final report

Project code: E.PDS.1407

Prepared by: David Smith and Dr Geoffry Fordyce
Department of Agriculture and Fisheries / QAAFI

Date published: 28 February 2017

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 1961
NORTH SYDNEY NSW 2059

Demonstrating the effect of live weight on heifer pregnancy rates in northern Queensland

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

A group of beef producers north of Charters Towers identified low heifer pregnancy rates as a consistent and significant problem, aligning with the regional median from the Cash Cow project of 67%. Results from their Producer Demonstration Site (PDS) over three years monitoring >1,300 heifers clearly demonstrated a highly significant ($p<0.001$) relationship between proportion pregnant and weight. To achieve rates of more than 75% in high-percentage Brahman type heifers, live weights of at least 400 kg at pregnancy diagnosis (end of mating) was required. Ovarian scanning demonstrated a pre-mating live weight of approximately 340 kg was required for 80% of heifers to be at or near puberty. Neither pestivirus nor vibriosis were shown to be contributing factors in this study. Use of fewer, better bulls (<2% v 4%; selected on scrotal circumference and semen traits) significantly reduced business costs without reducing pregnancies. A 2% bull: female ratio was subsequently adopted by the host property across the entire breeding herd. This project's findings are relevant to the entire northern beef industry and highlighted the importance of managing for high heifer growth prior to their first mating.

Executive summary

High expectations of heifer performance is quite widespread within the beef industry. Often forgotten is that cattle of most breeds have been bred to be larger over the past decades. This has positive implications for sale animals, but some drawbacks such as delayed heifer puberty, which is directly related to mature animal size. Heifer management in northern Australia typically includes segregating weaned females until mating at approximately two years of age. In general, live weight of heifers is not known and a 'mate most or all heifers' strategy is commonly practiced and recommended by agency and private specialists. Unfortunately, quick diagnosis of the causes of lower than expected heifer pregnancy rates is difficult due to inadequate herd records, especially live weight and reproductive disease status.

A group of beef producers north of Charters Towers identified low heifer pregnancy rates as a consistent and significant problem, aligning with the regional median from the Cash Cow project of 67%. A producer demonstration site (PDS) was established at Mt Oweenee Station, located in north Queensland, in December 2013 to demonstrate that low heifer live weight is the primary cause of lower than expected pregnancy rates. A producer group consisting of 11 properties, representing approximately 40,000 cattle on 320,000 ha was formed to participate in this study.

The evidence, collected over the three years (three different cohorts of heifers), clearly demonstrated the negative effect of low live weight during mating on heifer pregnancy. A logistic regression analysis showed the relationship between proportion pregnant and live weight was highly significant ($p<0.001$), with no effect of either breed or year group.

This data was specific to one herd, however it validates previous research data. It is recommended that beef producers build their own simple set of heifer weight and pregnancy data to understand what is achievable for their current phenotype. For this herd, live weights of at least 400 kg needed to be attained by the end of mating to achieve higher than 75% pregnancy rates. This finding is consistent with previous research results for Brahmans (Beef CRC). Although this project was only able to obtain pubertal data in the first cohort prior to mating, it demonstrated weights of around 340 kg are required to have at least 80% of animals at or near puberty prior to mating (Fig 7). This finding aligns with other research; in particular Johnston et al., (2009) who indicated average weight at puberty in Brahmans and Tropical composites was 334 kg; with a range of + or - 90 kg for 95% of heifers. A spreadsheet model to predict heifer weight at puberty based on *Bos indicus* content and mature cow weights had been developed using CRC research data, but needs further validation in commercial situations.

