates over the Summer 08/09 period despite only 8 mm of rain being received from mid December 2008 until late April 2009. In fact during this period 9 (out of 79) maiden heifers grew at more than 1 kg/day and one of them put on 238 kg in 195 days (a growth rate of 1.22 kg/day).

Even if the data from summer 2008/09 is excluded (as it followed a rainfall event unlike any other during the period of the research) growth tended to be higher in the summer months (average = 0.35 kg/day) than the winter months (0.25 kg/day). This is likely to be because pasture growth (after any rain that did fall) is depressed by cold temperatures and short day length during the winter months.

The growth rates of dry (non-lactating heifers) between musters are shown in Table *4.1.2*-2 and Figure *4.1.2*-3. After each season (the time period between two musters), heifers that were not lactating during that period were classified as either;

- "Small heifers" if they weighed less than 250 kg at the end of that period.
- "Maiden heifers" if they weighed greater than 250 kg at the end of that period and had not previously had a calf.
- "Dry after 1st calf weaned" if they had a calf weaned at a muster and then were dry over the following period between musters.

Figure *4.1.2*-3 shows that there was not much difference in growth between these different classes of heifers although the small heifers tended to grow less. Again rainfall greatly influenced the growth rates of all classes of heifers.

Table *4.1.2*-2. Average growth rates (kg/head/day) between musters for different classes of heifers.

	Winter 2005 (101 mm)	**Summer 2005/06** (67 mm)	**Winter 2006** (30 mm)	**Summer 2006/07** (84 mm)	**Winter 2007** (12 mm)	**Summer 2007/08** (70 mm)	**Winter 2008** (28 mm)	**Summer 2008/09** (143 mm)
Small heifers (<250 kg)		0.426	0.229	0.219	0.260	0.205	0.042	
Maiden heifers	0.328	0.484	0.274	0.241	0.359	0.330	0.047	0.731
Dry after 1st calf weaned	0.379	0.490	0.391	0.200	0.393	0.276	0.063	0.801

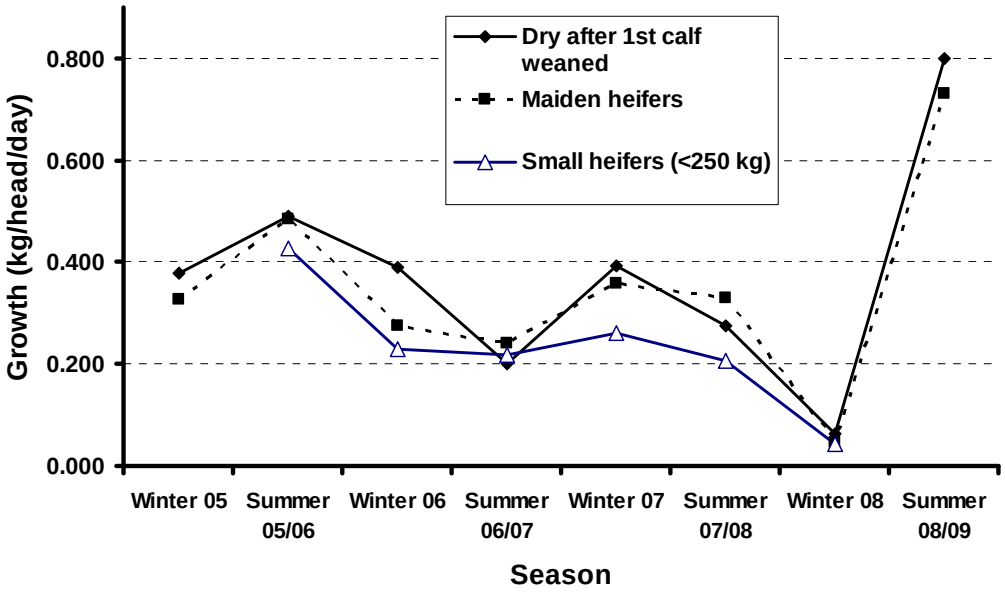

Figure *4.1.2*-3. The growth of three classes of non-lactating heifers in different seasons.

Apart from the rainfall one of the biggest factors influencing the growth of heifers is their lactation status. Figure *4.1.2*-4 shows the growth in each season of heifers that either;

- Had a calf weaned at the start of the season and then were dry through that season (i.e. were wet at the 1st muster and dry at the 2nd muster).
- Were dry for the second season in a row (i.e. were dry at the 1st muster and also dry at the 2nd muster).
- Already had a calf at the start of the season but it was not weaned and so they were wet for the second season in a row (i.e. were wet at the 1st muster and also wet at the 2nd muster).
- Calved during the season (i.e. were dry at the 1st muster and wet at the 2nd muster).

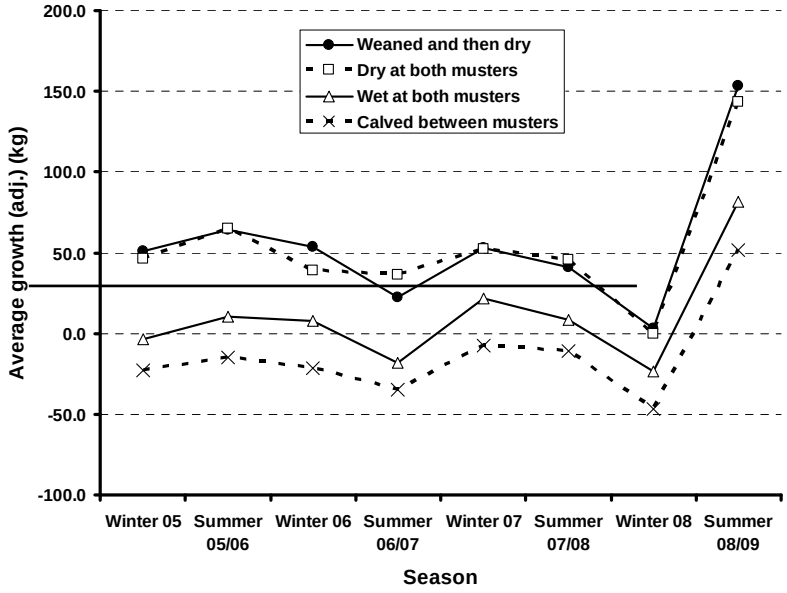

Figure *4.1.2*-4. The effect of lactation status on the growth (adjusted for stage of pregnancy) of heifers in different seasons.

Figure *4.1.2*-4 and Table *4.1.2*-3 show that dry heifers (not lactating) grow much more than wet (lactating) heifers. Heifers that were wet long term (i.e. were already wet at the start of a season and their calves were not weaned) tended to just maintain weight (either gain or lose a small

amount of weight depending on the season) apart from in summer 08/09 when good rainfall resulted in them growing 82 kg. Heifers that calved and then lactated through a season lost the most weight (or gained the least in the case of summer 2008/09).

Table *4.1.2*-3. Weight change in heifers of different lactation status over the seasons.

	Winter 2005	Summer 2005/06	Winter 2006	Summer 2006/07	Winter 2007	Summer 2007/08	Winter 2008	Summer 2008/09
Weaned and then dry (WD)	50.8	64.4	53.7	22.3	52.8	40.9	3.2	153.6
Dry at both musters (DD)	46.1	64.8	39.1	36.4	52.3	45.6	-0.4	143.7
Wet at both musters (WW)	-3.6	10.7	7.8	-18.1	21.8	8.2	-23.8	81.8
Calved between musters (DW)	-22.8	-14.8	-21.3	-35.1	-7.2	-10.8	-47.0	51.8

Even within classes of heifers growth can be extremely variable. Figure *4.1.2*-5 shows the variation in growth within maiden heifers during the summer period in 2005/06. While the average growth during this time was 72 kg (or 0.48 kg/day), some heifers gained less than 25 kg and some gained more than 125 kg.

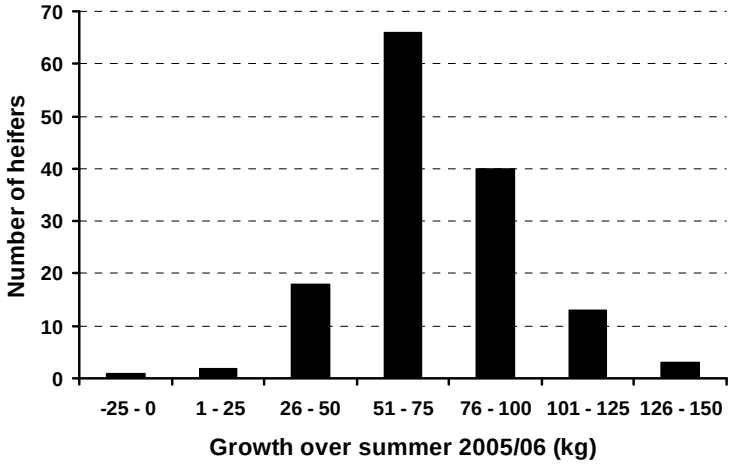

Figure *4.1.2*-5. The variation in growth of maiden heifers over the 2005/06 summer period.

This variation in growth means that within each year's calf crop that some young heifers will grow to reach puberty much more quickly than others, and so in each year the heifers getting pregnant for the first time may come from the calf crops from 3 different years i.e. most will come from one year group but some from the previous year group that grew slowly and some from the following year group that grew fast will also get pregnant. For example 65% of heifers that conceived for the first time in summer 2005/06 were born in 2004 while 25% had been born in 2003 and 10% in 2005 (Tieyon uses a tagging system where each year calves are given a different coloured tag to show which year they were born in). Due to this variation in growth (and the fact that the late born calves from one year and the early born calves from the next year are similar in age [with continuous mating]) the heifers were classified into groups according to when they first conceived and calved rather than by the colour of their ear tag.

When the longer term performance of heifers that conceived around the same time but were from different year groups (different coloured ear tags) is examined it was found that the heifers from

the older year groups tended to have shorter inter-calving intervals and so, on average produced more calves over time. Table 4.1.2-4 shows the performance of heifers that were from three different year groups and classified as maidens (not previously pregnant and heavier than 250 kg) at the first round musters in 2006 and 2007. The average number of calves produced by April 2009 tended to be higher in the heifers from the older year groups.

Table *4.1.2*-4. Performance of heifers born in different years.

Classified as maiden	Year born	N	No. of calves produced by R109
WR1 2006	2003	40	1.93
	2004	74	1.86
	2005	13	1.51
WR1 2007	2004	60	1.36
	2005	100	1.30
	2006	7	1.25

Effect of weight on fertility

Research has shown that liveweight/body condition is the major factor influencing the fertility of heifers (providing that there are no major problems with disease). Fertility increases as weight increases. Figure *4.1.2*-6 shows the percentage of maiden heifers in each weight range that were pregnant at the start of the research at Tieyon on 7/5/06 and shows that conception rate increased with weight.

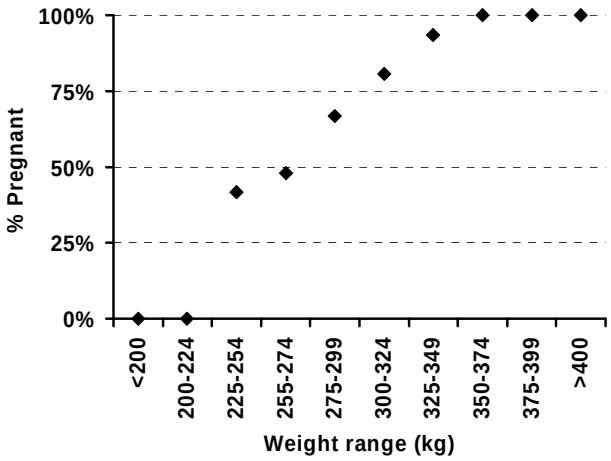

Figure *4.1.2*-6. The effect of weight on maiden heifer fertility.

Figure *4.1.2*-7 shows the re-conception rates in lactating first calf heifers recorded on 12 different commercial properties spread right across the NT between 2003 and 2008. It shows that conception rates in first calf heifers are strongly affected by the weight of the heifers at the time when their calves are weaned. Each data point represents the average weight of a group of lactating first calf heifers and their re-conception rate. The relationship was produced from data from heifers of tropically adapted genotypes ranging from pure Brahmans to tropical composites. Data from the performance recording at Tieyon has been added to this graph and these data points represented by triangles for the first round musters at Tieyon in 2005 and 2006 and the square data point shows the most recent recording in April 2009, where the good rain that fell in Nov/Dec 2008 resulted in first calf heifers being heavier and hence having higher re-conception rates in April 2009.

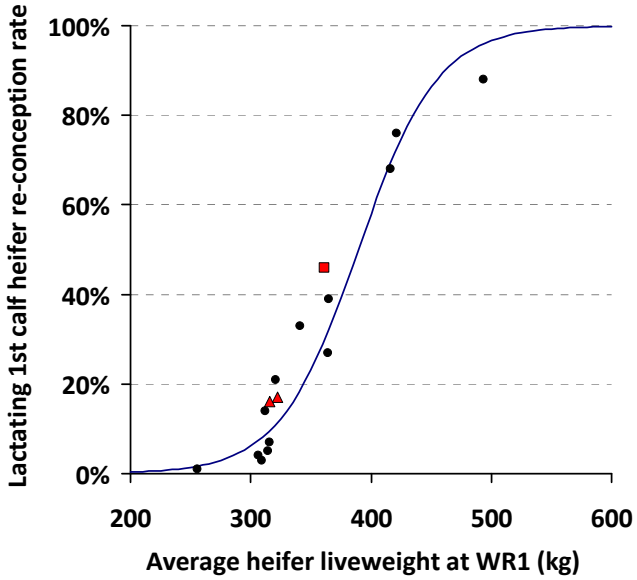

Figure *4.1.2*-7. The effect of the weight of first calf heifers at the time when their calves are weaned on their re-conception rate.

Estimated weight at 1st conception

Heifers cannot reproduce until they reach puberty and the age at which heifers reach puberty has a large effect on their lifetime calf output. There are a number of factors that influence the age at which heifers reach puberty including weight, breed and other genetic factors, nutritional factors / growth rate, disease, frame size and photoperiod however it is generally accepted that weight has the greatest effect (Entwistle 1983).

The estimated weight of heifers when they first conceived was calculated using their preg-test result and their growth rate over the period before they conceived. The formula used was:

Weight at conception = Weight at preg test – (Number of days pregnant x Growth rate [kg/day])

The average estimated weight at first conception varied between seasons over the course of the research (Figure *4.1.2*-8). Generally more heifers conceived in the summer months and the average weight at first conception was lighter in the summer months than the winter months. This is because photoperiod (day length) affects the onset of puberty with more heifers reaching puberty when day length is longer (Schillio *et al.* 1992) (i.e. It seems to be harder for heifers to reach puberty during the winter months). The exception to this pattern was in heifers that reached puberty for the first time in Summer 08/09. Their average weight at first conception was higher than expected and this is likely to be due to the fact that growth rates during the preceding period (winter ‘08) were very low (which delays the onset of puberty) and then following the rainfall in November and December ’08 they grew very rapidly.

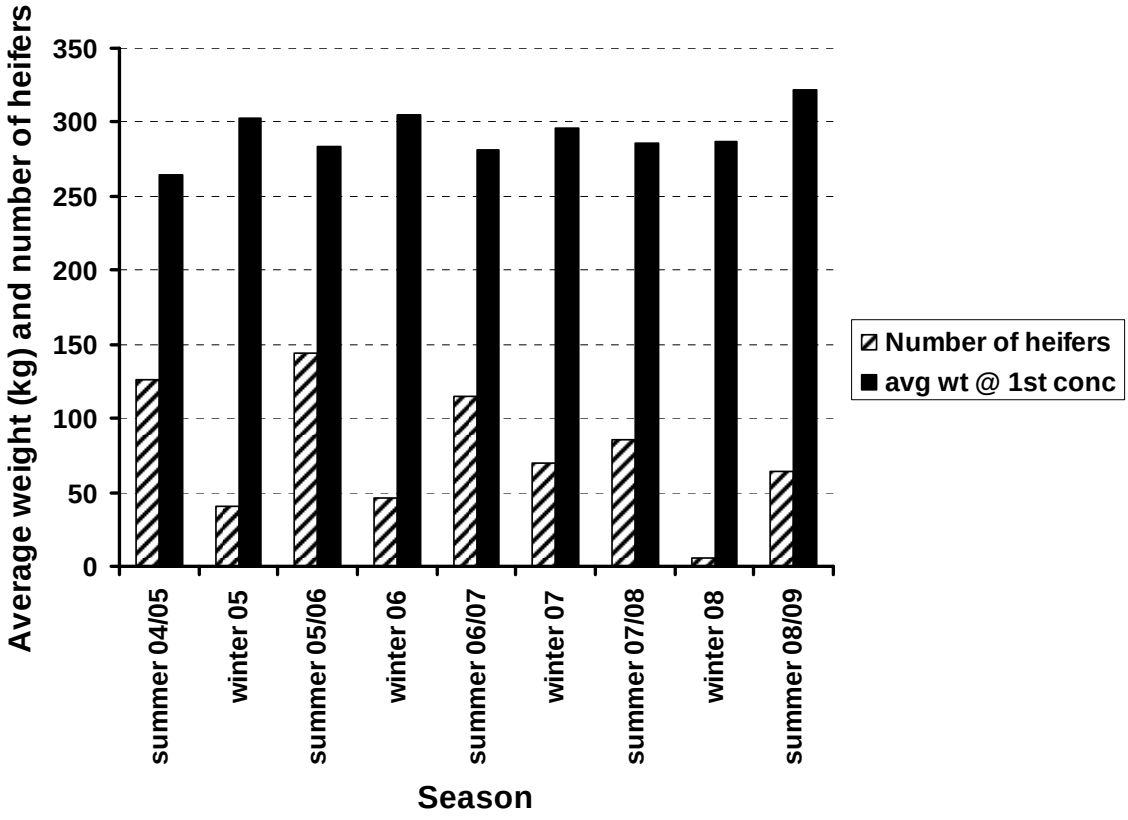

Figure *4.1.2*-8. The average weight at first conception and the number of heifers conceiving for the first time in each season.

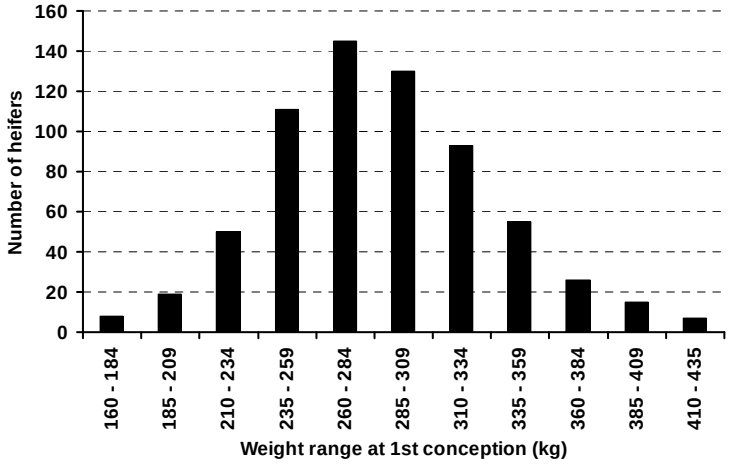

Figure *4.1.2*-9. Range of estimated weights at first conception (all heifers over the duration of the study n = 697).

While there was a large range of weights at which heifers first conceived (see Figure *4.1.2*-9), overall the average estimated weight at first conception was 284 kg. While other studies have found similar variation in the weights at which heifers conceive for the first time, the average weight at first conception (284 kg) is higher than what some other studies have found for Angus heifers. A study in south-east WA found that the average weight at conception in Angus heifers was 255 kg (Sawyer *et al.* 1991) while an American study found that the average weight was 274 kg (Laster *et al.* 1972). While the results from this study are not that much higher than the Laster *et al.* (1972) figure (especially since the 5% of heifers that did not reach puberty by 15 months of

age were excluded from their calculation of age at puberty), there are a number of explanations for the why weight at first conception at Tieyon was considerably higher than the Sawyer *et al.* (1991) figure;

- Conditions in southern Australia are much more favourable for growth of Angus cattle. Higher growth rates mean that heifers tend to reach puberty at younger ages.
- The Angus heifers at Tieyon are likely to be genetically different to the commonly used Angus genotypes in southern Australia as the traits that are targeted when bulls are purchased for Tieyon are quite different to what most producers desire in southern Australia. While producers in southern Australia target productive traits almost exclusively, at Tieyon some of these have been sacrificed to breed cattle that are better adapted to surviving in a harsh environment.
- Disease may be having an impact. The fact that the distribution of weights at which heifers first conceived seems skewed towards the heavier weight ranges (figure *4.1.2*-9) would indicate that there is something causing a delay in first conception. This is commonly seen where vibriosis is a problem, and vibriosis has been detected in the herd. Also high levels of Pestivirus (BVDV) were found in the herd and BVDV causes early abortions which then result in delays in the first pregnancy that is sustained through to calving. It is likely that the heifers that were very heavy (eg. >400 kg) when found to be pregnant for the first time may have conceived previously and aborted that calf before the next pregnancy was discovered by preg testing.
- There could also have been some error in the calculation of the estimated weights at first conception as these were calculated using preg test results (and it is difficult to accurately determine the stage of pregnancy during the latter stages of pregnancy, and growth rates which were calculated over 6 month intervals (between biannual musters). The growth rates may have been different leading up to the time of first conception than during the whole 6 month period between musters. Also where there was not sufficient data to calculate an individual's growth rate during a period, the average growth rate during that period was used to calculate estimated weight at first conception and this may or may not have been accurate for each individual animal.

Fertility in maiden heifers

Initially it was planned to compare the fertility of heifers that were kept segregated from bulls until their first joining to those continually exposed to bulls, but due to the drought conditions the money intended for the fencing to allow this to happen could not be used for this purpose. As a result young heifers were always exposed to bulls in One Tree paddock and it is assumed that they were mated once they reached puberty and started cycling.

Since bulls were present with the heifers from the time that they were born it is somewhat difficult to assess when they should be considered maiden heifers. For the purposes of this study young heifers were classed as "maidens" if they weighed more than 250 kg at a muster and had not previously had a calf. This is because heifers which weighed less than 250 kg at a muster would have been unlikely to have conceived during the previous season as they are likely to have been too light during that period, although this was not always the case and some heifers conceived for the first time at estimated weights of between 160 – 170 kg (see figure *4.1.2*-9).

The figure of 250 kg was used to classify maiden heifers as it was identified as the average weight at first conception in Angus heifers by an Australian study (Sawyer *et al.* 1991). However this study was conducted in southern Western Australia where conditions are much more favourable for growth of Angus cattle and so growth rates would have been higher (which usually results in lower weights at puberty). Other studies have found that puberty in Angus heifers occurred at heavier weights eg. 268 kg (Morris and Wilson 2000) and 310 kg (Jones *et al.* 1991), and so the question of how heifers should be classified as maidens is not easily answered in continuously mated situations.

If maiden heifers are considered to be heifers that had not previously had a calf and weighed more than 250 kg then the pregnancy rate in maiden heifers (at first round musters) over all was 67%. However if heifers are considered to be maidens if they weighed more than 300 kg at a first round muster then the average pregnancy rate was 83% (see table *4.1.2*-5).

The percentage of maiden heifers (using the >250 kg definition) that were pregnant at each muster and their average weights at that muster are shown in table *4.1.2*-5. The pregnancy rate in maiden heifers was higher after the summer months than the winter months (see Table *4.1.2*-5 and Figure *4.1.2*-10). This is likely to be due to the fact that growth rates were lower during the winter months (see figure *4.1.2*-2). In addition, perhaps heifer fertility is affected by photoperiod with short day length (in winter) depressing fertility.

Table *4.1.2*-5. The pregnancy rate in maiden heifers at each muster.

	Heifers weighing > 250 kg			Heifers weighing > 300 kg	
	Number	Pregnant	Avg Weight (kg)	Number	Pregnant
Jun '05	152	**77%**	315	132	87%
Nov '05	115	**37%**	308	65	66%
Apr '06	189	**64%**	320	142	84%
Oct '06	170	**48%**	308	112	74%
Apr '07	167	**56%**	296	114	81%
Oct '07	203	**54%**	310	134	81%
Apr '08	148	**66%**	315	112	87%
Oct '08	85	**41%**	286	45	78%
Apr '09	90	**76%**	394	87	78%
Average -All Summers		**67%**	328		**83%**
Average -All Winters		**45%**	303		**75%**

The pregnancy rates found in this study are likely to be lower that what would be found in years when normal to good rainfall is received. The extended drought meant that growth rates were reduced and body weight is the major factor affecting maiden heifer pregnancy rates. Pregnancy rates in maiden heifers (>250kg) were around 77% at the first round musters in seasons where good/average rainfall was received (summer 04/05 and summer 08/09). In the drought years, pregnancy rates at first round musters averaged 62%. Pregnancy rates averaged 45% at the second round musters (after the winter months).

Figure *4.1.2*-10 shows that pregnancy rate increased with the average weight of the group of maiden heifers. The pregnancy rates after summer 08/09 are lower than expected for the weight of the heifers and this is likely to be due to the very low growth rates experienced over the preceding 2008 winter months. The average growth of maiden heifers during this period was only 0.05 kg/head/day (or 7.5 kg in 160 days) and even though heifers grew rapidly (0.73 kg/head/day) after the rainfall event in late Nov/early Dec, there would likely be some carryover effect from the growth setback that the heifers experienced earlier in life.

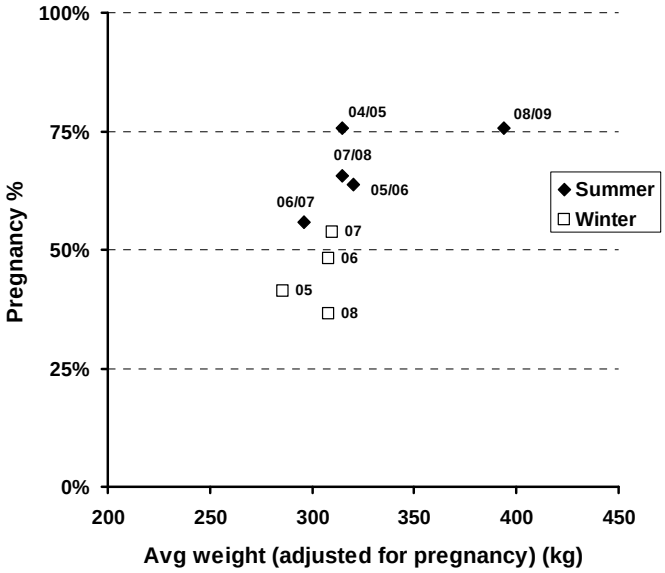

Figure *4.1.2*-10. The effect of average weight and season on pregnancy rates in maiden heifers.

Calf loss

The calf loss rates in first calf heifers recorded in One Tree paddock over the course of the research are shown in table *4.1.2*-6. Calf loss ranged from 5% to 16% but the average over time was 12%. This is actually quite low for calf loss in first calf heifers as recent performance recording on NT commercial cattle stations found an average calf loss of 22% in first calf heifers (Schatz and Hearnden 2008).

Table *4.1.2*-6. Calf loss rates in first calf heifers in each season in One Tree paddock

	Number of heifers due to calve	Calf loss rate
winter 2005	85	5%
summer 2005/06	55	7%
winter 2006	65	14%
summer 2006/07	88	16%
winter 2007	57	16%
summer 2007/08	91	14%
winter 2008	68	9%
summer 2008/09	44	11%
Total	553	12%

Calf loss is higher in heifers having their first calf than in older breeders that have experienced raising a calf. There was sufficient information to determine the calving outcomes of 206 heifers that were due to have their 2nd calf and of these 8.7% lost their calf. It should be noted that 10% is considered a normal rate of calf loss in breeders in extensive situations. Also it is likely that the extended drought conditions experienced at Tieyon during the course of the research would have had detrimental effect on calf survival, and that calf loss rates are likely to be even lower in a run of good/average seasons.

First calf heifer fertility

Table *4.1.2*-7 shows the percentage of lactating first calf heifers that were pregnant at each muster and their average weight. Note that some heifers were lactating at several musters and so are included in the figures for more than one muster. This is because some took more than 18 months to re-conceive, especially where their calf was not weaned.

Table *4.1.2*-7. Conception rates and average weights of lactating first calf heifers.

	% Pregnant	Avg Weight (kg)	Avg Weight (adjusted for preg.) (kg)	Number of heifers
Jun '05	15%	322	321	110
Nov '05	6%	306	305	147
Apr '06	17%	316	316	148
Oct '06	11%	321	320	96
Apr '07	16%	293	293	151
Oct '07	11%	307	306	123
Apr '08	22%	320	319	137
Oct '08	5%	300	299	135
Apr '09	46%	361	359	114

As with conception rates in maiden heifers, re-conception rates in first calf heifers were higher at the musters after the summer months. The average of the re-conception rates after the summer months was 23% if the April 2009 figure is included and 18% if it is excluded and only the drought years are included, while it was only 8% after the winter months (i.e. at October musters). This is likely to be due to the fact that growth rates were lower during the winter months (see figure *4.1.2*-10) and that heifer fertility is affected by photoperiod with short day length (in winter) depressing fertility (Schillio *et al.* 1992).

Figure *4.1.2*-11 shows that pregnancy rate in lactating first calf heifers at each muster increased with weight. This is consistent with many research findings elsewhere (eg. see figure *4.1.2*-7) that have shown that the major factor affecting re-conception rates and post partum anoestrous interval (PPAI) in lactating first calf heifers is their weight (or body condition) during the time between calving and when their calves are weaned. Over all of the musters, on average the wet heifers that had re-conceived were 31 kg heavier than those that had not re-conceived (341 vs. 310 kg).

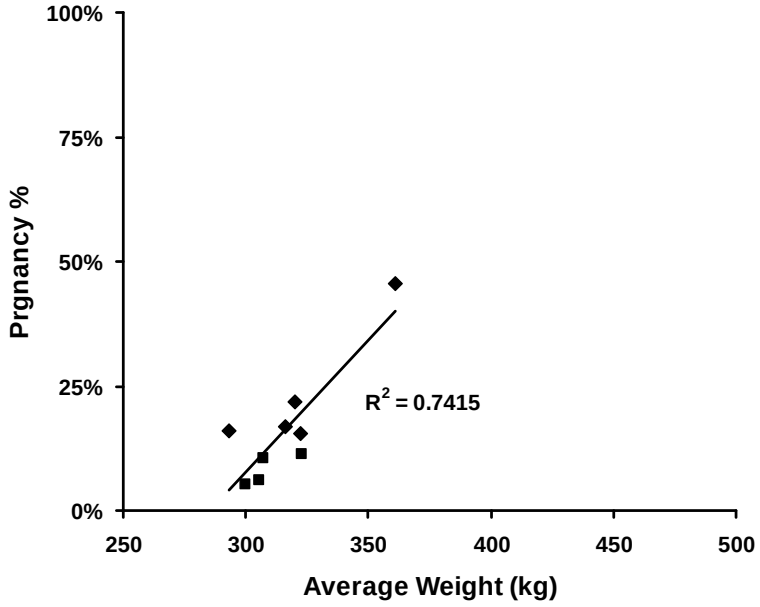

Figure *4.1.2*-11. The effect of average weight at a muster on pregnancy rates in lactating first calf heifers at that muster.

The low re-conception rates in first calf heifers found in most seasons during this research are due to the low weights of the heifers as a result of the drought. The good conditions experienced during summer 2008/09 resulted in a higher re-conception rate (46%), and it would be likely that re-conception rates would be even higher following several good seasons in a row.

The time taken for heifers to re-conceive after calving for the first time varied greatly (see figure *4.1.2*-12). Some heifers re-conceived in less than 3 months while others took longer than 18 months. Weaning had a large effect on the time taken to re-conceive (this will be dealt with in the next section) and the fact that female calves were not weaned meant that many of their dams had extended post partum anoestrus periods. The average time taken to re-conceive for heifers whose calves were weaned before 9 months of age (or that re-conceived while lactating before weaning could occur in this time) was 7.8 months.

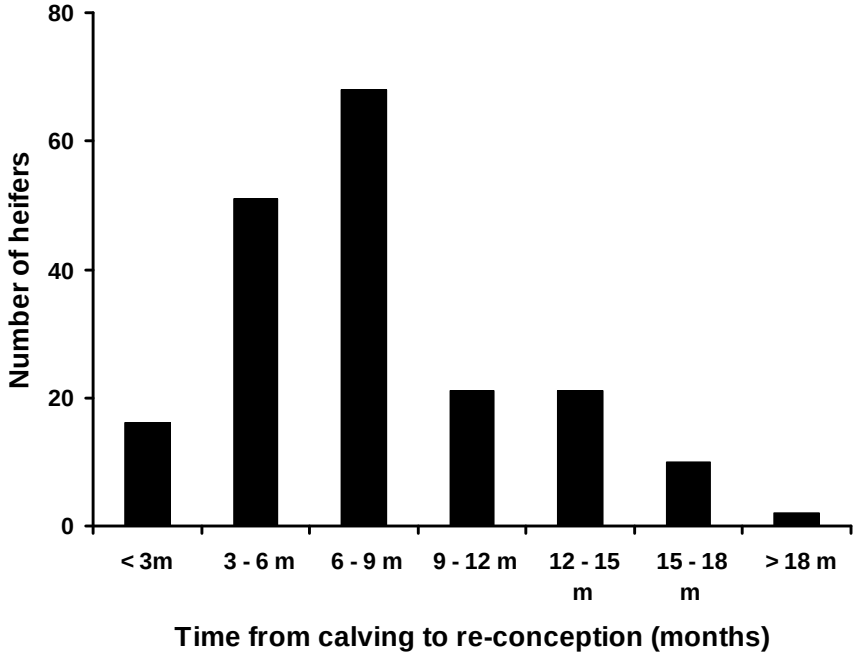

Figure *4.1.2*-12. Variation in the time from calving to re-conception in heifers whose calves were weaned by 9 months of age. (Note – this includes heifers whose calves were weaned younger than 9 months of age and heifers that reconceived while lactating before their calves could be weaned at 9 months of age).

For a cow to have a calf every year it must re-conceive within 3 months of calving. As figure *4.1.2*-12 shows, only a small proportion of first calf heifers (8%) in this study re-conceived within 3 months after calving.

At each muster some of the wet heifers would have calved recently and others quite some time ago. Figure *4.1.2*-13 shows the re-conception rates in wet heifers that;

- had only been lactating for a short while. DD: i.e. they were dry at the previous muster and wet at the current one (had calved between musters)
- had been wet for a longer time. WW: i.e. they were wet at both the previous muster and the current one.

Obviously since most heifers took more than 6 months to re-conceive, re-conception rates were higher in heifers that had been lactating for longer.

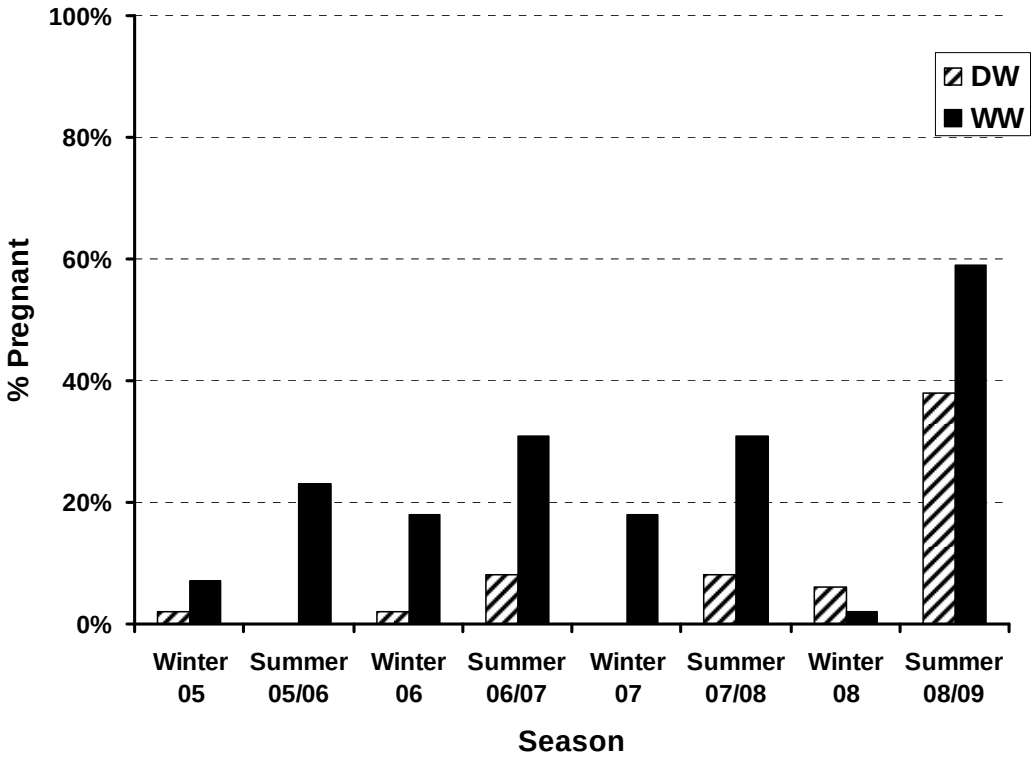

Figure *4.1.2*-13. Re-conception rates in first calf heifers that had been lactating for a short (DW) or long (WW) period of time. (DW = heifers were dry at the previous muster but wet at the current one. WW = Heifers were wet at both the current and the previous muster).

The effect of weaning on re-conception rates

Lactation has a negative effect on the resumption of cycling after calving through two main actions;

(i) directly by the hormonal negative feedback signals that suckling has on the resumption of cycling, and

(ii) also indirectly through reducing the body condition of the heifer. When nutrition is not adequate to supply all the energy requirements for lactation, body reserves are mobilised for this purpose and as a result heifers can loose weight rapidly which also inhibits the resumption of cycling.

Removing the effects of lactation through weaning has been found by many studies to reduce the time taken for heifers and cows to re-conceive after calving. It should be noted that for a cow to have a calf every year that she needs to re-conceive within 3 months of calving i.e. before weaning, but typically the majority of females in northern Australia do not do this.

During the research in One Tree paddock, male calves were weaned when they were considered to be big enough but female calves were not. This allowed the effects of weaning to be studied within the herd. Since the herd was continuously mated and calving occurred all year round, calves were weaned at a range of ages. Some which were considered to be just big enough were weaned quite young especially during the drought conditions, while others that were considered to be just too small to wean at one muster were quite old when they were weaned at the next muster. For the purposes of data analysis a calf was only considered to have been

weaned if it was weaned by about 9 months of age. Age at weaning was calculated from the estimated date of calving (using preg-test results) and weaning dates.

In One Tree paddock weaning was found to reduce the time taken for heifers to re-conceive. Figure *4.1.2*-14 summarises data for heifers that were lactating for the first time and had not re-conceived by April 2007 (i.e. were empty and wet in April 2007). Some male calves were weaned in April '07 and some later in October '07 while the female calves were not weaned. Figure *4.1.2*-14 shows that the weight of heifers increased in the period after their calves had been weaned. Their conception rates also increased following weaning so that by April 2008; 100% (N=17) of heifers whose calves were weaned in April had re-conceived, 83% (N=30) of heifers weaned in November had re-conceived, while only 50% (N=22) of heifers whose calves were not weaned had re-conceived (note 30 heifers that were EW in Apr '07 subsequently went missing).

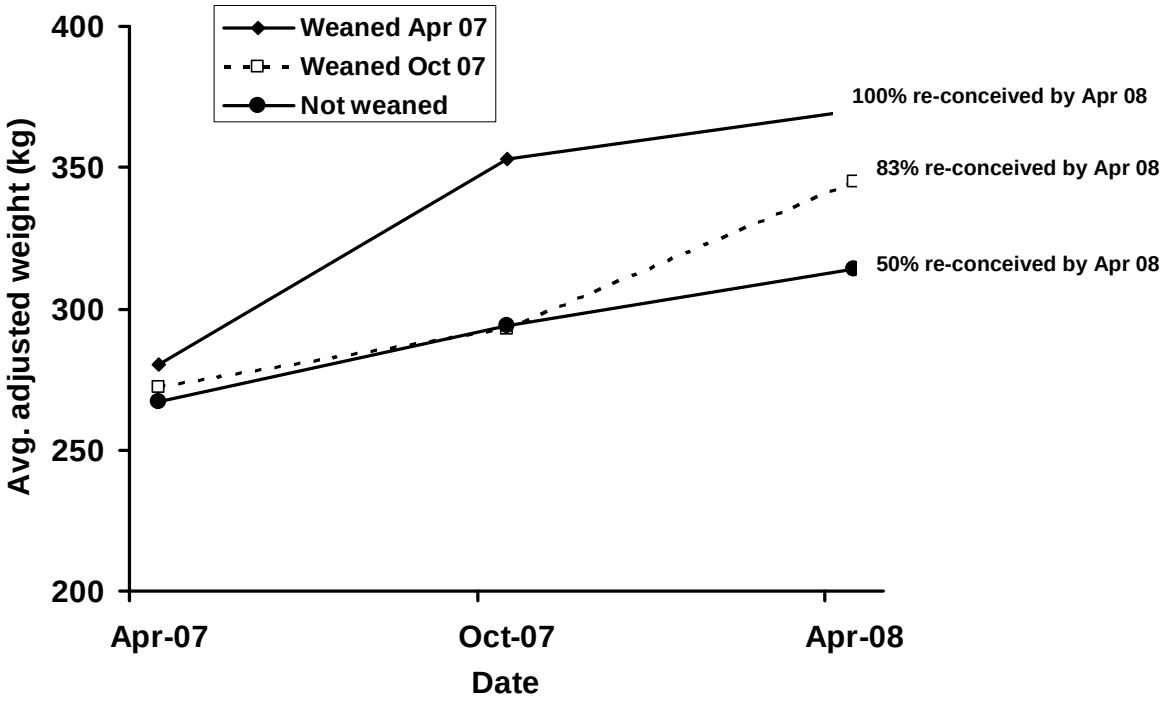

Figure *4.1.2*-14. The effect of weaning on heifer weight and re-conception rates in first calf heifers that calved prior to April 2005.