A pre-mating weight, at the time the bulls go in also known as a Critical Mating Weight (CMW), is commonly recommended as a target weight for maiden heifers in southern Australia. However, recording heifer weight data prior to mating is often difficult and not commonly practised in the northern industry. As at least two fertile cycles are required to achieve 90% pregnancy (Fordyce, 2006), an alternative target is to have heifers reach sufficient live weight to achieve a potential third ovulation before the end of mating, i.e., reach puberty within six weeks of the end of mating. This target weight is primarily a function of the cow herd's mature live weight and will vary depending on the proportion of Bos indicus content. Freetly etal 2011, concluded that 'within species of cattle, the relative range in proportion of mature body weight at puberty (Bos Taurus 0.56 through 0.58, and Bos indicus 0.60) *was highly conserved*'. Fordyce, (Pers Comm 2017), has similarly concluded that average weight at puberty is ~60% of mature cow weight in Bos taurus cattle and closer to 70% of mature cow weight in Bos indicus cattle. Crossbreds with low Brahman content will be closer to 60% of mature cow live weight and in herds selected for earlier age at puberty. This was also reported by Fordyce etal 2014 at the World Buriatrics Conference. The data in this study suggests an end of mating weight

of at least 400kg is required to achieve at least 75% pregnancy rates. This target, although after the event, is a practical measure that can be targeted by nutritional management from weaning and used for diagnostics to help discriminate causes of low heifer pregnancy rates.

Vibriosis and pestivirus are generally the most prevalent and detrimental reproductive diseases in northern Australia. It is common for producers to assume disease is the main cause of poor heifer performance whereas this study counters this view. Neither disease was found to be causing significant impacts on heifer performance for the three study years and is consistent with the recent Cash Cow project (McGowan et al., 2014).

Using fewer, better bulls can drastically reduce costs with minimal risk. Sound, veterinary tested bulls that passed a Bull Breeding Soundness Evaluation (BBSE) were used for each heifer mating eliminating bull performance as a causal factor for low pregnancy. For genetic improvement, preference was given to bulls with average or better scrotal size for their breed and weight, and high percentage normal sperm that will sire more fertile female progeny.

A common industry practice is a bull: female ratio of 4% (4 bulls per 100 females). This project demonstrated a ratio as low as 1% could be used without penalty to pregnancies, and can improve business outcomes greatly by significant cost reductions and eliminate most bull behaviour problems. This finding supports previous Bull Power project research (Holroyd RG et al., 2000) which recommended a bull ratio of no more than 1 bull to 40 cycling females. Mt Oweenee station is now applying this strategy across the entire cow herd which is now mated at no more than one veterinary tested bull to 50 females (2% bulls). This simple practice change, resulting in large short term and longer term costs savings has been well received by both the producer group and wider industry. This was an unintended, yet positive project outcome.

Pre and post survey audits of the producer group showed substantial knowledge gains in heifer management and a measurable change in practice change intent. Their improvements in knowledge, from pre project and post project survey data, included awareness and understanding of past research work (40% improvement), understanding better bull selection techniques (30% improvement), and how to use a more diagnostic approach (44% improvement). The producer group indicated there was intent of practice change with either agreeing or strongly agreeing that plans would be put in place for testing and understanding the disease status of their herd for pestivirus and vibriosis, and for using scrotal size as a tool when selecting bulls. Five out of six respondents also agreed they would start weighing heifers, although no start date was suggested.

In summary, the key to the success of this project was clear, practical messages that were supported by previous research. The messages are:

- As a general rule, to consistently achieve high heifer pregnancy rates, live weight during the mating period will need to be higher than general industry expectations. Reproductive disease may cause intermittent crashes. Management, in particular nutrition and growth patterns, is the major cause of low performance.
- Target live weight should typically be at least 400 kg at the end of mating to get high pregnancy rates in high Brahman content herds. In this management system the end of mating was also the time of pregnancy diagnosis (PD). This target may be higher or lower for different herds, depending on mature cow live weights, breed and whether there has been selection for lower age at puberty within breed.
- Reproductive diseases can be a significant problem sporadically, but more commonly low heifer pregnancy rates are due to insufficient live weight to reach puberty before the end of mating. To control the main two reproductive diseases producers should vaccinate bulls

annually for vibriosis (where bulls can be controlled) and test each year's heifer group for pestivirus antibodies to assess the need for vaccination.
- Use fewer better bulls (maximum 2.5% bulls to cycling females), which can dramatically reduce business costs at almost nominal risk.