Statistical Analysis: The proportion of heifers that had re-conceived by April 2008 in the three groups ("weaned in Apr 07", "weaned in Oct 07", and "not weaned") was compared using binomial proportion tests. There was a significant difference between all three groups (χ 2 = 14.7, df =2, P = 0.0006), Both the weaned groups had a significantly higher proportion of re-conceptions than the non-weaned group (χ 2 = 5.14, df = 1, P = 0.0233 for the "weaned in Oct 07" group).

It is not surprising that the percentage of heifers that had re-conceived by April 2008 was higher in heifers whose calves had been weaned in April 2007 than those whose calves were weaned in October 2007. These heifers would have calved earlier for their calves to have been big enough to wean in April and so they had a longer time after calving in which to re-conceive. However there was still a 33% higher re-conception rate in heifers whose calves were weaned in October 2007 than in heifers whose calves were not weaned (some of whom would have calved at the same time as heifers whose calves were weaned in April and some at the same time as those weaned in October).

Figure *4.1.2*-15 summarises the data from all the first calf heifers over the duration of the research for which complete records exist (N = 335). It shows that weaning increased conception rates in first calf heifers at whatever age their calves were weaned, and that the earlier calves were weaned, the higher the conception rates were in their dams.

The proportion of heifers that had re-conceived by 9-12 months after calving were;

- 90%[a] of heifers whose calves were weaned between 3 – 6 months of age.
- 79%[a] of heifers whose calves were weaned between 6 – 9 months of age.
- 63%[b] of heifers whose calves were weaned between 9 – 12 months of age.
- 58%[b] of heifers whose calves were not weaned.

**Means with different letter superscripts are statistically different (see statistical analysis section below).*

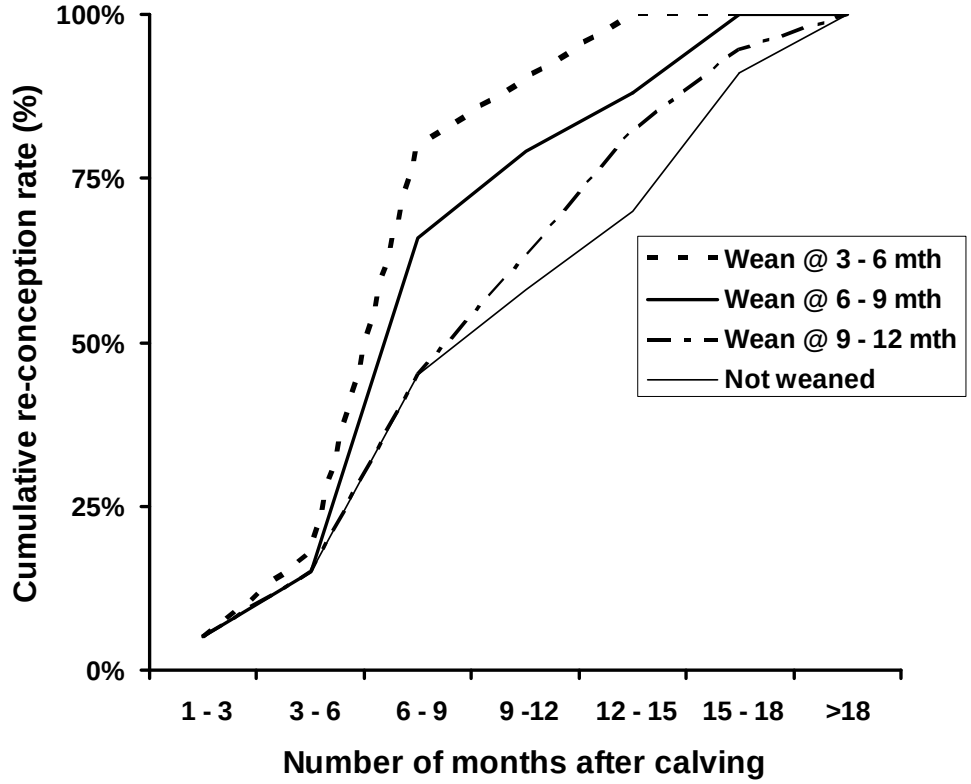

Figure *4.1.2*-15. The effect of weaning at different times after calving on the proportion of first half heifers that had re-conceived at different times after calving. Data from all first calf heifers that re-conceived over the duration of the study (N= 335).

Statistical Analysis: The proportion of heifers that had re-conceived by 9-12 months after calving in the four groups ("wean @ 3-6 mth", "wean @ 6-9 mth", "wean @ 9-12 mth", and "not weaned") were compared using binomial proportion tests. There was a significant difference between all the groups (χ 2 = 36.9, df = 3, P < 0.0001), and the groups that were significantly different from each other are shown in the list above where re-conception rates which don't have the same letter superscript are significantly different.

From this it is evident that weaning markedly increases re-conception rates in heifers and reduces the inter-calving interval in many instances. As a result it is a very effective management practice in increasing heifer fertility and hence the profitability of cattle stations in central Australia.

Furthermore about 4% whose calves were not weaned did not re-conceive again for 2 years after they had calved which shows that even in *Bos taurus* heifers PPAI can be extended for long periods of time when calves are not weaned.

Re-conception in second calf heifers

In cattle re-conception rates are usually lowest in heifers during their first lactation and are higher at subsequent lactations (Entwistle 1983). In this study re-conception rates were higher in 2nd calf cows than in 1st calf heifers at any point in time after calving (see figure *4.1.2*-16). Figure *4.1.2*-16 also shows that as with first calvers, weaning increased conception rates in 2nd calf cows.

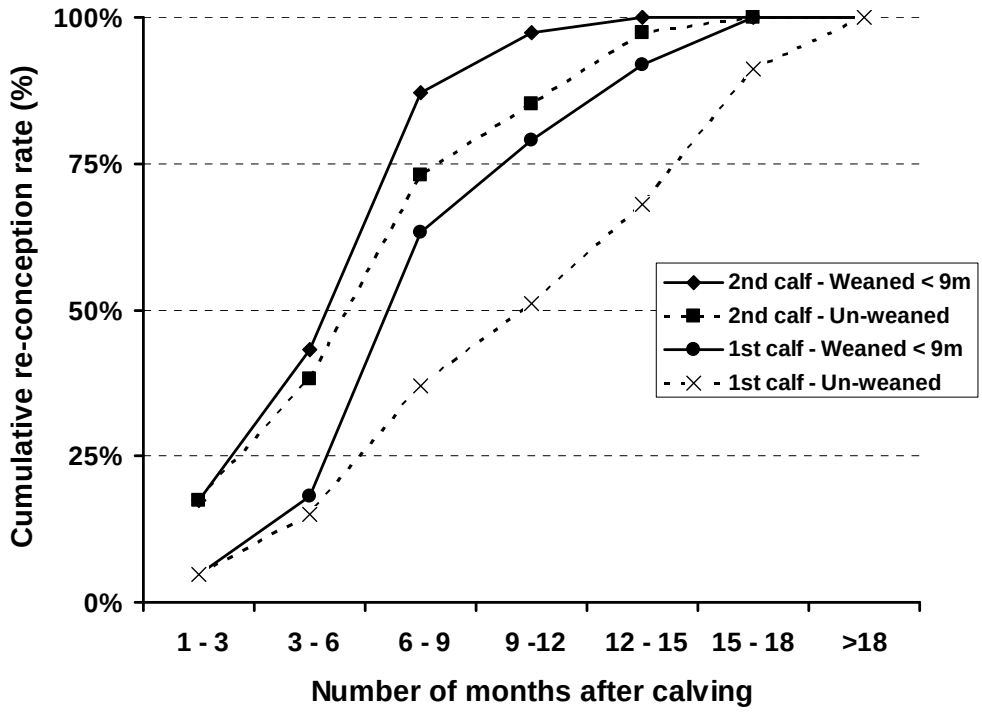

Figure *4.1.2*-16. Time taken to re-conceive in first calf heifers (N = 335) and 2nd calf cows (N = 97) whose calves were either weaned or not weaned by 9 months of age.

The data recorded at Tieyon shows that heifers which had shorter re-conception times had produced more calves by April 2009 (see table *4.1.2*-8). There were 78 heifers with records available to examine the effect that the length of time taken to re-conceive after first calving had on the length of time taken to re-conceive after 2nd calving. Figure *4.1.2*-17 shows that there was no clear effect.

Table *4.1.2*-8. The effect of time taken to re-conceive after first calving on the average number of calves produced by April 2009.

Months from 1st calving to re-conc.	Maiden heifers at WR1 2006	Maiden heifers at WR1 2007
1 - 3		1.53 (n=3)
3 - 6	2.09 (n=17)	1.45 (n= 6)
6 - 9	1.98 (n=12)	1.43 (n=15)
9 -12	2.01 (n=20)	1.34 (n=16)
12 - 15	1.85 (n=19)	1.34 (n=22)
>15	1.59 (n=10)	1.29 (n=30)
> 18	1.35 (n=11)	1.31 (n=7)

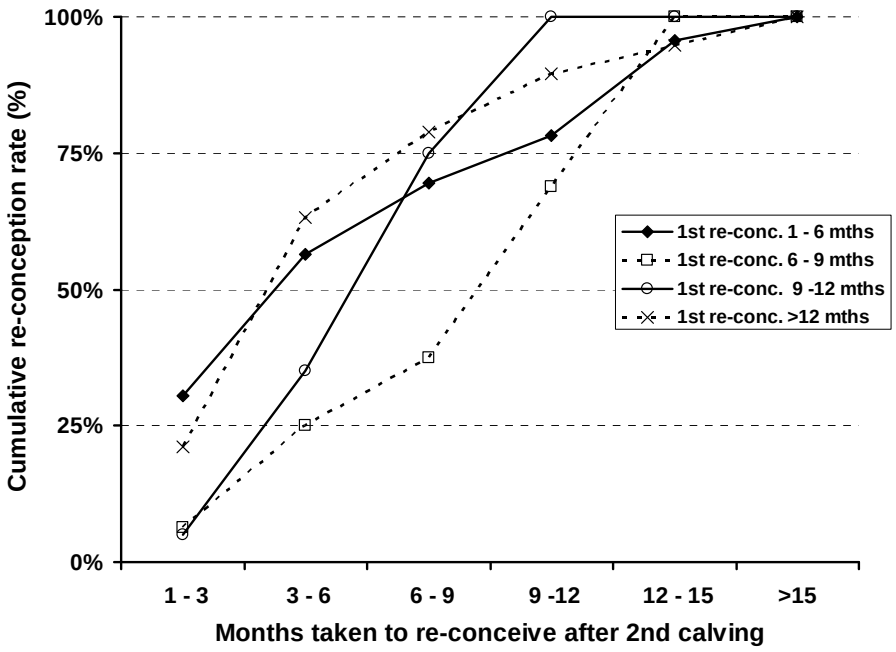

Figure *4.1.2*-17. The effect of the length of time between first calving and re-conception on the time taken to re-conceive after the second calving (N = 78).

Pestivirus (BVDV) research.

At the first round muster in April 2007 an attempt was made to set up an experiment to see if there was any benefit from vaccinating young heifers against BVDV (Bovine Viral Diarrhoea Disease Virus also known as pestivirus) in One Tree paddock.

Young heifers within the 100 – 250 kg weight range were randomly allocated to one of the following three treatments.

1) *Control* – Heifers that were not vaccinated (these heifers were born in One Tree paddock).
1) *1st Vacc*. - Heifers that were given their 1st vaccine on 25/4/07 (these heifers were born in One Tree paddock).
2) *2nd Vacc*. - Heifers that were given their 2nd vaccine on 25/4/07. These heifers had received 1 vaccination earlier when they had been weaned from a different paddock and transported to One Tree (they were identifiable by their ear tags).

Blood samples were taken from heifers intended be in the control group (i.e. heifers that were not vaccinated on 25/4/07), however after these blood samples were tested it was found that 59% (26 of 44) of the heifers had already had been exposed to BVDV. Follow up testing was done at the next muster on 31/10/07 when blood samples were taken from heifers that had tested negative to BVDV in April 2007. From the testing of these samples it was found that 50% of these heifers had contracted BVDV virus between 25/4/07 and 31/10/07. As a result (since so many of the heifers intended to be in the control group had already had exposure to the disease), the heifers needed to be separated into different treatment groups when analysing the data. These were;

1) *Control* – Heifers that were not vaccinated and that tested negative to BVDV on both 25/4/07 and 31/10/07.
2) *1st Vacc.* - Heifers that were given their 1st vaccine on 25/4/07
3) *2nd Vacc.* - Heifers that were given their 2nd vaccine on 25/4/07.
4) *Previously exposed* – Heifers that were not vaccinated on 25/4/07 but that testing showed had previously been exposed to BVDV before 25/4/07.
5) *Infected between testings* – Heifers that testing showed were negative to BVDV on 25/4/07 and then positive antibody titres on 31/10/07 (i.e. they had been exposed to BVDV between these dates).

Not all animals that were originally selected for involvement for this study were mustered on 31/10/07. Table *4.1.2*-9 summarises the data for heifers that were present at both muster dates.

Table *4.1.2*-9. The effect of BVDV vaccination on growth from 25/4/07 to 31/10/07.

Treatment group	N	Avg Wt (kg) on 25/4/07	Avg Growth (kg) from 25/4/07 to 31/10/07
1) Control (-'ve on both 25/4/07 & 31/10/07)	7	158	45.3
2) 1st Vacc. On 25/4/07	13	169.6	54.8
3) 2nd Vacc. on 25/4/07	10	159.8	54.7
4) Previously exposed	9	177.6	53.9
5) Infected between testings	8	157.9	47.9

Statistical Analysis: There were no significant differences in average growth between the five treatment groups (ANCOVA, $F_{4,36} = 0.396$, $P = 0.8099$) nor were there any when growth was adjusted for initial weight on 25/4/07 (ANCOVA, $F_{4,36} = 0.501$, $P = 0.7349$).

The results of this study need to be treated with caution as the numbers of heifers in each treatment group are low. The low numbers in each treatment group make it very difficult to find statistical differences in growth between the groups (there were no significant differences in growth rates between groups), however BVDV vaccination and BVDV infection did not seem to effect growth. In fact heifers that contracted the disease between testings (group 5) tended to grow more than the control group (group 1), and the control group grew the least of all the treatment groups (note that none of these differences are statistically significant).

It is not surprising that BVDV did not reduce growth much as cattle infected with BVDV in extensive situations rarely show any signs of disease. When infected they are viremic for about a week and may experience a very mild increase in rectal temperature, however the main problem is that during this time they are immuno-suppressed and so are at risk of infection with other agents. This is mainly a problem for animals in feedlots where other diseases are more prevalent. The other main cause of economic loss due to BVDV is when females get the disease during the early stages of pregnancy. This can cause abortion or if the foetus does survive it becomes a PI (Persistently Infected) and usually fails to thrive, has a high risk of dying post weaning and continually spreads the disease while it is alive.

It was not possible to examine the effects of BVDV immunity on fertility and calf loss since nearly all heifers had gained immunity (either through vaccination or previous infection with the disease) before they became pregnant for the first time. In other words it was not possible to get enough animals for a control group of heifers that had not had the disease before their first pregnancy due to the high prevalence of the disease in the herd.

Blood samples were also taken from heifers from a number of different age groups in the One Tree herd on 25/4/07 and testing found that more than 90% of heifers had already had BVDV before they reached 2 years of age (see table *4.1.2*-10).

Table *4.1.2*-10. Results of BVDV testing in One Tree paddock.

Test date	Tag colour	Year weaned	Average Weight (kg)	Number of heifers tested	% that previously have had BVDV
25/4/07	Green	2004	337	15	87%
25/4/07	Purple	2005	303	16	100%
25/4/07	Yellow	2006	225	24	96%
25/4/07	Red	2007	167	20	45%
30/4/08	Blue	2008		21	90%

In April 2008, 21 weaners were tested and 90% of them had previously been infected with BVDV. Once they have had the disease, animals acquire natural immunity to it for the rest of their lives, and so there would seem to be little point in vaccinating against BVDV in this herd at this time. This is because the main problem with BVDV in extensive herds is when females catch it during the early stages of pregnancy (and either abort or produce persistently infected [PI] calves) and our testing has shown that most animals in One Tree paddock have already acquired immunity before they reach breeding age.

For there to be these high levels of BVDV in the herd there must be a number of PI animals in it (PI's are continually spreading the disease and infecting other animals). Since testing has shown that most animals acquired immunity to BVDV before reaching breeding age, in theory eventually PI animals will stop being produced as cows will no longer catch the disease during the early stages of pregnancy (as is required for PI's to be produced) and the BVDV prevalence in the herd will decline. Once this happens then vaccinating from this point onwards would probably be profitable. A good strategy would be to test a couple of groups of animals each year to find out current infection levels. If BVDV prevalence in the herd is found to be low then a vaccination

program may be considered as modelling has found this to be profitable (Phil Holmes *pers. comm.*).

Vibriosis research

Recent research on a commercial property in the VRD district (NT) found that there was a significant benefit from vaccinating maiden heifers once against vibriosis prior to their first joining (Schatz *et. al.* 2007). An attempt was made to determine whether vibriosis vaccination resulted in similar benefits in heifers in the One Tree herd, as previous recent disease testing had shown that vibriosis was present in the herd. It proved difficult to set up a good experiment as the smaller herd size and the fact that calves are born all year round meant that there were not large numbers of maiden heifers in the desired weight range at each muster.

Heifers weighing between 190 kg and 270 kg were vaccinated with a single dose of Vibrovax™ at 3 separate musters and compared to heifers of a similar weight that were not vaccinated at those musters. The normal measurements (weight, condition score, pregnancy diagnosis and lactation status) where then recorded at the biannual musters. In examining the effect of the vibriosis vaccine, the heifers from each of the 3 musters at which vaccination occurred were treated as 3 separate replicates of the trial. The dates on which vaccination and control treatment groups were set up were;

1. Started on 24/11/05 – Total number of heifers in trial = 74
2. Started on 21/04/06 – Total number of heifers in trial = 55
3. Started on 25/10/06 – Total number of heifers in trial = 54

Table *4.1.2*-11. Results for vibriosis replicate/trial 1 (set up on 24/11/05).

	Avg wt 24/11/05	% preg 21/4/06	Avg wt 21/4/06	% preg 5/10/06	Avg wt 5/10/06	% preg or calved by 25/4/07
Control 24/11/05	226 kg (n=37)	51 % (n=35)	297 kg (n=35)	90 % (n=30)	342 kg (n=30)	97% (n=29)
Vacc. 14/11/05	241 kg (n=37)	63 % (n=35)	304 kg (n=35)	97 % (n=24)	330 kg (n=30)	97% (n=30)

Statistical Analysis: The proportion of heifers that had conceived by 5/10/06 and that had conceived or calved by 25/4/07 in the "Control" and "Vacc" treatment groups were compared using binomial proportion tests. There was no significant difference in conception rate between the "Control" and Vacc" groups on 5/10/06 (χ 2 = 0.0843, df=1, P = 0.7714), and the proportion of heifers that had conceived or calved by 25/4/0706 (both were 97%).

Table *4.1.2*-12. Results for vibriosis replicate/trial 2 (set up on 21/4/06).

	Avg wt 21/4/06	% preg 25/10/06	Avg wt 25/10/06	% preg 25/4/07	Avg wt 25/4/07	% preg or calved 24/10/07
Control 21/4/06	220 kg (n=28)	4 % (n=23)	266 kg (n=23)	50% (n=26)	302 kg (n=26)	88% (n=25)
Vacc. 21/4/06	219 kg (n=27)	5 % (n=22)	268 kg (n=22)	45% (n=20)	302 kg (n=20)	95% (n=19)

Statistical Analysis: The proportion of heifers that had conceived by 25/4/07 and that had conceived or calved by 24/10/07 in the "Control" and "Vacc" treatment groups were compared using binomial proportion tests. There was no significant difference in conception rate between the "Control" and Vacc" groups on 25/4/07 (χ 2 = 0.0015, df=1, P = 0.9690), or in the proportion of heifers that had conceived or calved by 24/10/0707 (χ 2 = 0.8410, df=1, P = 0.3590).

Table *4.1.2*-13. Results for vibriosis replicate/trial 3 (set up on 25/10/06).

	Avg wt 25/10/06	% preg 25/4/07	Avg wt 25/4/07	% preg 24/10/07	Avg wt 24/10/07	% preg or calved 30/1/08
Control 25/10/06	221 kg (n=27)	22% (n=27)	265 kg (n=27)	71% (n=17)	324 kg (n=17)	100% (n=16)
Vacc. 25/10/06	220 kg (n=27)	19% (n=27)	259 kg (n=27)	75% (n=24)	324 kg (n=17)	89% (n=19)

Statistical Analysis: The proportion of heifers that had conceived by 24/10/07 and that had conceived or calved by 30/1/08 in the "Control" and "Vacc" treatment groups were compared using binomial proportion tests. There was no significant difference in conception rate between the "Control" and Vacc" groups on 24/10/0707 (χ 2 = 0.0986, df=1, P = 0.7534), or in the proportion of heifers that had conceived or calved by 30/1/08 (χ 2 = 0.3668, df=1, P = 0.5447).

Discussion

While vaccination seemed to have a positive effect in the short term in the 1st trial (+12% conceptions after 6 months and +14% after 11 months) it had very little effect in the longer term (+ 5% after 17 months) (see table *4.1.2*-11), and had no effect in the 2nd and 3rd trials (see tables *4.1.2*-12 and *4.1.2*-13). Also the 1st trial may have been slightly biased due to the heifers in the vaccinated group being heavier (15 kg) on average than the control group at the start of the experiment and this is likely to cause an earlier conception pattern (as more heifers would be likely to have reached their critical weight for puberty).

It should be noted in regard to these trials that due to the low numbers of animals involved it is difficult to prove statistical differences or allow interpretation of the results with much confidence (i.e. the low number of animals involved means that results could be just due to chance). The herd size meant that it was not possible to get large numbers of heifers in a similar weight range for these experiments. However an effort was made to make the most of the information that could be collected and the data from these trials can give us an indication on the effectiveness of the vaccine in this herd even though we can't make definitive statements from it.

Recommendations

It is not possible to come to conclusive findings from these 3 trials but the results suggest that Vibriosis is not a major problem in this herd and that an ongoing vaccination program (consisting of a single Vibrovax injection prior to first mating) is unlikely to give significant benefits. This is supported by the fact that when the data from all 3 trials was pooled, that the average estimated weight at first conception was not lower in vaccinated heifers (see table *4.1.2*-14). If vibriosis was a real problem in this herd then it would be expected that the average estimated weight at first conception would be lower in vaccinated heifers, since the most common symptom of vibriosis in a herd is an apparent delay in conception pattern (due to early embryonic loss).

Table *4.1.2*-14. Effect of vibriosis vaccination on the estimated weight at first conception* (data from all 3 trials/replicates combined).

	Avg est. weight at 1st conception	Number of heifers that conceived
Control	278 kg*	54
Vaccinated	281 kg*	49

** Weight at first conception was calculated by; estimating the date of conception from a heifer's preg test result, and then using the weight at the muster after it was detected pregnant and it's growth rate during the preceding period to estimate weight at first conception using the following formula;*

= weight at muster – (number of days pregnant x growth rate [kg/day] in preceding period)

Statistical analysis: There was no significant difference in the average weight at first conception between the control and vaccinated groups (ANOVA, F1,156 = 0.824, P=0.0365).

It should be noted that the manufacturer's recommendations are that heifers under 18 months of age should receive two injections of the vaccine about 6 weeks apart, and that only one injection was given in these trials. However two vaccinations is not a practical management practice on many central Australian properties (as it requires two musters about 6 weeks apart) and since one injection is sufficient to give immunity to heifers older than 18 months of age, it was decided to see whether there was any benefit from this simple, practical treatment.

Since this is a continuously mated herd it is difficult to tell the ages of heifers and some will have been older than 18 months of age and some will have been younger. Using the average growth rates recorded in this study it is estimated that an 18 moth old heifer would weigh about 255 kg. Obviously many heifers in these trials would then have been less than 18 months old and so should have received 2 vaccinations, but this was not practical and the purpose of the experiment was to see if there was any benefit from a single vaccination.

Controlled Mating

Segregation of heifers and controlled mating (joining to bulls for a restricted period of time) has several advantages and disadvantages.
The main advantages are;

- That heifers don't conceive too early (while they are small) which may cause dystocia and result in the death of the calf and/or the heifer.
- That most calves are born just before the time of year when pasture conditions are at their best so there is more energy available for lactating heifers (this is less important in central Australia where there is not a distinct seasonal rainfall pattern).
- That calves are all born at a similar time (tight calving pattern) so that only one weaning muster is required. This also results in each year group of animals being of similar age and so makes their management and marketing easier.
- Improved selection of replacement animals as all are exposed to similar seasonal conditions.

The main disadvantages are;

- That overall herd branding rates are usually reduced as the bulls are not with the cows/heifers for as long. This is especially a problem in central Australia where there is not a distinct seasonal rainfall pattern and so in a controlled mating system bulls may not be with the cows after a rainfall event.
- That a paddock is required where bulls can be kept securely away from the females.
- The extra work of removing bulls and then putting them back in at the right time. Problems can arise if rain occurs just before the bulls are due to be put back in making transport difficult.
- Problems with undesirable genetics getting into the herd if neighbours bulls get into the herd during the period when the bulls are removed.

It was originally intended to set up an experiment to examine the advantages and disadvantages of control mating, however this had to be abandoned due to the drought conditions (the money earmarked for the fencing to enable this comparison was required elsewhere). As a result the control mating work had to be a desktop study where the performance of heifers conceiving at different times of year was compared. Preg-test results were used to estimate the date of first conception and calving and then the subsequent performance of heifers conceiving at different times was examined. It should be noted that pregnancy diagnosis (by manual palpation) is less accurate between 4 and 8 months of pregnancy and the estimated date of first conception may be about 1 month either side of what is estimated.

More heifers conceived for the first time over the summer months (Oct – Mar). This corresponded to better nutrition and perhaps a day length affect on the onset of puberty and

consequent conception rates. The greatest proportion of heifers conceived in the Jan-Mar quarter and heifers that conceived during this quarter also had the highest re-conception rate after calving but they had the highest rate of calf loss as well (see table *4.1.2*-15). It is likely that the high temperatures during the summer months contribute to the higher rates of calf loss in these months.

Table *4.1.2*-15. The performance of heifers that conceived at different times of year (data from all years bulked together).

Season 1st conception	N	Calf loss (%)	Season 1st calve	N	% re-conc. in < 6 months
Jan-Mar	202	20% [a]	Sep-Nov	143	29% [a]
Apr-Jun	86	14% [a,b]	Dec-Feb	69	22% [a,b]
Jul-Sep	77	9% [a,b]	Mar-May	50	6% [c]
Oct-Dec	162	5% [b]	Jun-Aug	117	14% [b,c]

Statistical Analysis: The proportion of heifers that lost their calf in the four groups (first conceived in "Jan-Mar", "Apr-Jun", Jul-Sep", "Oct-Dec") were compared using binomial proportion tests. There was a significant difference between all the groups (χ 2 = 19.0, df = 3, P = 0.0003), and the groups that were significantly different from each other are shown in the table above where calf loss rates which don't have the same letter superscript are significantly different.

The proportion of heifers that had re-conceived by 6 months after calving in the four groups were also compared using binomial proportion tests. There was a significant difference between all the groups (χ 2 = 16.0, df = 3, P < 0.0011), and the groups that were significantly different from each other are shown in the table above where re-conception rates with different letter superscripts are significantly different.

When calf loss and re-conception rates are taken into account; then for every 100 heifers that conceive during each of these quarters there are likely to be 128 calves produced from heifers conceiving between Jan-Mar, 121 from those conceiving between Apr-Jun, 106 for Jul-Sep and 114 for Oct-Dec (assuming that 95% of heifers that lose a calf re-conceive within 6 months). From this it is evident that if control mating was to be implemented then the best time to put the bulls in is likely to be around the Jan-Mar period. It is likely that most managers would prefer the mating period to be longer than 3 months and so the optimum time for the control mating period is likely to either start a month earlier or finish a month later than Jan-Mar if a 4 month period is desired (or both if a 5 month period is desired).

While the rainfall pattern is not as seasonal in central Australia as it is further north, most of the large falls of rain still tend to occur during the summer months. Of the 168 months between January 1995 and December 2008, the total monthly rainfall exceeded 30 mm 18 times and 75% of these months were between October and April. This rainfall pattern reinforces that if control mating was to be introduced then the optimum time for the mating period would be around Jan-Mar.

While this study has shed light on the optimum time for a mating period in a control mating system, it does not provide any information on how much herd branding rate would be reduced should control mating be introduced. The reduction in branding rate is greatest during the transition from continuous to control mating and while the difference is not as great once control mating has been established for several years, there is still likely to be some reduction in branding rates. This study does not provide any information as to the extent of this difference, so it cannot be used to determine whether the advantages of control mating outweigh the disadvantages in this environment.

4.2 Heifer performance recording on NT commercial properties.

4.2.1 Methodology.

Data were collected on 14 commercial cattle properties located throughout the NT. It was intended that cooperating properties would be representative of the whole NT cattle industry, so they were selected to achieve a wide geographical spread and to represent typical management systems of each region.

Some properties were unable to see the work through until completion (usually due to drought conditions) and so performance was recorded for maiden heifers only. On some properties performance was only recorded in first calf heifers. In total the performance of maiden heifers was recorded from 18 mobs of heifers on 10 commercial properties and the performance of first calf heifers was recorded from 21 mobs of heifers on 11 different properties.

With 14 properties spread over a range of environments, it was difficult to establish a standardised measurement and recording procedure that could be implemented on every property at the same time of year. In most cases a group of maiden heifers (heifers mated for the first time) were individually identified (with numbered ear tags and electronic identification devices), weighed and pregnancy diagnosis performed (by manual palpation per rectum) to confirm that they were not already pregnant prior to their first mating. The average size of the maiden heifer group studied was 322 heifers per property (the actual numbers at each property are shown in the results section (appendix 9.6). Most heifers were around 2 years old at the first mating (judged by year brands and the management group that they had been in since weaning), although one property practiced yearling mating (see appendix 9.6). All matings involved multiple sires. On all except two properties (see appendix 9.6) mating was continuous after bulls were introduced to the maiden heifers. After the first mating it was endeavoured to record weight, pregnancy status and lactation status at the following times (although data could not be recorded at all of these times on all stations);

- Post first mating (P1M). Usually around May after the first mating.
- Pre-calving (PC). Usually around September after the first mating.
- First weaning round muster (WR1). Usually around May after first calving.
- Second weaning round muster (WR2). Usually around September after first calving.

Heifers were mustered on the day before measurements were recorded and kept in yards over night with access to water but not feed. Pregnancy rate was calculated on the basis of the number of heifers pregnant as a percentage of the number of heifers present at each muster. Maiden heifer pregnancy rate was calculated from the P1M data and first lactation heifer pregnancy rate was calculated from the WR1 data. Only heifers which were found to be pregnant while lactating at WR1 were included in the calculation of first lactation heifer pregnancy rate. Any calves that the station manager considered to be big enough (usually down to a minimum weight of 120 kg) were weaned at the WR1 and WR2 musters.

On some stations it was not possible to take measurements prior to the maiden mating and so recording commenced after the first mating (P1M) with heifers that were diagnosed as pregnant (no record of maiden heifer pregnancy rate in the table in appendix 9.6 shows where this occurred). In one case it was not possible to record liveweights at WR1 (see appendix 9.6). On one property in the Alice Springs district the work had to be abandoned after the maiden mating results were recorded due to drought conditions. The genotype of the heifers studied on each property is shown in appendix 9.6.

Heifers were deemed to have lost their calf if their pregnancy status data (from P1M and PC) showed that they should have calved before WR1 but they were not lactating at that time. Calf

loss rates were calculated on the basis of the number of heifers that had lost their calf prior to WR1 as a percentage of the number of heifers present at WR1 that should have had their first calf by that time (according to their previous pregnancy diagnosis results).

In addition to the heifers on commercial properties, the performance of heifers at Victoria River Research station was also included in the study as they were run under similar conditions to the heifers on commercial properties and their pregnancy rate (39%) was in a range that no others were and so was useful in developing the relationship between body weight and pregnancy rates.

Statistical analysis

The data were analysed using a logistic generalised linear model with binomial errors (McCullagh and Nelder 1989) to fit the relationship of mean liveweight of first lactation heifers at WR1 to the corresponding proportions of re-conception successes and failures in first lactation heifers recorded at WR1 the following year. The fit of the model was assessed using the ratio of the residual deviance to residual degrees of freedom.

The data were analysed twice, firstly (this model is shown in figure *4.2*-1) for the paper published in 2008 (Schatz and Hearnden 2008) and then again in 2009 (this model is shown in figure *4.2*-2) to include data that was collected after the publishing of the 2008 paper.

The model in the 2008 analysis used data from tropically adapted genotypes only, so the *Bos taurus* herds in the Alice Springs district (appendix 9.6) were not included. Data from the Sturt Plateau site was also excluded since the weight and pregnancy status data were not collected until later in the year and do not accurately portray the weight of the heifers at the time when they were re-conceiving (first lactation heifers are typically mustered earlier in the year to wean their calves but circumstances prevented this occurring in this case). The results of the foetal aging at pregnancy diagnosis in July at that property showed that all heifers that re-conceived had done so at least 4 months earlier. The property manager observed that their body condition was much better then than it was in July when data was recorded (K Holzwart, pers. comm.) and the fact that no heifers re-conceived in the 4 months preceding the July measurements shows that the effect of liveweight on re-conception rates in this herd would have been better represented if the heifers could have been weighed closer to the time when the re-conceptions were occurring. The model in the 2009 analysis included all data.

Year was not fitted in the statistical model as the year effects on re-conception rate are indirect through the effect of seasonal conditions on liveweight and it is actually liveweight that has the major effect on the length of postpartum anoestrous interval and hence re-conception rates in first lactation heifers (Short *et al*. 1990).

Proportions of calf loss at various times of the year were analysed in one herd (Table *4.2*-2) with a binomial test for equality of proportions without continuity correction (Fleiss 1981).

The results from this work that were available in early 2008 were published in a scientific paper in the Australian Journal of Experimental Agriculture (Schatz and Hearnden 2008). Some results that became available since then have been added to the results here.

4.2.2 Results and discussion.

A comprehensive summary of the results of the performance recording of heifers on NT commercial properties is presented in large table in appendix 9.6. The major findings of this work are:

Maiden heifers.
Pregnancy rates in maiden heifers were generally adequate (> 75% on all but 1 property where heifers were first mated at 2 years of age) to achieve sufficient numbers of pregnant replacement heifers in the herds observed in this study (appendix 9.6). Liveweight is the major factor influencing the onset of puberty and pregnancy rates in maiden heifers (Entwistle 1983), and heifers on most NT properties are able to reach sufficient joining weights by 2 years of age for adequate fertility if moderate stocking rates are implemented.

Where low pregnancy rates were recorded in maiden heifers it was due to low joining weights. There were 4 instances where low pregnancy rates in maiden heifers were recorded (appendix 9.6). These were;
1) At the VRD (North) property pregnancy rates of 59% (2005) and 65 (2006) were recorded. The main reason that this occurred was that a high stocking rate in the heifer paddocks resulted in low joining weights (236 kg in 2005 and 255 kg in 2006). The high stocking rates were not set intentionally but occurred through poor paddock security with many extra cattle entering the heifer paddocks.

2) At the VRD (South) property a pregnancy rate of 32% was recorded in 2006. This occurred because the wet season failed that year and the average growth over the wet season by the heifers was only 17kg. These heifers were mated as maidens again the following year and 92% became pregnant.

3) At the Sturt Plateau property a pregnancy rate of 53% was recorded in 2007. This was because the heifers were mated as yearlings in that year. Those that did not get pregnant the following year were mated again with some other heifers and a pregnancy rate of 87% resulted.

4) Pregnancy rates of 64%, 56% and 66% were recorded on the Alice Springs (South property) These recordings occurred during an extended period of drought (the average annual rainfall received in those years was 135 mm) which resulted in light joining weights. Pregnancy rates in maiden heifers are likely to be much higher in better years.

First calf heifers
The results of this study show that pregnancy rates in first lactation heifers are often low (eg. <20%) on NT commercial cattle properties (appendix 9.6) and that this is mostly due to the low liveweights of heifers during the period after calving and while they are lactating (Figure *4.2*-1). However they also show that high pregnancy rates are achievable on some NT properties when heifer liveweights are high during this period. The 2 properties where high pregnancy rates were recorded were on the Barkly Tableland (which is considered one of the best regions for cattle production in the NT), both of which had received good rainfall throughout the year resulting in excellent seasonal conditions. The heifers recorded had also been grazing at moderate stocking rates.

There was a strong relationship between the average weight of first lactation heifers at WR1 and their re-conception rates (Figure *4.2*-1) (the model fitted is a highly significantly better fit than the null [no fit] model [$p<0.0001$]).

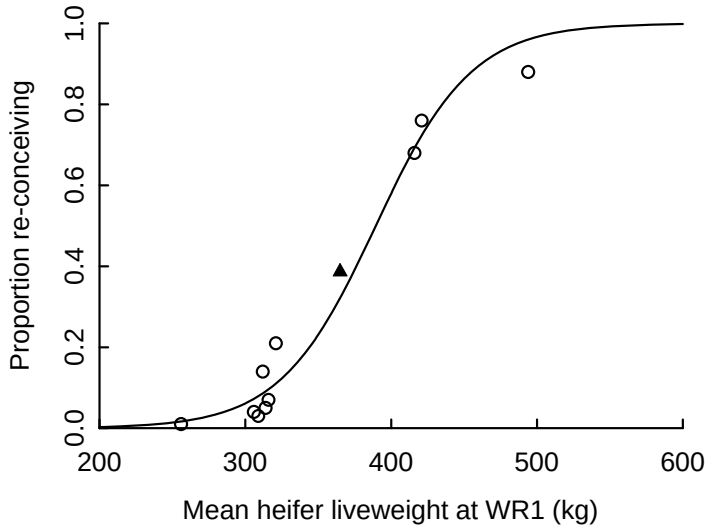

Figure *4.2*-1. Logistic model of proportion of first lactation heifers re-conceiving by WR1 dependent on mean herd weight at WR1. The data point marked with a filled triangle symbol is from VRRS (a research station) rather than a commercial property. *Bos taurus* herds were excluded from the analysis.

The data point denoted by a filled triangle is identified separately from the other data points as it is not a commercial property but a NT Department of Resources (DoR) research station (VRRS). However this herd is run under extensive conditions similar to most commercial herds in the region and was included as there were no groups of heifers from commercial properties in this study that had an average weight at WR1 in that range.

Note that figure *4.2*-1 comes from Schatz and Hearnden (2008) and does not include some of the extra data in appendix 9.6 that was recorded after the publication of that paper. Also *Bos taurus* data was excluded from figure *4.2*-1 for scientific reasons. The data from extra years recording and from *Bos taurus* herds have been added in figure *4.2*-2 and the results are very similar to the relationship in figure *4.2*-1 (again $p<0.0001$).

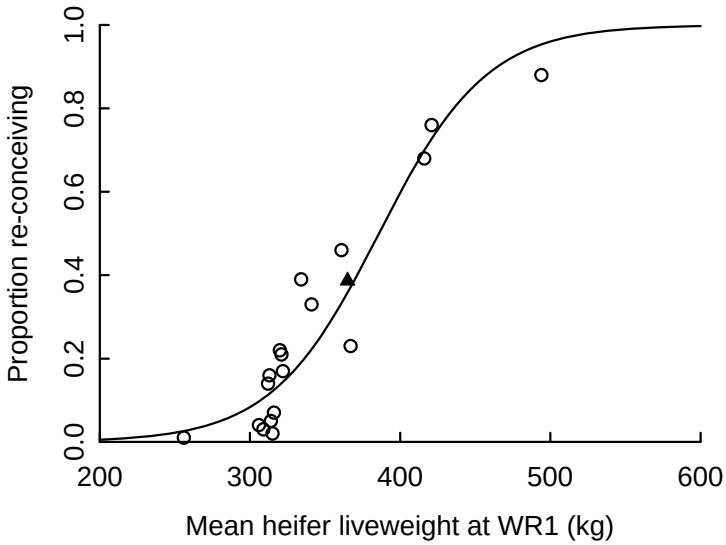

Figure *4.2*-2. Logistic model of proportion of first lactation heifers re-conceiving by WR1 dependent on mean herd weight at WR1. *The data point marked with a filled triangle symbol is*

from VRRS (a research station) rather than a commercial property. The difference from figure 4.2-1 is that data from extra years recording and Bos taurus herds were included.

Pregnancy rates in first lactation heifers increased as liveweight increased (figure *4.2*-1 and figure *4.2*-2) and these results are consistent with several other studies that have shown that pregnancy rates increase as liveweight increases (Goddard *et al.* 1980, Rudder *et al*. 1985 and Doogan *et al.* 1991), although weight was measured at the start of mating in those studies and it was recorded at the WR1 in this study. The reason that WR1 weight was used in this study is that there was large variability in weight gain (or loss) between PC and WR1 on the different properties, and as a result the relationship between PC weight and re-conception rate was not found to be strong. O'Rourke *et al.* (1991) also found that re-conception rates in first calf heifers (in the NT) were influenced by WR1 weight but not pre calving weight.

While WR1 weight is not a predictive measurement of pregnancy rate in first lactation heifers, it is indicative of what their weights have been during the period from calving to weaning and was found to have a highly significant ($p<0.0001$) effect on re-conception rates during this time. Also many NT cattle managers do not like to muster heifers close to the time of calving (as is required to collect a pre-mating weight) as they believe it might lead to increased calf losses, therefore specific pre-calving target weights are not that relevant to them but rather the principle that weight/body condition of first lactation heifers through the period between calving and weaning strongly effects re-conception rates (Richards *et al*. 1986).

In 2004 an extensive survey of managers of NT cattle stations was conducted prior to commencement of this project and is discussed later in this report. Managers were interviewed from 169 stations across the NT and the average of their estimates of conception rates in first lactation heifers was 63% (Oxley *et al*. 2004). The results of this study however show that pregnancy rates in first lactation heifers on NT cattle properties are often much lower than the managers of those properties realise.