Although this study was complicated by serious drought conditions for all three years (below the fifth percentile), with animals being relocated to several properties during the data collection period; the data still confirmed the original hypothesis that low heifer live weight during mating was the primary cause of sub-optimal pregnancy rates. While age at puberty is also highly heritable the project clearly demonstrated that weight, rather than age is the trait which commercial producers need to target. This was evident in the drought year as pregnancy rates were only about half that achieved in heifers of the same age in better seasons. The value of this work was reinforced by comments from the producer group on the practical nature and 'real life' scenarios that the project endured while still remaining focussed on the outcome.

Table of contents

1 Background

The Mt Oweenee producer group consisting of 11 properties representing approximately 40,000 cattle on 320,000 ha and was formed in 2013 with the aim of better understanding their herds' heifer performance and applying options for improvement. The group members' previous experience with learning activities was diverse ranging from those who had actively participated with previous research, completed Grazing Land Management and Business Edge and other training packages, through to a property that has had minimal contact with research and training organisations. The common motivation across all of the group was the need to improve heifer performance.

The environmental conditions and the relatively low production potential (kg live weight produced annually) in the forested areas of northern Australia limits the onset of puberty to at least two years of age (Burns, 2010). The most realistic strategy for heifer management in northern Australia to optimise female lifetime productivity is to ensure that a majority of heifers have attained puberty before the end of mating at two years of age. Schatz and Hearnden (2016) concluded that Brahman type heifers in northern Australia needed to achieve live weights of around 344kg by the start of mating for 80% pregnancy rates and such growth rates are generally not achievable by one year olds.

A literature review (Burns, Fordyce et al., 2010), reports that the onset of puberty is primarily a function of live weight, that is, at a physiological rather than a chronological age (Moran et al., 1989). This is supported by (Fordyce, 2006) stating weight is the most significant factor influencing puberty and this is mainly a function of breed, nutrition, season and genetic variation. A reported mean live weight at puberty of *Bos indicus* cross heifers using behavioural oestrus as the indicator was 285 kg at 20.5 months of age (Holroyd and Fordyce 2001). However, recent work (Johnston et al., 2009) found the mean age and live weight at puberty in Brahman heifers was 25.2 months and 337 kg and in Tropical Composites, 22.4 months and 332 kg.

Recent large scale research (McGowan et al., 2014) demonstrated the large range in heifer pregnancy rates for all regions in northern Australia. This was particularly seen in the low productivity northern forest areas where the median was 67% and the interquartile range (25-75 percentiles) was 40-81% indicating there is substantial improvement potential for many situations. Although there have been numerous studies in this field, with fairly conclusive evidence, there is an obvious lack of understanding and application of available recommendations by the northern beef industry. This project utilised previous research on heifer puberty and pregnancies in northern Australia and validated findings on a commercial beef business as a demonstration and extension activity.

The purpose of this study was to monitor a host heifer herd with consistently lower than expected pregnancy rates and demonstrate that live weight of heifers during the mating period is the main driver of puberty and subsequent pregnancy rates. Developing the process of a practical, relevant, on-property demonstration that adequately defined the problem and narrowed down the causal factors over a number of years was seen as critical. This would be achieved by basic, focussed data recording of critical information (live weight and pregnancy).

2 Project objectives

By December 2016:

- Describe the current heifer management practices of the project mobs to demonstrate how heifer weight affects puberty and subsequent pregnancies.
- Demonstrate strategies for producers to manage heifer growth and to ensure a large percentage of these have reached puberty and achieve satisfactory mating outcomes at first mating.
- Develop a series of practical recommendations including nutritional and genetic options in a Tips and Tools publication for producers to manage and select for reduced age at puberty (Appendix 9.6).
- Recorded uptake of changed management and selection practices in the group at the end of the project.

3 Methodology

This demonstration project monitored the three consecutive year groups of heifers in the commercial Mt Oweenee beef herd with the primary aim to define the problem of lower than expected pregnancies. The study commenced in December 2013 and monitoring was completed in June 2016.

Our hypothesis was that low heifer live weight during mating was the primary cause of sub-optimal pregnancy rates, mostly due to the inherently low productive potential much of northern Australia or nutritional mismanagement. It is also recognised that the genetic makeup of the herd is also a factor, however this was out of scope for this project.