From the data collected during the performance recording on commercial properties, general guidelines are that when management and seasonal conditions result in first lactation heifer liveweights of less than 320 kg at WR1, that re-conception rates are likely to be less than 15% (which is not uncommon on many NT properties). The model from figure *4.2*-1 shows that a liveweight around 390 kg at WR1 is required for a pregnancy rate of 50%, and around 420 kg for a pregnancy rate of 70%.

There are not many properties in the NT where high pregnancy rates in first lactation heifers (eg. > 70%) will be consistently achievable. This study shows that to maintain heifers at the liveweights required for this, that the property would have to be in one of the more fertile areas of the NT (eg. Barkly Tableland) and have received the rainfall required for good pasture growth while implementing moderate stocking rates. A more realistic target for first lactation heifer pregnancy rates on most extensive NT properties in an average year would be 40% as was achieved at VRRS (Fig. 1) from heifers grazing native pasture at moderate stocking rates with year round mineral supplementation. While this target is considerably lower than is expected in southern Australia, there would be large economic benefits in increasing pregnancy rates to this level on properties where first lactation heifer pregnancy rates are typically less than 20%.

Calf loss

This study found that calf loss in first lactation heifers is often very high (> 30%) on NT cattle properties (appendix 9.6). On one property 39% of heifers lost their calf between pregnancy diagnosis and weaning. The figures reported here (eg. 39%) are higher than those reported by Holroyd (1985) who reviewed calf loss in northern Australia and reported losses in the range of 4 to 28%, although these figures were for mature cows and calf loss tends to be higher in first lactation heifers than mature cows (Reynolds *et al*. 1980).

Calf loss of 30% or higher was recorded on 5 of the 14 herds that were recorded and the average of the measurements of calf loss over all the properties was 22.7%. Note - The figure for average calf loss in first calf heifers on NT commercial properties (22.7%) was calculated by averaging the calf loss rates recorded on all the properties. Where more than one years results were recorded on a property, those results were averaged and that figure was used as the calf loss rate for that property (the only exception to this was on the Barkly [E] property where two separate herds of different genotypes were recorded and so were not averaged).

Due to the large numbers of cattle and the vast size of the paddocks in which they graze, many of the managers of these properties were not aware of the scale of these losses since very few of the calf carcases were actually seen. It is only when heifers are individually identified and records kept of their performance that the extent of the losses becomes apparent.

With few calf carcases found, clinical investigations are rarely possible and it is difficult to identify the reason for these large calf losses since there are many factors that can contribute to high rates of calf loss including predation, disease, nutritional deficiency, heat, dystocia, bottle teats and poor mothering ability of heifers (Entwistle 1983). Holroyd (1987) also noted the difficulty of finding calf carcases on extensive properties in northern Australia and in a review of 12 years data from Swans Lagoon research station reported that most calf losses were post natal and that almost half of these were from unknown causes since in the majority of cases it was not possible to locate a calf carcase.

There was no apparent relationship between calf losses and the timing of peak calving season (using the date of calving estimated from pregnancy diagnosis) that was consistent across all properties. However it was not possible to test this properly since the peak calving of most herds was at a similar time of year so the numbers of calves born at other times of year were not high enough to provide a valid comparison. Table *4.2*-1 shows the calf loss that occurred in heifers calving in different months on one property on the Barkly Tableland. There was no significant difference in the proportions of calf loss in the different months (Chi-square = 2.034, df = 4, p= 0.7294).

Table *4.2*-1. The effect of estimated date of calving on calf loss in first lactation heifers on a Barkly Tableland property.

Estimated date due to calve	Number of heifers	Calf loss
31/10/2006	24	38%
30/11/2006	89	30%
31/12/2006	180	29%
31/1/2007	82	27%
28/2/2007	9	44%
Total	385	30%

In conclusion this study shows that re-conception rates in first lactation heifers are strongly influenced by their liveweight between calving and weaning. On many NT cattle properties the liveweights of first lactation heifers during this period are often so low that re-conception rates are less than 20%. Much higher re-conception rates were observed on properties where management and seasonal conditions resulted in heifers being heavier through this period. Calf loss in first lactation heifers was found to be very high (> 30%) on a number of properties.

4.3 Best practice manual.

The results from this project together with findings from 2 other heifer projects running concurrently with this project (namely NBP.339 "Understanding and improving heifer fertility in the Northern Territory" and NBP.345 "Industry Initiatives to Improve Young Breeder Performance in the Pilbara and Kimberley regions of Western Australia") will be critically assessed and will form the basis of a Best Practice manual for producers in the N.T. and the Kimberley and Pilbara regions. The best practice manual will be a joint publication and will be submitted separately in 2010 for desk topping and publishing. The contents of the manual are listed in Appendix 9.4.

4.4 Survey - Start of project.

The results of the both the start and end of project surveys are presented in detail in appendix 9.6, only selected highlights of the results are shown in this section.

The initial survey was far more comprehensive than the end of project survey as it was able to be done in "face to face sessions" by NT Pastoral Production staff at the same time as the 2004 Pastoral Industry Survey (Oxley *et al*. 2004). This was not possible with the end of project survey as Pastoral Industry Surveys are a very time consuming and costly exercise and so are not done very often.

A summary of the main findings of the start of project survey is as follows:

Property size - The size of properties surveyed ranged from 50 km^2 to > 10,000 km^2 but the majority of properties were between 2,000 – 5,000 km^2 (Table 4.4-1 in Appendix 9.5).

Ownership – 67% of the properties surveyed were privately owned, 25% company owned and 8% had indigenous ownership (Table 4.4-2 in Appendix 9.5).

Cattle breeds – The majority of properties in the NT run Brahman and Brahman cross cattle although *Bos Taurus* cattle are more commonly run in the southern parts of the NT (Table 4.4-4 in Appendix 9.5).

Production statistics – Managers were asked to estimate production statistics but it should be noted that the figures are estimates as such their accuracy is not known in many cases. Mortality rates in heifers were generally estimated at between 2 and 4% (Table 4.4-5 in Appendix 9.5). The average estimates of branding rates were 67% in maiden heifers, 63% in first calf heifers and 73% in breeders (Table 4.4-6 in Appendix 9.5). On average managers estimated that they culled around 10% of cows each year except for in the Alice Springs district where the average figure was 18% (Table 4.4-8 in Appendix 9.5).

One of the major findings of the survey was that many managers were not aware of the extent of the problem of low fertility in first calf heifers. Table *4.4*-6 shows the average of the manager's estimates of branding rates from first calf heifers for each region. When estimates from all the regions were combined, the average was 63% for the whole of the NT. This is much higher than what was found by the performance recording work in section 4.3 where re-conception rates were found to be less than 10% on more than a third of properties on which performance was recorded and were found to be less than 25% on 8 of the 11 (i.e. 73%) properties. Re-conception rates were only found to be greater than 50% on 2 of the 11 properties. It should be noted that these figures are for conception rates which are often considerably higher than branding rates

due to calf loss (and so these figures actually underestimate the discrepancy between the manager's estimates and the performance recording figures).

Joining practices – Most heifers are joined for the first time between 18 months and 2 years of age (Table 4.4-9 in Appendix 9.5) and the majority of properties aim to segregate heifers from breeders (Table 4.4-11 in Appendix 9.5). The proportion of properties that practice controlled mating is higher in the north than in the south but most properties practice continuous mating in all regions (Table 4.4-11 in Appendix 9.5).

Weaning – Most properties try to wean the calves from first calf heifers as one of the first groups that they wean and they wean down to lighter weights than with older females (Table *4.4*-20).

Replacement heifers – Although it depends on whether a property is aiming to increase, maintain or reduce herd size, on average properties keep around 60% of their heifers as replacements (Table *4.4*-22). Selection of replacement heifers most commonly occurs just before fist joining at around 18 months of age (Table *4.4*-22) and the criteria identified by managers as being most important in selection are temperament, conformation and type (Table *4.4*-23).

Vaccinations – Most properties vaccinate against botulism but only a minority regularly vaccinate against other diseases (Table *4.4*-26).

Supplementation – The proportion of properties that regularly practice supplementation is lower in the Alice Springs district than other regions. In the other regions the majority of properties practice supplementation in the dry season (winter months) and a considerable amount of properties supplement year round especially in the Barkly and Darwin districts (Table *4.4*-27).

Manager's attitudes to different management practices and to changing them - The following two tables from appendix 9.5 are shown here as they show the attitudes of managers to different management practices and to changing their management practices. The tables will be referred to in the next section and compared to the results from the end of project survey to show how producer attitudes changed over the duration of the project.

Table *4.4*- 28. Manager's opinion of the importance of different management strategies in improving fertility. Average of scores given by region where 1 = strongly don't agree, 3 = neutral, 5 = strongly agree.

	Darwin	Katherine	Barkly	Alice Sp.
Managing young heifers separate from breeders	4.3	4.5	4.2	3.5
Preventing out of season pregnancies (bull control)	4.5	3.8	3.9	2.6
Improving joining weights through supplementation	4.4	4.3	3.8	3.4
Improving joining weights through use of better paddocks for heifers	4.4	4.2	4.1	3.9
Vaccination against disease	4.2	4.0	4.5	3.2
Time of year that calves are weaned from heifers	4.5	4.2	4.4	3.1
Early weaning of calves from heifers	3.7	4.1	3.3	3.4
Mating heifers for the first time as yearlings	2.3	2.1	2.4	3.0
Use of pregnancy testing	4.1	3.7	3.9	2.9
Bull fertility testing	4.3	4.1	3.7	3.4
Bull percentage used at mating	4.7	4.2	4.3	3.8
Age of bulls used	4.3	3.9	4.1	3.7
Genetics/selection for fertility	4.1	4.3	4.3	4.0

Table *4.4*-29. Attitudes to changing current heifer management practices. Average of scores given by managers in each region where 1 = strongly don't agree, 3 = neutral, 5 = strongly agree.

	Darwin	Katherine	Barkly	Alice Sp.
Unlikely to change management as couldn't do it any better	2.6	2.0	2.6	2.9
Unlikely to change management due to lack of resources (eg paddocks, labour, finance etc.)	1.8	2.4	2.8	2.4
Would consider changing management if had more resources	3.2	3.7	3.6	3.4
Can't change much as other practices are not practical in our situation	2.8	2.0	2.9	3.0
Would consider changing if more information on alternative management practices was available	3.0	3.2	3.1	2.7
Would consider changing if new techniques were demonstrated to be better in our district	3.8	4.0	3.8	3.2
Are definitely thinking of changing our management	3.2	3.9	3.0	2.9

4.5 Survey - End of Project

There were considerably fewer properties surveyed in the 2009 end of project survey than in the 2004 survey. This was because the 2004 survey was done in conjunction with the 2004 Pastoral Industry Survey (which involved many NT DoR staff visiting stations and doing "face to face" interviews with managers), while the end of project survey had to be done in isolation as it did not coincide with a major survey. As a result far less staff and resources were available to conduct the end of project survey and so it had to be done on a smaller scale (see method in section 3.5). Although the number of properties in the second survey was lower, a considerable number of properties (53) were still surveyed and these are likely to be representative of the NT cattle industry.

The results of the end of project survey are presented in detail in appendix 9.5. Some aspects of particular interest are shown in this section and compared to the results from the start of project survey.

Production statistics – The average estimates of branding rates by managers in the end of project survey were similar to the start of project survey results for maiden heifers and breeders but considerably lower for first calf heifers (42% vs 63% [Table *4.5*-3 in appendix 9.5]). It is unlikely that the performance of first calf heifers declined over the duration of the project but rather that there was an increase in the manager's knowledge of what the branding rates from first calf heifers are likely to be. The low fertility rates in first calf heifers found in this study were communicated to producers at field days and through the rural media, and so it is likely that awareness of the issue increased during the project. Feedback at field days and conversations with managers indicated that this is almost certainly the case (T Schatz *pers. obs*.) and this has been a major outcome of the project. The first step in solving a problem is realising that there is one and finding out the extent of it and this project seems to have been successful in doing this.

Calf loss rates were estimated to be 11% in first calf heifers and 6% in breeders (Table *4.5*-4 in appendix 9.5). In the view of the author these figures are likely to be under-estimates since calf loss rates have been found to be difficult to asses accurately (Holroyd 1987), and since the performance recording in this project found an average calf loss rate of 22.7% in first calf heifers (see section 4.2).

Joining practices - Nearly half of the producers surveyed control mate their maiden heifers but most use continuous mating thereafter (Table *4.5-5* in appendix 9.5). Control mating is used more in regions where the property size is smaller (eg. the Top End and Sturt Plateau). Control mating does seem to be increasing in popularity when the results of the end of project study are compared to the results of the start of project study (Table *4.4-13* in appendix 9.5). There was no real change in the age at which properties mate their heifers for the first time over the duration of the project and around ¾ of properties mate their heifers for the first time between the ages of 18 months and 2 years.

Vaccination – The proportion of properties that vaccinate against botulism remained high and relatively unchanged (Table *4.5-9* in appendix 9.5) but the proportion of properties that vaccinate their heifers against vibriosis increased over the duration of the project. In 2004 no properties in the Darwin or Alice Springs districts said that they vaccinated against vibriosis but by the end of the project 50% of Alice springs properties and 43% of Top End (Darwin district) properties said that they vaccinate against vibriosis. When the VRD and Sturt Plateau properties are included in the Katherine district (as they were in the 2004 survey), 27% of properties surveyed in the end of project survey vaccinated against vibriosis compared to 17% at the start of the survey. The proportion of properties on the Barkly that vaccinate against vibriosis declined slightly over the duration of the project (compare tables *4.4*-26 and *4.5-9* in appendix 9.5).

It is likely that this increase in vibriosis vaccination is due at least in part to the research done in this project. The trial that was done at Newry (reported in section 4.1.1) where vaccination against vibriosis increased pregnancy rates in maiden heifers by 11% (by the first round muster) was widely publicised and is likely to have resulted in an increase in the adoption of vibriosis vaccination. This work was published in scientific papers and presented at the 2004 NABRUC conference and field days where it generated quite a bit of interest. It also received quite a bit of interest in the media (eg. articles in Feedback magazine and Queensland Country life).

Vaccination against other diseases remained much the same although the use of botulism vaccination in the Alice Springs district seemed to increase (from 37% to 67%) over the duration of the project (perhaps due to the drought conditions experienced during the project as conversations with producers in the district revealed that they tend to vaccinate for botulism more when there are more bones around eg. during drought)..

Most important factors affecting heifer fertility - The end of project survey results (tables *4.5*-10 and *4.5*-11 in appendix 9.5) show that most managers are aware of the importance of the effect that body weight / condition and rated it as the most important factor affecting heifer fertility. While a significant number of producers nominated nutrition and season as the biggest factors affecting heifer fertility, the mechanism by which these factors affect fertility is actually through body weight/condition and so they are really much the same thing.

Manager’s attitudes to different management practices and to changing them - The following tables from appendix 9.5 are shown here to show the attitudes of managers to different management practices and to changing their management practices at the time of the end of project survey. The tables are compared to the results from the start of project survey (in section 4.4) to show how producer attitudes changed over the duration of the project.

Table *4.5*-12. Importance of different management strategies in improving fertility. Average of scores given by managers in each region where 1 = strongly don't agree, 3 = neutral, 5 = strongly agree. *Note: +, - and = signs have been used to show where the 2009 results were higher, lower or the same as the 2004 survey results (where a result was within + or – 0.2 it was considered to be the same i.e.=).*

	Darwin	Katherine	Barkly	Alice Springs	Over All
Segregation of heifers from breeders	3.6 -	4.3 =	4.5 +	4.5 +	4.2
Bull control (prevent out of season preg.)	4.1 -	4.0 =	3.1 -	3.0 +	3.8
Supplementation to increase weight	3.9 -	4.3 =	4.1 +	4.5 +	4.3
Use of better paddocks to increase weight	4.0 -	4.1 =	4.5 +	4.8 +	4.3
Vaccination against disease	3.1 -	4.4 +	3.9 -	4.3 +	4.2
Timing of weaning	4.4 =	4.5 +	4.4 =	4.0 +	4.4
Early weaning of calves from heifers	3.6 =	4.3 =	4.4 +	4.8 +	4.2
Bull fertility testing	3.9 -	3.7 -	3.9 =	3.5 =	3.7
Bull % used when mating heifers	4.0 -	4.3 =	4.1 =	4.0 =	4.2
Genetics / selection for fertility	4.4 +	4.5 =	4.6 +	4.0 =	4.4
Using lighter stocking rates to increase weights	2.9	3.6	3.6	4.7	3.7

Most strategies listed here were seen to be important in improving fertility except for fertility testing of bulls, bull control (preventing out of season pregnancies) in the Barkly and Alice Springs districts and using lighter stocking rates to increase fertility (except for in the Alice Springs district where this was seen to be quite important).

The importance that managers placed on bull control (or preventing out of season pregnancies) was highest in the region with the highest rainfall (Top End) and decreased as rainfall decreased.

Over all the regions the strategies considered to be most important for improving heifer fertility were genetics and timing of weaning followed closely by the use of supplementation and better paddocks to improve joining weights.

It is interesting to note that other than in the Alice Springs district, station managers don't see using lighter stocking rates as being very useful in increasing fertility. This is somewhat surprising as, in the opinion of the author it was one of the major reasons for poor body condition and hence low pregnancy rates where they occurred during the performance recording work.

In all regions except for the Top End, most of the strategies listed above were rated equal or higher by managers in the 2009 survey for their importance in improving heifer fertility than in the 2004 survey.

Table *4.5*-13. Attitudes to changing current heifer management practices. Percentage of managers in each region that identify with each attitude towards changing their heifer management.

	Would change if had more resources	Won't change – other practices are not practical	Would change if more information was available on alternative practices	Would change if other practices are demonstrated to be better	Are definitely planning to change
Darwin	29%	14%	14%	29%	14%
Katherine	30%		10%	37%	20%
Barkly	25%		38%	38%	
Alice Springs	33%			17%	50%
East Kimberly			100%		
Over all	29%	2%	17%	33%	19%

These questions were asked slightly differently in the 2004 survey where people rated how much they agreed with each statement on a 1-5 scale, whereas in the 2009 question they were asked which statement described their attitude the most. Nevertheless the statements given the highest scores over all the regions in the 2004 survey were that they would change their heifer management if other practices were demonstrated to be better and next highest rating attitude was that they would change if they had more resources. These statements were also the most commonly identified as describing manager's attitude to change in the 2009 survey.

Only one property manager chose the option "won't change as other practices are not practical in our situation" as best describing his attitude to change. This property is in the Top End near the coast and most of the land is floodplain which is submerged by water for long periods each year which makes management there very different to all the other properties that were surveyed.

In summary the two surveys showed that awareness of the problem of low fertility in first calf heifers increased over the course of the project and that by the end of the project most producers were aware that weight / body condition is the major factor affecting heifer fertility. Also most NT producers indicated a willingness to change their heifer management practices to improve heifer fertility. Evidence of this was seen in practice by the increase in the proportion of producers vaccinating their maiden heifers against vibriosis over the duration of the project (when it had been demonstrated to improve pregnancy rates at one of the heifer demonstration sites).

5 Success in Achieving Objectives

5.1 Demonstration sites on commercial properties

Objective : By December 2009, the Research Organisation will have identified (in consultation with industry), evaluated and demonstrated practical management strategies to improve the performance of heifers and young breeding females on one commercial property in each of the Katherine, Barkly and Alice Springs regions (total 3 sites).

This objective has been met in the Katherine and Alice Springs regions but only partly met in the Tennant Creek region as the work had to be abandoned there due to drought conditions.

Initially a co-operating property (Helen Springs) and the heifer management strategies to be evaluated and demonstrated were identified, and a heifer demonstration site was set up in the Tennant Creek district. However Helen Springs only received 2 inches of rain over the 2004/5 wet season and drought conditions were experienced on the Barkly Tableland in 2005 resulting in a lot of properties reducing stock numbers by transporting cattle to other regions. As a result the management of Helen Springs decided that they could not continue with the work and the demonstration site was abandoned there. This was clearly communicated to the MLA project managers at the time and was done in consultation with them.

Since the demonstration site work was only completed at 2 sites, the performance recording work was expanded to compensate.

The things studied at each of the demonstration sites were:

Newry
- Performance recording of pregnancy rates in maiden heifers.
- Performance recording of calf loss rates and re-conception rates in first calf heifers.
- Performance recording of calf loss rates and re-conception rates in second calf cows.
- The effect of time of calving on calf loss and re-conception in first calf cows.
- The effect of supplementation on re-conception in first calf heifers.
- The effect of vibriosis vaccination on pregnancy rates in maiden heifers.
- The effect of vitamin A injection on calf loss.
- Controlled mating.
- Growth at various stages of the heifer production cycle.
- Prevalence of pestivirus (BVDV).
- Assessment of NLIS tag retention rate.

Tieyon
- Performance recording of pregnancy rates in maiden heifers.
- Performance recording of calf loss rates and re-conception rates in first calf heifers.
- Performance recording of calf loss rates and re-conception rates in second calf cows.
- The effect of time of calving on calf loss and re-conception in first calf cows.
- The effect of weaning on re-conception.
- Growth at various stages of the heifer production cycle.
- The effect of vibriosis vaccination on pregnancy rates in maiden heifers.
- Controlled mating (desk top study).
- Prevalence of pestivirus (BVDV).
- The effect of weight on pregnancy rates in maiden and first calf heifers.

5.2 Heifer performance recording on NT commercial properties.

Objective : By December 2009, the Research Organisation will have recorded the reproduction performance of heifers and young breeders on 9 representative stations in the N.T. and established benchmarks for young breeder reproductive traits on each of those stations.

This objective has been met. In fact this work was expanded (for the reason explained in 5.1 above), and performance recording was completed on 14 properties throughout the NT.

5.3 Best practice manual

Objective : By December 2009, the Research Organisation will have produced a Best Practice Manual for heifer management in the N.T. and northern W.A (in conjunction with WA DAF).

This objective has not been completed yet but should be completed in 2010. Completion of this objective requires collaboration with the WA DAF heifer research project.

5.4 Survey - Start of the project.

Objective : By December 2009, the Research Organisation will have surveyed N.T beef producer heifer management practices at the start of the project to identify barriers (real and perceived) to implementation of other known practices.

This objective has been met.

5.5 Survey - End of the project.

Objective : By December 2009, the Research Organisation will have surveyed N.T beef producer heifer management practices at the end of the project to document changes during the life of the project.

This objective has been met.

The results from the end of project survey showed that most NT managers are willing to change their heifer management to improve production. The most commonly identified obstacles to change were lack of resources, information on different practices and a desire to see the different practices demonstrated to be better. This project and the associated best practice manual should provide managers with much of the information that they require on different management practices. Some areas where future research could be done to demonstrate the outcomes and profitability of different management practices in the NT include controlled mating, determining the length of time of pre-partum supplementation of first calf heifers that is most likely to be profitable, as well as research to try to reduce calf loss which this project has found to be significant

6 Impact on Meat and Livestock Industry – now & in five years time

This project has already had considerable impact on the NT meat and livestock industry. The start (2004) and end (2009) of project surveys showed that the awareness of the extent of the problem of low fertility in first calf heifers in northern Australia has increased greatly during the course of this project.

The surveys showed that the average of the manager's estimates of branding rates from first calf heifers had dropped by 21% from 2004 to 2009. It is unlikely that the performance of first calf heifers declined during this time but rather that there was an increase in the manager's knowledge of what the branding rates from first calf heifers are likely to be (since few actually collect reliable objective data to measure it). Need also to comment on what changes managers will make to their heifer management as a result of the project. This project was as much about increasing awareness and changing attitudes as it was about benchmarking performance.

The findings of the performance recording work in this project have received wide exposure in the NT and have caused considerable discussion. It is highly likely that this is the reason why managers now believe that branding rates from first calf heifers are lower than was estimated in the 2004 survey. The increase in the awareness of low fertility in first calf heifers is a positive thing as the first step in solving a problem is realising that there is one and quantifying the extent of it. Once this has been done steps can be taken to improve the problem.

This project and a concurrent project on heifer fertility in the NT – NBP.339 (Schatz 2010) have shown that the low pregnancy rates commonly found in first calf heifers on NT properties are mostly due to low liveweights (poor body condition) between calving and weaning. These projects have raised the profile of the relationship between weight and heifer fertility and the end of project survey showed that most producers were aware of it at that time. It is likely that as a result of these projects that many managers have an increased awareness of this relationship and will place increased importance on efforts to have their heifers in good condition during joining periods and this will result in improved heifer productivity.

The survey results also show an increase in the practice of vaccination against vibriosis. This is also likely to be a result of this project as the work that was done at Newry (reported in section 4.1.1) where vaccination against vibriosis increased pregnancy rates in maiden heifers by 11% (by the first round muster) was widely publicised, and is likely to have resulted in an increase in the adoption of vibriosis vaccination.

This project has shown that there is scope for large improvements in first calf heifer fertility on most NT cattle stations and this would result significant economic benefits to the properties on which such improvements were made.

Economic modelling using the "Bcowplus" program (Holmes 2009) that was part of MLA project NBP.339 (Schatz 2010) showed that for an average sized herd in the Katherine/VRD region that each 5% increase in first calf heifer re-conception rate results in an increase in herd gross margin (GM) of around $26,229 or $1.20/AE.

Performance recording in the Katherine/VRD region of the NT found pregnancy rates in maiden heifers ranging from 59% to 84%, calf loss in first calf heifers ranging from 12% to 34% and re-conception rates from 1% to 17% (Schatz and Hearnden 2008). Using these figures as a guide, the "Bcowplus" program was used to examine the impact of improving heifer management on an average sized property in the Katherine/VRD region with a conception rate in maiden heifers of 75%, calf loss in first calf heifers of 20% and a re-conception rate of 15%. If a greater emphasis was placed on heifer management resulting in higher joining weights and hence fertility, then it would be realistic to expect that branding rates could be increased to 85% in maiden heifers and

45% in first calf heifers. Assuming that calf loss stays the same then this scenario would result in an increased herd GM of $175,250 per year for an average sized property in the VRD.

Templates have been produced for the “Bcowplus” program that represent the total cattle herds in the Alice Springs, Barkly, Katherine/VRD and Top End regions of the NT (Holmes 2009). When these templates are used to calculate the effect of increasing first calf heifer re-conception rates by 30% (from 15% to 45%) in each region then this would result in an annual increase in GM of $10.95 million for the NT pastoral industry (see appendix 1). This economic modelling shows that increasing first calf heifer fertility on NT cattle properties can result in large benefits for the NT pastoral industry and for individual properties. It is quite possible that this could be achieved in 5 years if properties were to implement the relevant management practices.

7 Conclusions and Recommendations

In general terms the aim of this project was to determine the current state of heifer fertility on NT cattle stations, both in terms of the actual performance of heifers and the attitudes, knowledge and practices of the people who manage them, and also to research and demonstrate management practices that can be used improve heifer performance.

The project has been successful in achieving these aims in that it;

- Has measured and documented actual heifer performance on a significant number of stations spread right across the NT.
- Has surveyed cattle managers (both before and after the project) in regards to the management practices they use as well as their knowledge of and attitudes towards different practices that affect heifer fertility.
- Has researched and demonstrated different heifer management practices on large heifer demonstration sites on properties in the Katherine and Alice Springs districts.
- Will result in the production of a best practice manual on heifer management.

The main findings of each aspect of the project are summarised in the Executive Summary at the start of this report. A general conclusion of the work is that; the performance recording showed that there is considerable potential for improvement of first calf heifer fertility on most NT properties. The surveys showed that the awareness of the extent of the problem of low fertility in first calf heifers increased over the duration of the project and that managers are open to change if new management practices are demonstrated to be better. Economic analysis showed that improving heifer performance can result in significant economic benefits with a 30% increase in first calf heifer re-conception rates likely to result in an increased annual gross margin of $10.95 million for the NT pastoral industry.

Recommendations for management to improve heifer performance can be summed up by one over arching recommendation: Heifer management should aim to have heifers in good condition (high body weights) during mating periods, as this is the biggest factor affecting heifer fertility. However this often not easy to achieve in northern Australia due to the harsh environment with challenges posed by the climate, parasites, seasonal poor pasture quality, high “on farm” costs of supplements and often large distances between feed and water. Specific recommendations of management practices that can be used to try to achieve good heifer fertility are;

- At a minimum, heifers should be segregated from weaning until first joining. Segregation from first joining until after weaning of the first calf is recommended if there are sufficient paddocks. Segregation of heifers from the rest of the herd allows targeted management and prevents “out of season” pregnancies.

- First mating should be timed so that lactation occurs during the time (wet season in the north) when nutrition from pasture is best.
- Conservative stocking rates, better paddocks and cost effective supplementation can be used to increase heifer joining weights in both maiden and first calf heifers.
- 270 kg at the start of joining is a good target weight to ensure high pregnancy rates in maiden heifers. Heavier heifers conceive earlier in the joining period and have higher chances of re-conceiving before their calves are weaned. Large (earlier born) weaner heifers are more likely to reach target joining weights than smaller (later born) weaner heifers. The strategies listed in the point above may be required to achieve target weights.
- All heifers should be vaccinated against botulism. Vaccination against vibriosis and pestivirus prior to first joining can give significant increases in heifer fertility in situations where these diseases are a problem. Blood testing (of 10 heifers) can show whether pestivirus vaccination is likely to be beneficial and an experiment where every second heifer is vaccinated prior to mating will show whether vibriosis vaccination is beneficial.
- Maiden heifers which do not become pregnant after a 4 month mating period should be culled for low fertility unless there are extenuating circumstances (eg. very poor seasonal conditions). If yearling mating is practiced then culling non-pregnant heifers may not provide sufficient replacement breeders and so some heifers may need another chance the following year.
- Calves should be weaned from first calf heifers as soon as is practically possible to remove the stress of lactation. First calf heifers are the most susceptible animals in the herd to getting into poor condition as they attempt to lactate and grow at the same time. While weaning will not affect the proportion of heifers that have re-conceived in time to have another calf within 12 months, it will reduce the length of time between calving and re-conception and the chances of mortality.
- Results from this project show that in first calf heifers, an average weight of around 390 kg at the time when their calves are weaned is required to achieve a re-conception rate of 50%. Low re-conception rates (eg. <15%) result when the average weight of first calf heifers is less than 320 kg at this time.
- It is recommended that young bulls are used for mating to heifers. If bulls are fertility tested then a bull percentage of 2.5% is considered to be sufficient, otherwise 4% if bulls are not tested.
- Supplementation of heifers with high protein supplements prior to calving can be used to increase re-conception rates in first calf heifers. However supplementation needs to continue until good pasture is available (the season breaks) otherwise its benefits can be lost if there is a late start to the wet season (ie. a long period between the end of supplementary feeding and good quality pasture being available). The profitability of this type of supplantation is highly dependent on the “on farm” cost of supplementary feed and the duration of feeding. If costs are too high then even large increases in re-conception rate may not be profitable. Also there is likely to be little benefit from feeding in years when conditions are good and heifers remain in good condition without supplementary feeding.

Areas identified for future research:

Some areas that have been identified during the course of this project where further research and demonstration would be beneficial are:

- reducing calf loss
- practical and economic strategies to increase heifer joining weights (specific to regions)
- the benefits and costs of controlled mating
- the most cost effective period of time for pre-partum supplementary feeding of first calf heifers

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9 Appendices

9.1 Appendix- Newry – Main pasture species

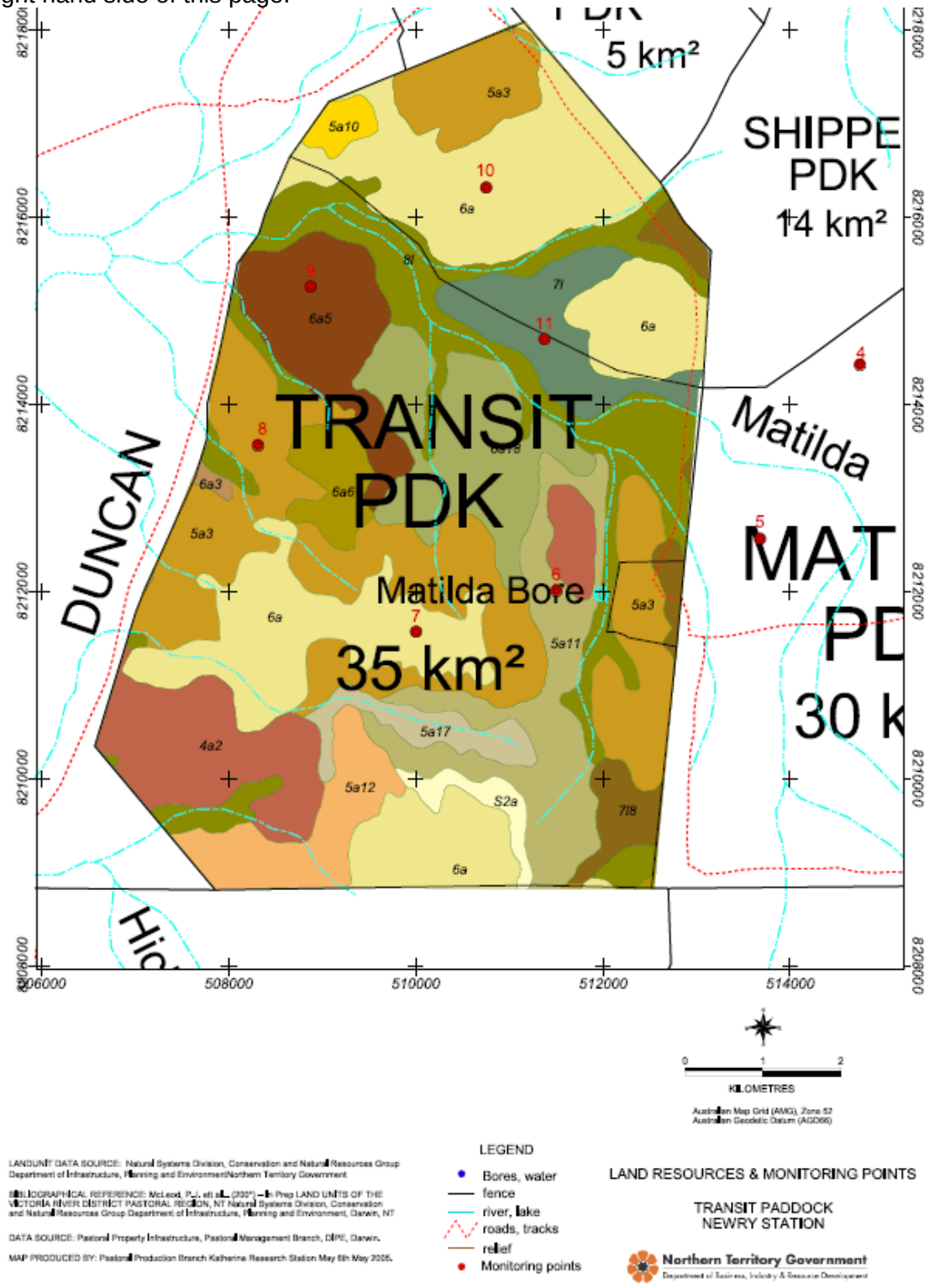
The main pasture species present in the Newry trial paddocks.

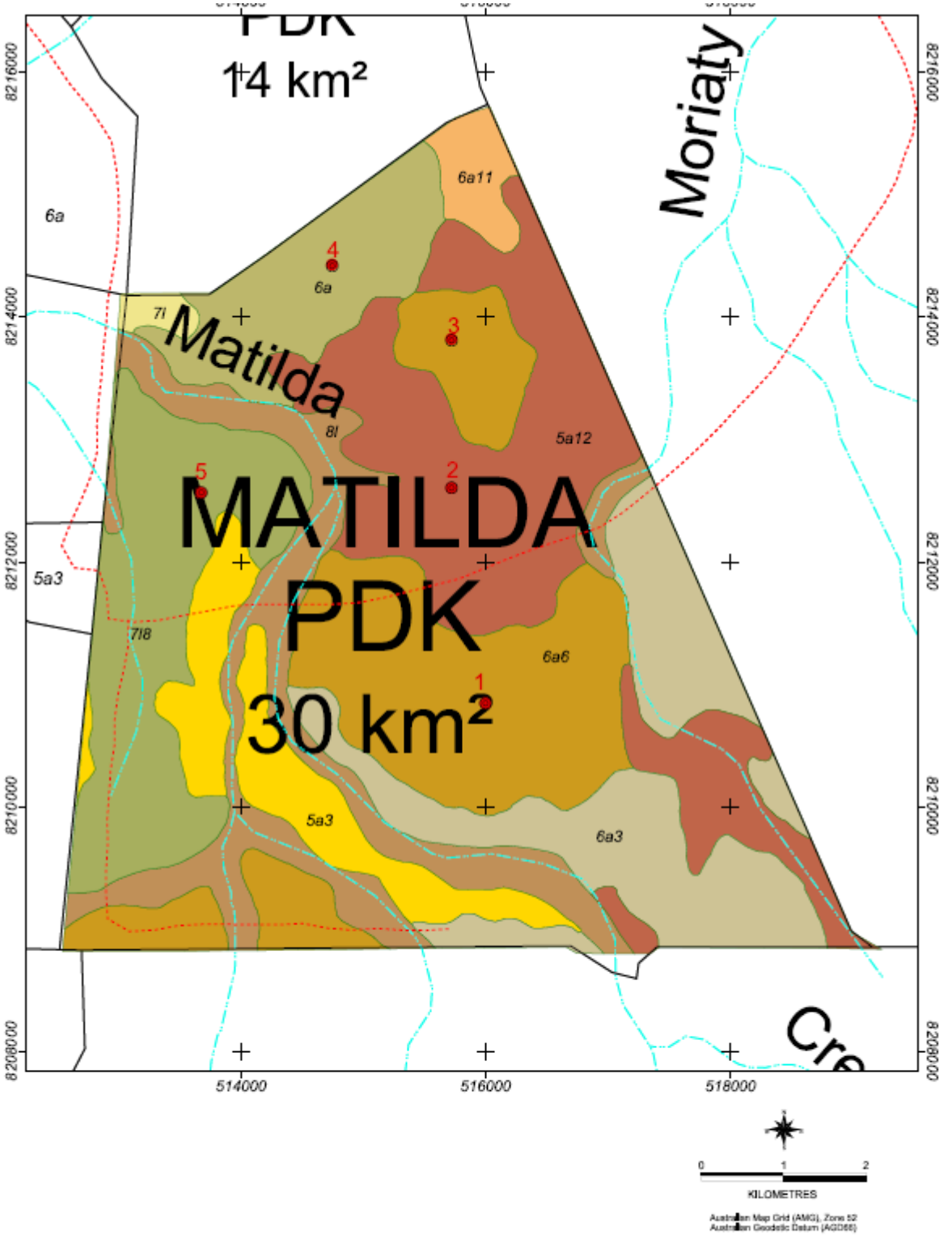
Common name	Scientific name	Features
Curly bluegrass	*Dicanthium fecundum*	Perennial grass. Highly palatable and nutritious especially when young.
White grass	*Sehima nervosum*	Perennial grass. Low nutritional value
Black speargrass	*Heteropogon contortus*	Perennial grass. Palatable when young, little value when older
Feathertop wiregrass	*Aristida latifolia*	Perennial grass. Unpalatable except when young
Golden beard grass	*Chrysopogon fallax*	Perennial grass. Palatable especially when young. Nutritive levels drop markedly when dry.
Annual sorghum	*Sorghum intrans*	Annual grass. Palatable when young, little value when older
Rhyncosia	*Rhyncosia minima*	Forb that lives for 2-3 years, moderately palatable
Fleming's bush	*Flemingia pauciflora*	Perennial forb, seldom grazed
Flinders grass	*Iseilema spp.*	Annual grass. Palatable and nutritious when young but value declines as it dries off.
Native millet	*Panicum decompositum*	Perennial grass. Moderately palatable especially when young
Kangaroo grass	*Themeda triandra*	Perennial grass. Palatable when young, little value when older
Camel bush	*Trichodesma zeylanicum*	Perennial forb, seldom grazed
Roly poly	*Salsola kali*	Annual forb. Unpalatable except when young
Cane grass	*Ophiuros exaltus*	Perennial grass in swampy areas. Unpalatable

9.2 Appendix - Newry trial paddocks- Land units.

Maps of the trial paddocks

Note - The two paddocks (Transit and Matilda) adjoin each other, sharing the fenceline shown on the right hand side of this page.





LANDUNIT DATA SOURCE: Natural Systems Division, Conservation and Natural Resources Group Department of Infrastructure, Planning and EnvironmentNorthern Territory Government

BIBLIOGRAPHICAL REFERENCE: McLeod, P.J. et al. (2007) – In Prep LAND UNITS OF THE VICTORIA RIVER DISTRICT PASTORAL REGION, NT Natural Systems Division, Conservation and Natural Resources Group Department of Infrastructure, Planning and Environment, Darwin, NT

DATA SOURCE: Pastoral Property Infrastructure, Pastoral Management Branch, DIPE, Darwin.

MAP PRODUCED BY: Pastoral Production Branch Katherine Research Station May 6th May 2005.

LEGEND

- Bores, water
- fence
- river, lake
- roads, tracks
- relief
- Monitoring points

LAND RESOURCES & MONITORING POINTS

MATILDA PDK
NEWRY STATION

Northern Territory Government
Department of Business, Industry & Resource Development

Legend

4a Basalt low hills; Rudosols and Dermosols; Open woodland of *E. terminalis* and *T. arostrata* over *Sorghum spp., Sporobolus australasicus, Brachyachne convergens* and *Plectrachne spp.;* surface gravel, stone and rock.

5a3 Basalt rises; Rudosols, Dermosols, Chromosols and Vertosols; Open woodland of *E. terminalis, E. pruinosa, T. arostrata, L. cunninghamii* and *Hakea arborescens* over *Brachyachne convergens, Sehima nervosum, Chrysopogon fallax* and *Sporobolus australasicus;* Western VRD *Aristida spp., Sorghum spp., Plectrachne spp*. and *Heteropogon contortus* are more prevalent; surface gravel, stone and rock.

5a10 Basalt rises; Dermosols and kandosols; Open woodland of *E. tectifica, E. terminalis, Erythrophleum chlorostachys* and *E. pruinosa over Sehima nervosum, Sorghum spp., Chrysopogon fallax, Themeda triandra* and *Heteropogon contortus;* surface gravel and stone.