3.1 Mt Oweenee property

Mt Oweenee station is located approximately 120 km north of Charters Towers, Queensland (S19.388 E145.635) (Fig. 1) and owned and managed by the O'Neill family. The predominant land type is Goldfields (red soil) that is undulating rising up to ranges with narrow leaved ironbark and bloodwood trees. Pastures are native grasses with some stylos. Fertility of this land type is typically classified as low with expected average annual steer growth of approximately 130 kg. Average long-term annual rainfall is approximately 550 mm falling mostly in the summer months.

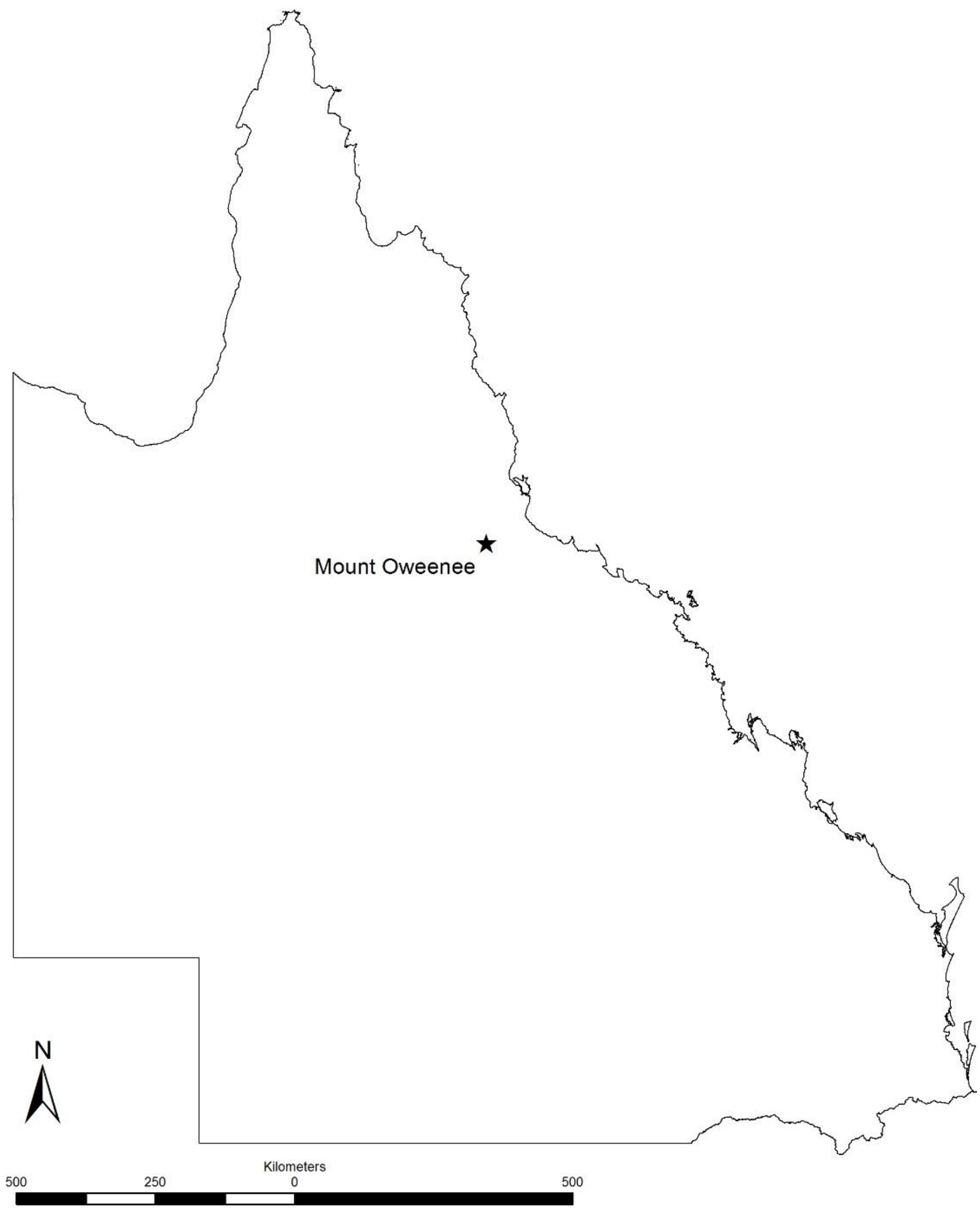


Fig. 1 Location map Mount Oweenee station

Cattle management for the crossbred breeding herd (Droughtmaster, Charbray, Brahman crosses) includes seasonal mating for approximately five months starting in January, and one main weaning period coinciding with the end of mating (May/June). Paddocks are opportunistically wet season spelled and typical stocking rates are 1 AE : 8 ha, which is common for the district.