5a11 Basalt rises; Rudosols, Dermosols and Kandosols; Shrubland to open woodland of *T. canescens, Cochlospermum fraserii, Hakea arborescens* and *Grevillea spp. Over Sorghum spp., Sehima nervosum, Triodia spp.* and *Eriachne spp.*; surface gravel, stone and rock.

5a12 Basalt rises; Chromosols, Dermosols and Kandosols; Grassland of *Sorghum spp., Chrysopogon fallax, Sehima nervosum, Aristida spp.* and *Brachyachne* with isolated trees and shrubs; surface gravel stone and rock.

5a17 Basalt rises(valley flats, drainage lines and footslopes within the hills and low hills); Dermosols and Kandosols; Open woodland of *E. brevifolia, E. pruinosa, E. terminalis* and *L. cunninghamii over Sehima nervosum, Aristida spp., Brachyachne convergens and Sorghum spp.;* surface grave and stone.

6a Basalt plains; Vertosols (and Dermosols on small rises); Grassland of *Chrysopogon fallax, Astrebla spp., Iseilema spp. and Brachyachne convergens*, with isolated trees and shrubs; surface gravel, stone and rock.

6a3 Basalt plains; Vertosols; Shrubland to open woodland of *T. volucris, L. cunninghamii, T. arostrata and Carissa lanceolata over Brachyachne convergens, Chrysopogon fallax, Aristida latifolia and Panicum decompositum*; surface gravel and stone.

6a6 Basalt plains; Vertosols (and Dermosols on small rises); Grassland of *Sorghum spp., Aristida spp., Chrysopogon fallax and Brachyachne convergens* with isolated trees and shrubs; surface gravel and stone.

6a18 Basalt plains; Vertosols (with Dermosols on small rises); Open woodland of *T. arostrata, L. cunninghamii, E. terminalis and T. volucris over Chrysopogon fallax, Iseilema spp. Astrebla spp. and Brachyachne convergens.;* surface gravel, stone rock.

Alluvial plains; Vertosols; Grassland of *Brachyachne convergens, Iseilema spp., Chrysopogon fallax, Astrebla spp. and Panicum decompositum* with isolated trees; surface gravel and stone.

Alluvial plains; Vertosols; Open woodland of *L. cunninghamii, T. volucris, Excoecaria parvifolia and Atalaya hemiglauca over Iseilema spp., Aristida spp., Chrysopogon fallax and Wedelia asperrima.*

81 River systems,; Vertosols, kandosols, Calcarosols and Chromosols; Open woodland to woodland or grassland of *E. papuana, T. platyphylla, E. camaldulensis, melaleuca spp. and E. microtheca over Brachyachne convergens, Chrysopogon fallax, Dichanthium fecundum and Heteropogon contortus;* surface gravel and stone.

9.3 Appendix- Tieyon - Land systems.

The major land systems on Tieyon are the Moorilyanna, Breakaway, Tieyon and Pedrika land systems. There are two main land systems in One Tree paddock and these are the Moorilyanna and Breakaway land systems

Moorilyanna. The Moorilyanna land system is characterised by highly resilient grassy woodlands. It is comprised of open mulga plains of pale red sands with often dense grass cover relative to other sand plain land types. Calcareous patches with sparser grass cover supporting saltbush. Patches of low bluebush with isolated patches of mallee also occur. Where fire is not as frequent the thickening of woody shrubs, particularly mulga often occurs.

The Moorilyanna land system is characterised by extensive sandplains, low rounded outcrops and associated stony slopes and plains. Minor units include small blocky ridge outcrops and smaller sandy drainage lines.

Sandplains form the major unit of the Moorilyanna land system. These areas have calcareous coarse red sands which support scattered mulga with Y-cassia over a mix of annual and perennial grasses. The dominant annual grass is mulga grass, while the perennial grasses are woollybutt, bandicoot grass and finger panic grass. Other species occurring in this unit include low but regular numbers of satiny bluebush and bitter saltbush.

Sandplain units occurring adjacent to the minor drainage lines support an open mixed woodland of long-leaved corkwood, dead finish, witchetty bush, sandplain wattle and mulga. The ground layer consists of annual grasses including bottlewashers, five minute grass, forbs and bogan flea.

The undulating plains unit with stony patches occurs between the sandplain and stony slopes units. These areas have a chenopod shrubland of low bluebush, with bladder saltbush and various other shrubs including satiny bluebush, woody bluebush, silky bluebush and emubushes such as crimson emubush and turpentine. The ground storey in these areas is characterised by copperburrs such as grey copperburr and woolly copperburr, with bottlewashers and umbrella grass.

The stony slopes and rises support a low open shrubland of rock emubush with variable cassia, witchetty bush and dead finish over a mix of chenopods including satiny bluebush, bladder saltbush, bitter saltbush and three wing bluebush. These occur with copperburrs such as western copperburr and woolly fruited copperburr. Annual grasses occurring here include mulga grass, five-minute grass and bottlewashers. The stony slopes have red duplex soils with fine sandy loam surface textures and fine sandy clay loam at depth.

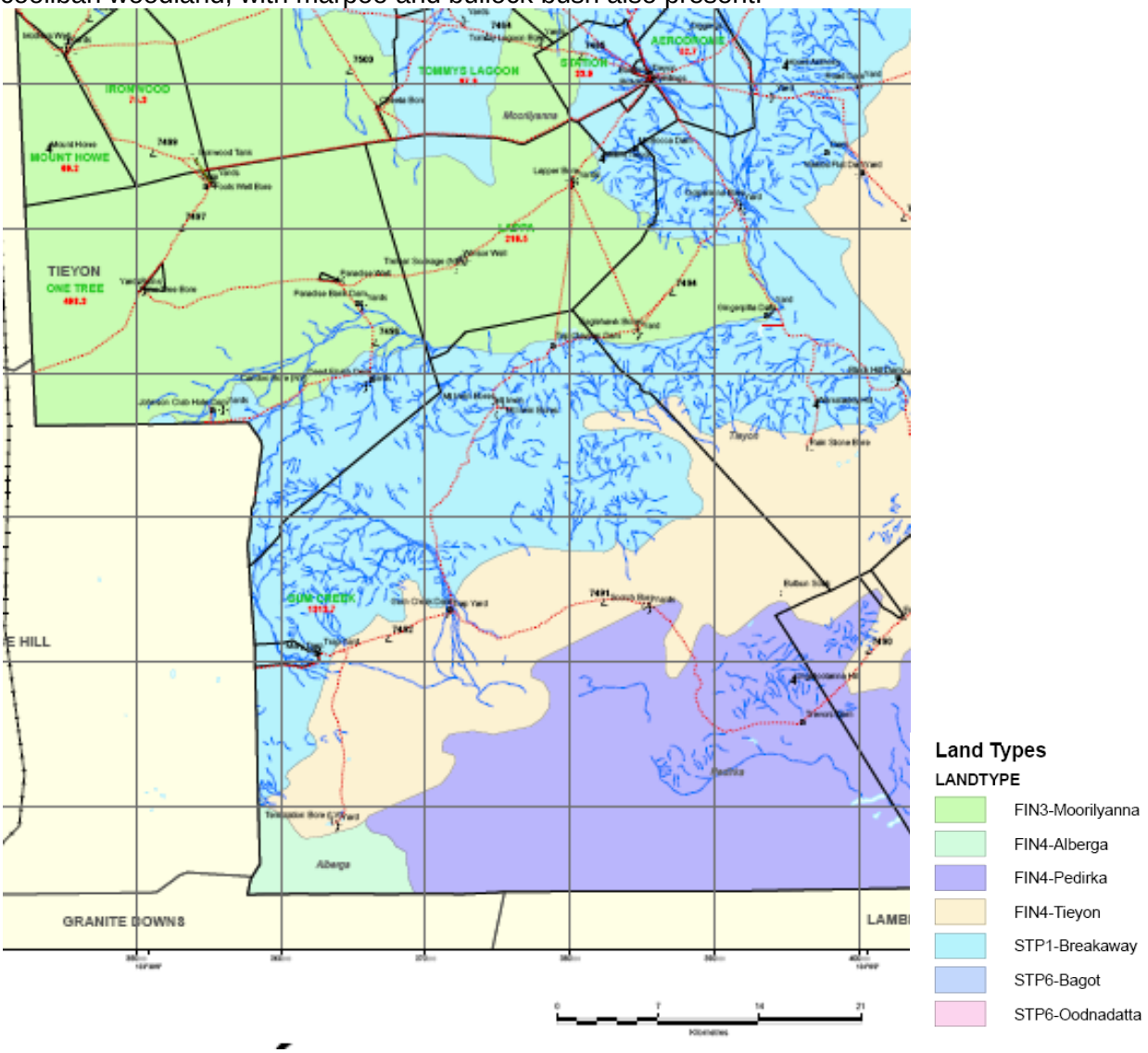
Granite outcrops form low rounded hills which support a variety of vegetation. The larger hills with significant run-off may support a dense thicket of trees and shrubs at their base including coolibah and wait-a-while. Smaller outcrops have low densities of mulga with dead finish, witchetty bush, rock emubush and green emubush. Satiny bluebush and needle leaved threeawn also occur at these sites.

The small sandy drainage lines, like the larger drainage line of the Alberga land system, are lined by river red gum and prickly wattle.

Breakaway. The Breakaway Land System consists of silcrete capped hills, slopes with eroding shales and gibber flats. It was formed from an eroding basement of Bulldog Shale and this has resulted in mixtures of silcrete gibber, grey shales and other variously coloured hard and soft shales.

Vegetation is dominated by chenopod low shrubland (except in broad watercourses). Tall shrublands of bastard mulga, mulga, northern myall and emubushes are also common. Clay soils over silicified shales of tablelands and low hills are dominated by bladder saltbush, low bluebush and three-winged bluebush, sometimes with mulga and cassias. Vegetation of footslopes also includes bristly sea-heath and samphires, reflecting the more saline nature of the soils and has fewer trees and tall shrubs. Solonized red duplex soils of plains support bladder saltbush, low bluebush, samphire and bristly sea-heath, but also have barley Mitchell grass in the gilgais.

Alluvial soils of smaller watercourses support bladder saltbush, cottonbush, spiny saltbush, round-leaf emu bush, native apricot and showy groundsel. Larger watercourses have mulga or coolibah woodland, with marpoo and bullock bush also present.



9.4 Appendix- Best practice manual for heifer management in Northern Australia - contents.

9.5 Appendix – Survey results.

The results of the start and end of project surveys are shown in detail in this appendix.

Note that the numbering system used in these sections relates to the relevant section in the report (eg. the 2004 start of project survey section in the main report is section 4.4 and the section for the end of project survey is 4.5 and so these numbers have been used for the numbering system of tables in this appendix).

4.4 Start of project survey results.

Table *4.4*-1. Number of properties surveyed in each region and their size (km^2).

	0 - 50	50 - 500	500 - 1999	2000 - 5000	5000 - 10000	>10000	Total
Darwin	8	10	7		1		26
Katherine		11	22	18	7	1	59
Barkly				14	4	6	24
Alice Sp.			3	24	10	1	38
Total	8	21	32	56	22	8	147

*Note – 7 of the Barkly properties were not presented with the heifer section of the survey.

Table *4.4*-2. Ownership of properties surveyed in each region.

	Company	Indigenous	Private/Family	# of properties surveyed
Darwin	8%	4%	88%	26
Katherine	27%	14%	59%	59
Barkly	50%		50%	24
Alice Sp.	18%	5%	76%	38
Total	25%	8%	67%	147

Table *4.4*-3. Number of paddocks per property in each region.

	Avg	Max	Min
Darwin	16	59	1
Katherine	15	60	2
Barkly	22	27	15
Alice Sp.	11	90*	3

This property practices cell grazing. The next highest number of paddocks on a property in the Alice region was 28.

Table *4.4*-4. Predominant breed which is run by properties. (The table shows the number of properties that predominantly run each breed of cattle).

	Bra/Bra X	Santa/Droughtmaster	British breeds	Composite
Darwin	26			
Katherine	57	2		
Barkly	19	4		1
Alice Springs	7	9	22	
Grand Total	109	15	22	1

Production statistics.

Note that the production statistics collated here are of estimates given by managers and as such their accuracy is not known in many cases.

Table *4.4*-5. Estimated mortality percentage of different classes of cattle.

	Weaner heifers	Maiden heifers	Lactating 1st calvers	Breeders	Old cows
Darwin	2.4 %	2.7 %	2.2 %	2.7 %	3.4 %
Katherine	2.6 %	2.9 %	3.0 %	3.0 %	4.1 %
Barkly	3.5 %	4.2 %	3.8 %	3.5 %	4.0 %
Alice Sp.	3.8 %	4.0 %	3.8 %	3.0 %	6.8 %

Table *4.4*-6. Estimated branding percentages of different classes of cattle. (The table shows the average of the estimates given by the managers in each region).

	Maiden heifers (1st joining)	Lactating 1st calvers (2nd joining)	Breeders	Old cows
Darwin	61 %	56 %	71 %	69 %
Katherine	68 %	61 %	72 %	73 %
Barkly	70 %	62 %	73 %	78 %
Alice Sp.	70 %	71 %	77 %	73 %
Over all average	67%	63%	73%	73%

Table *4.4*-7. Estimated herd branding percentages in each region. (The table shows the average of the estimates given by the managers in each region).

	Avg	Max	Min
Darwin	67	95	10
Katherine	71	85	50
Barkly	71	86	35
Alice Sp.	77	97	35

Table *4.4*-8. Estimated percentage of cows culled each year. (The table shows the average of the estimates given by the managers in each region).

	Percentage of cows culled each year (avg)
Darwin	9.2 %
Katherine	8.8 %
Barkly	11.0 %
Alice Sp.	18.1 %

Joining practices

Table *4.4*-9. Age (years) at which heifers are first joined. (The table shows the percentage of properties that join maiden heifers at each age).

	Age at which heifers are 1st joined (years)				
	1	1.5	2	2.5	3
Darwin	5 %	5 %	77 %	5 %	9 %
Katherine	4 %	24 %	51 %	20 %	
Barkly		30 %	65 %	5 %	
Alice Springs	19 %	35 %	42 %	3 %	

Table *4.4*-10. Estimated joining weights of maiden heifers (weights are as estimated by the manager).

	Avg joining weight (est)	Min joining weight (est)	% of properties that weigh heifers	Avg joining weight of those that actually weigh
Darwin	297 kg	284 kg	11%	275 kg
Katherine	285 kg	279 kg	22%	298 kg
Barkly	311 kg	282 kg	21%	284 kg
Alice Sp.	274 kg	265 kg	5%	250 kg

Table *4.4*-11. Percentage of properties that segregate heifers from breeders

	% of properties that segregate heifers from breeders
Darwin	65%
Katherine	78%
Barkly	82%
Alice Springs	58%

Of those properties that don't segregate, the reason most managers give is that they don't have enough paddocks while a few think it is not worth the hassle for the benefits that are obtained.

Table *4.4*-12. Amount of time that properties (in each region) keep heifers segregated from breeders for.

	Darwin	Katherine	Barkly	Alice
Until start of 1st Joining	41 %	13 %	14 %	38 %
After first joining	6 %		7 %	10 %
After weaning of their first calf	18 %	44 %	29 %	10 %
Until start of 2nd joining	24 %	11 %		24 %
Until preg with 2nd calf		4 %		
After weaning of their second calf		9 %		5 %
Until start of 3rd joining	6 %		7%	
For first three calves		4 %		
Heifers stay in an age group for life	6 %	13 %	43%	14 %

Table *4.4*-13. Percentage of properties in each region that practice controlled mating.

	1st joining	2nd joining	breeders
Darwin	46 %	35 %	35 %
Katherine	25 %	24 %	19 %
Barkly	6 %	6 %	
Alice Springs	16 %	3 %	3 %

*Note – 50% of properties in the Roper district of the Katherine region practice control mating of their maiden heifers.

Table *4.4*-14. Main reasons given for not control mating.

	Paddock & labour shortage	Bull control is too difficult	Expect lower fertility	Too much hassle	No reason given
Darwin	42 %	4 %		4 %	50 %
Katherine	25 %	25 %	14 %	3 %	32 %
Barkly	41 %	24 %	12 %		23 %
Alice Sp.	53 %	3 %	13 %	8 %	24 %

Table *4.4*-15. Average length of joining period (months) on properties that do practice control mating.

	1st joining	2nd joining
Darwin	3.9	4.6
Katherine	5.0	5.0
Barkly	5.0	5.0
Alice Sp.	5.8	5.5

Table *4.4*-16. Month in which properties commence control mating.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Darwin		8 %	50 %	42 %			
Katherine			53 %	33 %	7 %	7 %	
Barkly	only 1 property control mates						
Alice Sp.		33 %	33 %	17 %			17 %

Table *4.4*-17. Bull percentage used in breeding herds.

	Avg	Max	Min
Darwin	4.0	10	2
Katherine	4.3	10	2
Barkly	4.0	7	3
Alice Springs	4.9	10	3

Table *4.4*-18. Age of bulls used to mate with maiden heifers (percentage of properties in each district that use bulls of that age over their maiden heifers).

	18 mths	2 y.o	2.5 y.o	3 y.o	> or = 4 y.o
Darwin		37 %	16 %	32 %	16 %
Katherine	4 %	47 %	20 %	22 %	7 %
Barkly	18 %	35 %	18 %	24 %	6 %
Alice Springs	33 %	52 %		5 %	10 %

Weaning

Table *4.4*-19. Summary of minimum weights that properties wean down to in each region (weights are as estimated by the manager).

	% of properties that wean	1st round			2nd round		
		Avg	Max	Min	Avg	Max	Min
Darwin	100	113	220	70	116	180	60
Katherine	100	111	210	40	98	210	40
Barkly	100	140	200	70	111	170	60
Alice Sp.	92	160	280	80	161	275	80

Table *4.4*-20. Average of the minimum weight of calves weaned from different classes of cattle (weights are as estimated by the manager).

	1st calf			2nd calf			Calves from breeders		
	Avg	max	min	**Avg**	max	min	Avg	max	min
Barkly	**108**	160	50	**115**	160	50	**122**	180	70
Darwin	**115**	200	70	**116**	200	70	**119**	200	70
Katherine	**97**	210	40	**102**	210	40	**117**	210	60
Alice Springs	**148**	270	90	**152**	275	90	**164**	275	90

Timing of weaning calves from lactating heifers. Most properties fit weaning the heifers into their normal mustering program but try to do them as one of the first paddocks they do, as a result it most commonly occurs in April/May although a small number in each region try to do it in March.

Table *4.4*-21. Main reason given for timing of weaning.

	Seasonal conditions	Condition of heifers	Access/condition of heifers	Labour availability	Size of calves	No special guidelines	No reason given
Darwin	7	5	8	2	1	2	1
Katherine	22	23	10	1	1	2	
Barkly	5	5	5		1		1
Alice Sp.	16	4	1	1	3	7	6

Selection of replacement heifers.

Table *4.4*-22. Estimated percentage of heifers kept as replacements.

	Avg	Max	Min
Darwin	63 %	100 %	2 %
Katherine	57 %	100 %	0 %
Barkly	61 %	100 %	20 %
Alice Sp.	62 %	100 %	10 %

Table *4.4*-23. Age (years) at which heifers are selected as replacements.

	Avg	Max	Min
Darwin	1.7	2.0	1.0
Katherine	1.8	3.0	0.5
Barkly	2	3	1
Alice Sp.	1.5	2.0	0.8

Table *4.4*-24. Importance of different selection criteria when selecting replacement heifers. Average of the scores given where 1 = low, 3 = neutral and 5 = high.

	Weight	Conformation	Type	Temperament	Colour	Fertility
Darwin	3.7	4.3	4.3	4.7	2.7	3.9
Katherine	3.8	4.4	4.1	4.3	2.4	4.0
Barkly	4.1	4.7	4.4	4.6	2.7	4.3
Alice Sp.	2.5	4.4	4.3	4.7	3.6	3.8

* Note - The other trait identified as being important was for polled cattle in the Alice Springs region.

Pregnancy testing, animal health and supplementation.

Table *4.4*-25. Percentage of properties that use pregnancy testing as a management tool on different classes of cattle.

	None	Drys/Culls	All	Heifers
Darwin	29 %	29 %	38 %	4 %
Katherine	29 %	54 %	12 %	5 %
Barkly	18 %	47 %	18 %	29 %
Alice Springs	81 %	11 %	1 property	5 %

Table *4.4*-26. Percentage of properties which give heifers different vaccinations.

	Botulism	Lepto	5 in 1	7 in 1	Vibrio
Alice	37%		8%	3%	
Darwin	42%	4%	15%	31%	
Katherine	92%	8%	19%	14%	17%
Barkly	88%	6%	6%		24%

Table *4.4*-27. Percentage of properties that supplement at different times.

	Darwin	Katherine	Barkly	Alice Sp.
Don’t supplement	20 %	5 %	18 %	31 %
Year round	60 %	44 %	65 %	33 %
Every dry season	4 %	27 %	12 %	18 %
Every wet season		2 %		
When condition starts to slip	4 %	5 %		8 %
As weaners	8 %	17 %		3 %
For survival in tough years				8 %
Dry season before 1st joining	4 %			
As per NIRS results			1 property	

Attitudes to management practices, change and research needs.

Table *4.4*- 28. Manager's opinion of the importance of different management strategies in improving fertility. Average of scores given by region where 1 = strongly don't agree, 3 = neutral, 5 = strongly agree.

	Darwin	Katherine	Barkly	Alice Sp.
Managing young heifers separate from breeders	4.3	4.5	4.2	3.5
Preventing out of season pregnancies (bull control)	4.5	3.8	3.9	2.6
Improving joining weights through supplementation	4.4	4.3	3.8	3.4
Improving joining weights through use of better paddocks for heifers	4.4	4.2	4.1	3.9
Vaccination against disease	4.2	4.0	4.5	3.2
Time of year that calves are weaned from heifers	4.5	4.2	4.4	3.1
Early weaning of calves from heifers	3.7	4.1	3.3	3.4
Mating heifers for the first time as yearlings	2.3	2.1	2.4	3.0
Use of pregnancy testing	4.1	3.7	3.9	2.9
Bull fertility testing	4.3	4.1	3.7	3.4
Bull percentage used at mating	4.7	4.2	4.3	3.8
Age of bulls used	4.3	3.9	4.1	3.7
Genetics/selection for fertility	4.1	4.3	4.3	4.0

Table *4.4*-29. Attitudes to changing current heifer management practices. Average of scores given by managers in each region where 1 = strongly don't agree, 3 = neutral, 5 = strongly agree.

	Darwin	Katherine	Barkly	Alice Sp.
Unlikely to change management as couldn't do it any better	2.6	2.0	2.6	2.9
Unlikely to change management due to lack of resources (eg paddocks, labour, finance etc.)	1.8	2.4	2.8	2.4
Would consider changing management if had more resources	3.2	3.7	3.6	3.4
Can't change much as other practices are not practical in our situation	2.8	2.0	2.9	3.0
Would consider changing if more information on alternative management practices was available	3.0	3.2	3.1	2.7
Would consider changing if new techniques were demonstrated to be better in our district	3.8	4.0	3.8	3.2
Are definitely thinking of changing our management	3.2	3.9	3.0	2.9

Table *4.4*-30. Future research needs identified by survey respondents. (The table shows the number of respondents who identified each area that they thought needed more research).

	Darwin	Katherine	Barkly	Alice Sp.
No research needed	12	3	7	9
Disease	3	12	2	
Effect of joining weight on fertility		8		3
Lots of research required in several areas	1	2		2
Supplementation	1		1	2
Not sure	1		1	2
Breeds	1	1		1
Bulls		3		
Research required that is specific to local areas	1			2
Mineral deficiencies	1		1	
Selection		2		
Behaviour/mothering	1	1		
Yearling mating		1		1
Out of season calving		1		
Crossbreeding		1		
HGPs		1		
Age effects			1	
No response given	4	23	4	16

4.5 End of Project survey results

The results of the end of project survey done in mid 2009 are presented below and where relevant compared to the results from the start of project survey.

One of the most noticeable things to come out of the surveys was that awareness of the extent of the problem of low fertility in first calf heifers increased over the duration of the survey. At the start of the survey the average estimate of branding rates in lactating first calf heifers by all the managers surveyed was 63%. In the end of project survey the average of the estimates of re-conception rates in first calf heifers was 42%. This shows that there does seem to be an increasing awareness of the problems with first calf heifer fertility. This is not surprising since the results of the performance recording work on NT properties were communicated to producers at many field days, and through many articles in the media and newsletters as well as on radio interviews. The first step in solving a problem is realising that there is one and finding out the extent of it and this project seems to have been successful in doing this.

2009 End of Project survey – summary of responses

Table *4.5*-1. Summary of the number of properties surveyed in each region and the types of ownership of the properties.

	Number of properties with each type of ownership				
Region	**Company**	**Family**	**Private**	**Indigenous**	**Total**
Top End	1	4	2		7
Katherine	1	6	1	1	9
VRD	6	1	2	1	10
Sturt Plateau		8	3		11
Barkly	3	3	2		8
Alice Springs	1	4		1	6
East Kimberly	2				2
Grand Total	14	26	10	3	53

Note. In the 2004 survey the VRD and Sturt Plateau regions were included in the Katherine region but they are listed as separate districts in the 2009 survey as they are quite different.

There were considerably fewer properties surveyed in the 2009 survey than in the 2004 survey. This was because the 2004 survey was done in conjunction with the 2004 Pastoral Industry Survey (which involved many NT DoR staff visiting stations and doing “face to face” interviews with managers), while the end of project survey had to be done in isolation as it did not coincide with a major survey. As a result far less staff and resources were available to conduct the end of project survey and so it had to be done on a smaller scale (see method in section 3.5).

Although the number of properties in the second survey was lower, the number of properties were surveyed (53) was considerable and these are likely to be representative of the NT cattle industry.

Table *4.5*-2. Average number of cattle on the properties surveyed in each of the regions.

Region	Average number of cattle per property
Top End	14,564
Katherine	8 222
VRD	22,950
Sturt Plateau	9,045
Barkly	32,022
Alice Springs	13,177
East Kimberly	46,000
Overall average	17,588

Table *4.5*-3.
Average estimated branding rates for different classes of females in each region.

	Maiden heifers	1st Calf heifers	Breeders
Top End	68%	30%	63%
Katherine	38%	26%	60%
VRD	70%	45%	73%
Sturt Plateau	65%	49%	74%
Barkly	68%	45%	67%
Alice Springs	76%	53%	78%
East Kimberly	73%	45%	73%
Overall average	64%	42%	69%

In comparison, the over all average branding rates from the start of project survey were 67% (maiden heifers), 63% (first calf heifers) and 73% (breeders). While the estimated branding rates from the start and end of project surveys were fairly similar in maiden heifers and breeders (i.e. 3% lower in maiden heifers and 4% lower in breeders in the end of project survey) the estimated branding rates from first calf heifers were considerably lower (21% lower) in the end of project survey. It is unlikely that the performance of first calf heifers declined over the duration of the project but rather that there was an increase in the manager's knowledge of what the branding rates from first calf heifers are likely to be. From feedback at field days and conversations with managers this is almost certainly the case (T Schatz pers. obs.).

Table *4.5*-4. Average estimated calf loss rates for different classes of females in each region.

	Heifers	Breeders
Top End	11%	6%
Katherine	8%	4%
VRD	15%	8%
Sturt Plateau	11%	6%
Barkly	12%	8%
Alice Springs	6%	4%
East Kimberly	9%	2%
Overall average	11%	6%

Calf loss rates are extremely difficult to asses accurately since very few of the calf carcases are actually seen (Holroyd 1987). To accurately asses calf loss rates detailed records of cows pregnancy and lactation status need to be kept and this is not common on NT properties.

Therefore it is likely that calf loss rates were underestimated in this survey as the performance recording found an average calf loss rate of 22.7% in first calf heifers (see section 4.2).

Table *4.5*-5.
Percentage of properties in each region that use continuous or control (limited joining period) mating with different classes of females.

	Maiden heifers		1st Calf heifers		Breeders	
	Continuous mating	Control mating	Continuous mating	Control mating	Continuous mating	Control mating
Top End	43%	57%	57%	43%	57%	43%
Katherine	56%	44%	56%	44%	67%	33%
VRD	30%	70%	80%	20%	100%	
Sturt Plateau	50%	50%	60%	40%	60%	40%
Barkly	63%	38%	75%	25%	75%	25%
Alice Springs	67%	33%	83%	17%	83%	17%
East Kimberly	100%		100%		100%	
Overall average	52%	48%	69%	31%	75%	25%

In summary nearly half of producers control mate their maiden heifers but most use continuous mating thereafter. Control mating is used more in regions where the property size is smaller (eg. the Top End and Sturt Plateau).

Control mating does seem to be increasing in popularity when these results are compared to table *4.4*-13 (the table is re-printed here for comparison).

Table 4.4-13 *Percentage of properties in each region that practice controlled mating.*

	1st joining	*2nd joining*	*breeders*
Darwin	*46 %*	*35 %*	*35 %*
Katherine	*25 %*	*24 %*	*19 %*
Barkly	*6 %*	*6 %*	
Alice Springs	*16 %*	*3 %*	*3 %*

Table *4.5*-6.
Percentage of properties in each region that mate heifers for the first time at different ages.

	Age at which heifers first joined			
	12 - 17 months	18 – 23 months	2 years	> 2 years
Top End	20%		80%	
Katherine	11%		56%	33%
VRD		44%	44%	11%
Sturt Plateau	30%	10%	50%	10%
Barkly		63%	38%	
Alice Sp.	60%	40%		
Overall average	17%	28%	45%	11%

The most common age at which heifers are mated for the first time is at 2 years old. Nearly ¾ of properties mate their heifers for the first time between the ages of 18 months and 2 years.

Table *4.5*-7. Percentage of properties that supplement maiden heifers at different times of year.

	All year	Dry season / Winter	Wet season / Summer	Depends on season	Never	Only if essential for survival
Top End	71%		14%	14%		
Katherine	67%	22%		11%		
VRD	10%	50%		10%	30%	
Sturt Plateau	82%		9%	9%		
Barkly	25%	13%		25%	25%	13%
Alice Springs	33%	17%	17%	33%		
Overall average	47%	21%	6%	15%	9%	2%

Year round supplementation is most common in the Sturt Plateau district. Historically it was not considered good cattle country but in more recent times properties have been able to achieve production statistics that are equal to or better than most other districts through higher supplementation and more intensive management.

Around 70% of all properties supplement maiden and first calf heifers during the dry season (or winter) months (either by supplementing all year round or just during the dry season). Wet season supplements are fed by 53% of properties to maiden heifers and 58% of properties to first calf heifers (either by supplementing all year round or just during the wet season).

Table *4.5*-8. Percentage of properties that supplement first calf heifers at different times of year.

	All year	Dry season / Winter	Wet season / Summer	Depends on season	Never	Only if essential for survival
Top End	71%		14%	14%		
Katherine	78%	22%				
VRD	10%	60%	20%	10%		
Sturt Plateau	82%		9%	9%		
Barkly	25%	13%		25%	13%	25%
Alice Springs	33%	17%	17%	33%		
Overall average	49%	23%	9%	13%	2%	4%

Table *4.5*-9. Percentage of properties that give certain vaccinations to their heifers.

	Botulism	7 in 1	5 in 2	Vibriosis	Pestivirus (BVDV)	No vaccinations
Top End	57%	29%		43%	14%	14%
Katherine	100%	11%	11%		11%	
VRD	100%	30%		30%		
Sturt Plateau	91%	27%	9%	45%	9%	
Barkly	75%			13%		13%
Alice Springs	67%			50%	17%	33%
Overall average	85%	17%	4%	28%	8%	8%

The proportion of properties that vaccinate their heifers against vibriosis increased over the duration of the project. In 2004 no properties in the Darwin or Alice Springs districts said that they vaccinated against vibriosis but by the end of the project 50% of Alice springs properties and 43% of Top End (Darwin district) properties said that they vaccinate against vibriosis. When the

VRD and Sturt Plateau properties are included in the Katherine district (as they were in the 2004 survey), 27% of properties surveyed in the end of project survey vaccinated against vibriosis compared to 17% at the start of the survey. The proportion of properties on the Barkly that vaccinate against vibriosis declined slightly over the duration of the project (see table *4.4*-26 in section 4.4.7).

It is likely that this increase in vibriosis vaccination is due at least in part to the research done in this project. The trial that was done at Newry (reported in section 4.1.1) where vaccination against vibriosis increased pregnancy rates in maiden heifers by 11% (by the first round muster) was widely publicised and is likely to have resulted in an increase in the adoption of vibriosis vaccination. This work was published in scientific papers and presented at the 2004 NABRUC conference and field days where it generated quite a bit of interest. It also received quite a bit of interest in the media (eg. articles in Feedback magazine and Queensland Country life).

Vaccination against other diseases remained much the same although the use of botulism vaccination in the Alice Springs district seemed to increase (from 37% to 67%) over the duration of the project.

Table *4.5*-10. The issue identified by managers as having the biggest effect on their maiden heifer fertility. (The percentage of properties in each region that identify an issue as the major factor affecting maiden heifer fertility).

	Weight / Condition	Nutrition / season	Genetics	Disease	Supplementation	Bull %
Top End	14%	57%		14%		14%
Katherine	67%	22%	11%			
VRD	60%	40%				
Sturt Plateau	36%	27%	18%		18%	
Barkly	25%	75%				
Alice Springs	67%		17%	17%		
Overall average	45%	39%	8%	6%	4%	2%

The survey results from tables *4.5*-10 and *4.5*-11 show that most managers are aware of the importance of the effect that body weight / condition has in determining heifer fertility. While a significant number of producers nominated nutrition and season as the biggest factors affecting heifer fertility, the mechanism by which these factors affect fertility is through body weight/condition and so they are really much the same thing.

Table *4.5*-11. The issue identified by managers as having the biggest effect on their first calf heifer fertility. (The percentage of properties in each region that identify an issue as the major factor affecting first calf heifer fertility).

	Weight / Condition	Nutrition / season	Weaning	Genetics	Disease	Supplementation	Bull %
Top End	14%	71%					14%
Katherine	78%	22%					
VRD	40%	30%	30%				
Sturt Plateau	18%	55%		9%		18%	
Barkly	25%	75%					
Alice Sp.	50%		17%	17%	17%		
Grand Total	37%	45%	8%	4%	4%	4%	2%

Table *4.5*-12. Importance of different management strategies in improving fertility. Average of scores given by managers in each region where 1 = strongly don't agree, 3 = neutral, 5 = strongly agree.

Note that the results from the Sturt Plateau, VRD and Katherine districts have been combined in tables *4.5*-12 and *4.5*-13 to allow easier comparison with the 2004 survey.
+, - and = signs have been used to show where the 2009 results were higher, lower or the same as the 2004 survey results (where a result was within + or – 0.2 it was considered to be the same i.e.=).

	Darwin	Katherine	Barkly	Alice Springs	Over All
Segregation of heifers from breeders	3.6 -	4.3 =	4.5 +	4.5 +	4.2
Bull control (prevent out of season preg.)	4.1 -	4.0 =	3.1 -	3.0 +	3.8
Supplementation to increase weight	3.9 -	4.3 =	4.1 +	4.5 +	4.3
Use of better paddocks to increase weight	4.0 -	4.1 =	4.5 +	4.8 +	4.3
Vaccination against disease	3.1 -	4.4 +	3.9 -	4.3 +	4.2
Timing of weaning	4.4 =	4.5 +	4.4 =	4.0 +	4.4
Early weaning of calves from heifers	3.6 =	4.3 =	4.4 +	4.8 +	4.2
Bull fertility testing	3.9 -	3.7 -	3.9 =	3.5 =	3.7
Bull % used when mating heifers	4.0 -	4.3 =	4.1 =	4.0 =	4.2
Genetics / selection for fertility	4.4 +	4.5 =	4.6 +	4.0 =	4.4
Using lighter stocking rates to increase weights	2.9	3.6	3.6	4.7	3.7

Most strategies listed here were seen to be important in improving fertility except for fertility testing of bulls, bull control (preventing out of season pregnancies) in the Barkly and Alice Springs districts and using lighter stocking rates to increase fertility (except for in the Alice Springs district where this was seen to be quite important).

The importance that managers placed on bull control (or preventing out of season pregnancies) was highest in the region with the highest rainfall (Top End) and decreased as rainfall decreased.

Over all the regions the strategies considered to be most important for improving heifer fertility were genetics and timing of weaning followed closely by the use of supplementation and better paddocks to improve joining weights.

It is interesting to note that other than in the Alice Springs district, station managers don't see using lighter stocking rates as being very useful in increasing fertility. This is somewhat surprising as, in the opinion of the author it was one of the major reasons for poor body condition and hence low pregnancy rates where they occurred during the performance recording work.

In all regions except for the Top End, most of the strategies listed above were rated equal or higher by managers in the 2009 survey for their importance in improving heifer fertility than in the 2004 survey.

Table *4.5*-13. Attitudes to changing current heifer management practices. Percentage of managers in each region that identify with each attitude towards changing their heifer management.

	Would change if had more resources	Won't change – other practices are not practical	Would change if more information was available on alternative practices	Would change if other practices are demonstrated to be better	Are definitely planning to change
Darwin	29%	14%	14%	29%	14%
Katherine	30%		10%	37%	20%
Barkly	25%		38%	38%	
Alice Springs	33%			17%	50%
East Kimberly			100%		
Over all	29%	2%	17%	33%	19%

These questions were asked slightly differently in the 2004 survey where people rated how much they agreed with each statement on a 1-5 scale, whereas in the 2009 question they were asked which statement described their attitude the most. Nevertheless the statements given the highest scores over all the regions in the 2004 survey were that they would change their heifer management if other practices were demonstrated to be better and next highest rating attitude was that they would change if they had more resources. These statements were also the most commonly identified as describing manager's attitude to change in the 2009 survey.

Only one property manager chose the option "won't change as other practices are not practical in our situation" as best describing his attitude to change. This property is in the Top End near the coast and most of the land is floodplain which is submerged by water for long periods each year which makes management there very different to all the other properties that were surveyed.

Appendix 9.6 requires a landscape formatted page and so is printed at the end of this report.

9.6 Appendix - Performance of heifers on NT commercial cattle properties.

Only heifers that conceived before their calves had been weaned were included in calculating the 1st lactation heifer pregnancy rate. VRD = Victoria River District, Barkly = Barkly Tableland, Alice Sp. = Alice Springs district, C = central, N = north, S = south, E = East, W = west, Bra = Brahman, Bra X = Brahman cross, Santa = Santa Gertrudis. The year and month in which the measurements were recorded are shown in superscript.

Property location	Breed	Maiden heifer pregnancy rate (%)	Maiden heifer N	1st lactation heifer pregnancy rate (%)	1st lactation heifer N	1st lactation heifer Avg. Wt. at WR1 (kg)	Peak calving months	1st lactation heifer calf loss (%)
VRD (N)	Bra	59 [2005]	594	4 [2006]	397	306 [May]	Oct-Dec	24
	Bra	65 [2006]	466	5 [2007]	284	314 [Apr]	Oct-Dec	34
VRD (S) [(1)]	Bra & Bra X	72 [2005]	321	17 [2006]	197		Oct-Feb	15
	Bra & Bra X	32 [2006 (5)]	375	2 [2007]	117	315 [Sep]	Nov-Feb	32
	Bra & Bra X	92 [2007 (6)]	203	23 [2008]	188	367 [May]	Dec - Mar	18
VRD (E)	Bra	84 [2003]	910	14 [2004]	519	312 [Apr]	Oct-Dec	12
VRD (C)	Bra	84 [2005]	230	1 [2006]	90	256 [May]	Dec-Feb	14
Sturt Plateau	Bra & Bra X			30 [2007]	217	294 [Jul]	Oct-Jan	25
	Bra & Bra X	53 [2007 (7)]	346	33 [2008]	195	341 [May]	Oct-Jan	11
	Bra & Bra X	87 [2008]	363	39 [2009]	245	334 [May]	Oct-Jan	12
Barkly (N)	Bra & Bra X	85 [2005]	447	3 [2006]	205	309 [Aug]	Sep-Dec	32
Barkly (NW)	Santa			7 [2005 (8)]	394	316 [Aug]		
Barkly (C) [(1, 2)]	Composite	86 [2006]	85	88 [2007]	73	494 [May]	Oct-Nov	10
Barkly (E)[3]	Composite			76 [2007]	385	421 [Aug]	Nov-Jan	30
	Santa			68 [2007]	892	416 [Aug]	Oct-Jan	39
Barkly (SW)	Santa			21 [2005]	121	321 [May]	Sep-Dec	35
Alice Sp. (N)	Shorthorn	84 [2005]	254					
Alice Sp. (N)	Santa	88 [2007]	146					
Alice Sp. (S)	Angus	81 [2004]	130	17 [2005]	102	322 [Jun]	Oct-Jan[9]	4
	Angus	77 [2005]	154	16 [2006]	135	313 [Apr]	Oct-Jan[9]	12
	Angus	64 [2006]	189	16 [2007]	151	293 [Apr]	Oct-Jan[9]	16
	Angus	56 [2007]	203	22 [2008]	137	320 [Apr]	Oct-Jan[9]	14
	Angus	66 [2008]	148	46 [2009]	114	361 [Apr]	Oct-Jan[9]	11
VRD (C)4	Bra	90 [2006]	110	39 [2007]	45	365 [May]	Sep-Dec	8

[(1)] These 2 herds were control mated for 3 months (all the other herds were continuously mated).
[(2)]This is a stud herd.
[(3)]Two groups of heifers (of different genotypes in separate paddocks) were recorded on this property.

[4] This was an extensively managed herd on Victoria River Research Station (VRRS).
[5] The wet season failed in this year (only 17 kg growth occurred over the wet season) and so pregnancy rates were much lower than normal.
[6] Heifers that did not conceive the previous year were held over and mated again.
[7] Heifers were mated at the end of the year in which they were weaned and so were almost a year younger at first mating than is normal for maiden heifers in the NT.
[8] Drier than average conditions were experienced in this year resulting in performance that is lower than normal on this property.
[9] Calving occurred throughout the year although there was a peak during these months.