3.2 Animals and measurements

Three consecutive heifer cohorts (No.12, 13 and 14; total of 1,302) were monitored. Supplementation was as per routine station management, i.e., we monitored management and measured the outcome. Mating commenced mid-January each year and bulls were removed at the pregnancy testing/weaning round in May-June. Any heifer culling was carried out prior to mating based on routine station policy, i.e., for poor temperament, conformation defects, etc. All bulls were vaccinated against vibriosis annually and subject to a full veterinary examination (Bull Breeding

Soundness Evaluation - BBSE) prior to mating. The final measurement for each cohort was at pregnancy diagnosis (foetal aging) after completion of mating when the heifers were ~2.5 years of age (Tables 1, 2).

Live weights were measured following an overnight wet curfew (on water, off feed) and on electronic scales mounted under a veterinary crush. Body condition was scored using a standard 5-point scale. Live weight and BCS monitoring began with the No.12 heifers prior to mating in December 2013 and finished in June 2014. The No.13 heifers were monitored from 18 months of age (Aug-Sep 2014) and finished in September 2015. The No.14 heifers were monitored from weaning (May-Jul 2014) to June 2016.

Ovarian scanning to detect early ovarian activity was planned at approximately 15-18mths of age (No.13 and No.14) and again at the start of mating (December of each year). Ovaries were scanned by a skilled veterinarian per rectum using a 60 mm linear array ultrasound probe (Honda 2100V®) for the presence or not of a corpus luteum which is indicative of the heifer having reached puberty. Foetal ageing using manual palpation was assessed by an accredited veterinarian. In addition, ultrasound was used to confirm non-pregnancy.

To assess the potential impact of pestivirus affecting pregnancies, BVDV antibody prevalence in each cohort was assessed (blood samples) either pre-mating or at foetal ageing.

Table 1. Management of each heifer cohort used

	No.12	No.13	No.14
Weaned	Mid-2012	Mid-2013	Mid-2014
Induction	Mid-2013	Mid-2014	Mid-2014
Maiden mating	Jan 2014	Jan 2015	Jan 2016
Foetal ageing	Mid-2014	Mid-2015	Mid-2016

Table 2. Animal data collection schedule (planned)

		No.12	**No.13**	**No.14**
Weights	Weaning	NA	NA	May-Jul 2014
	18 months	NA	Aug-Sep 2014	Apr-Jul 2015
	Pre-mating	Dec 2013	Dec 2014	Dec 2015
Reproduction	18 months scan	NA	Aug-Sep 2014	Aug-Sep 2015
	Pre-mating scan	Dec-13	Dec-14	Dec-15
	Foetal ageing	May-Jun 2014	May-Jun 2015	May-Jun 2016

NA – monitoring had not yet commenced

3.3 Environmental measurements

Rainfall measurements were calculated through interpolated SILO data drill (Bureau of Meteorology). Pasture diet quality was measured by faecal NIRS analysis of paddock-collected dung samples. Phosphorus adequacy of the diet was measured annually at the end of the wet season using P-Screen methodology.

3.4 Demonstration/information/field days

PDS group meetings were held on-property at each pregnancy diagnosis muster. Producers were invited to participate in the yard work, and following lunch the group discussed the results and learnings.

Two open field days were held at the end of the project (June and December 2016). The field days were informal and held at the cattle yards. The days provided a brief summary of key findings followed by a lengthy question and answer session with technical specialists. The producers determined the direction of the discussion.

3.5 Monitoring and evaluation

A pre-project online survey to assess current skills, knowledge and understanding of heifer management was completed by the PDS group members in December 2013. A similar post-project survey was completed by group members in Jan 2017. An evaluation at the final field day also determined the value of the study.

4 Results

4.1 Seasons and management

Rainfall during the project (Fig. 2, Appendix 9.5) was low. The region was classified as a 1 in 20 year drought with the lowest percentile rainfall period between 1 October 2014 and 31 December 2015, i.e., within the lowest 5% of rainfall records. These conditions were widespread with many areas of Queensland in a 1 in 10 rainfall event (Fig. 3).

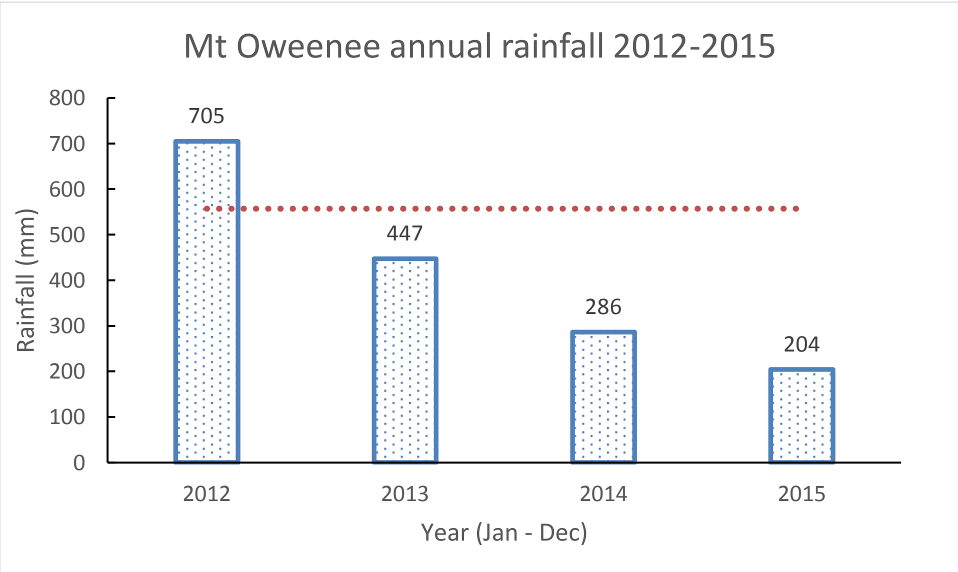


Fig. 2. Mt Oweenee annual rainfall (January to December) for interpolated SILO data (-19.40, 145.65 Dec deg) Source: The Long Paddock

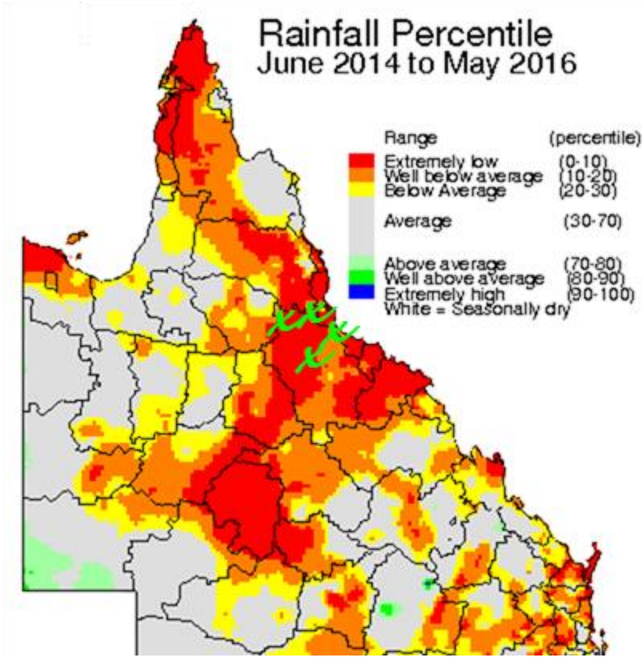


Fig. 3. Rainfall over the last 24 months of the project. Source: The long paddock. Properties used for agistment are marked with ✱

The proposed schedule of animal measurements changed due to the serious drought conditions which endured for the three years of the project. However, enough critical information was collected and, with extraordinary cooperation from Mt Oweenee management, we were able to complete the project with useful findings for the producer group and broader northern beef industry. The No.13 and No.14 heifers endured drought conditions from birth until the end of the project. Starting their lives at Mt Oweenee, these heifer groups were relocated several times as feed reserves on agistment properties ran out during the demonstration period. From June 2014 the No.13 group were split between an agistment properties south west of Mt Oweenee on the basalt land types, and on a property west of Home Hill on coastal poplar gum land types. On 23 March 2015 the basalt mob was shifted to a property south west of Bowen and another near Collinsville. The No.14 heifers were relocated onto agistment properties near Bowen and Collinsville on 9 April 2015. A small group of No.14 heifers remained at Mt Oweenee. Table 3 shows the actual schedule for all animal recordings.

Table 3. Actual data collection schedule

		No.12	No.13	No.14
Weights	Weaning	NA	NA	May-Jul 2014
	18 months	NA	Aug-Sep 2014#	Apr-Jul 2015#
	Pre-mating	Dec-13	NA	NA
Reproduction	pre mate ovarian scan	Dec-13	NA	NA
	Foetal age	May-14	Jul-Sep 2015	Jun-16

NA not available (mostly due to drought condition, poor cattle condition or unable to coordinate musters at the different agistment properties).
only part of the total mob weighed at certain agistment properties (mostly due to logistical problems with poor facilities or unable to coordinate musters between multiple properties.

4.2 Summary of weight and pregnancy

Traditionally the most quoted weight for heifers is a pre-mating target weight. The most reliable weight data we obtained was at pregnancy diagnosis after mating (Fig. 4). The growth of the No.13 heifer group was very different to the other two years with almost half of the mob weighing less than 350 kg by the end of mating. The opportunities for other live weight measures were impaired due to logistical issues arising from severe drought and cattle being shifted to several agistment properties. A No.13 subset weighed four times from yearlings (March 2014) achieved an average annual live weight gain to March 2015 of only 77kg (Table 4).

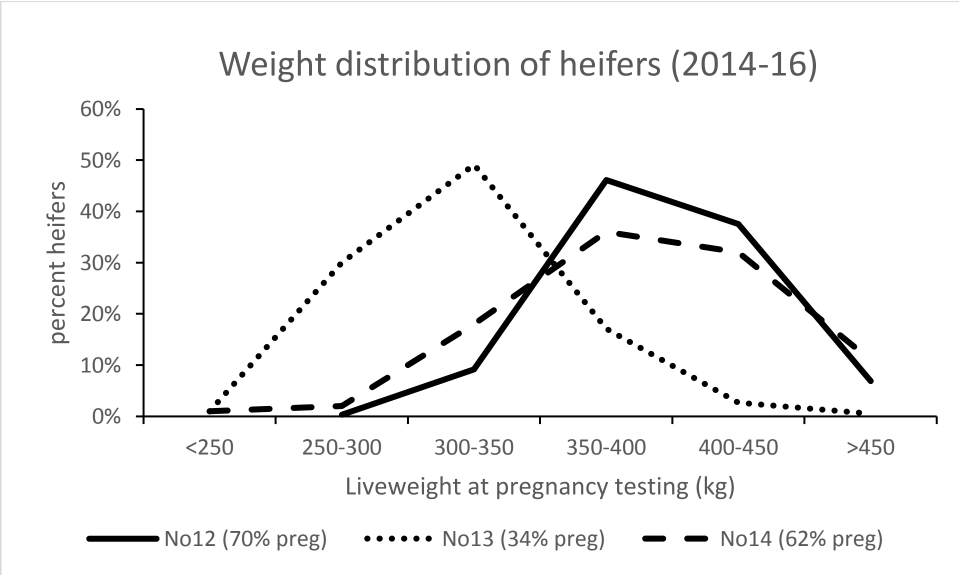


Fig. 4. Distributions of live weight of each Mt Oweenee heifer cohort after mating at pregnancy diagnosis

Table 4. Number of heifers in each weight range category and over-all average weight of the No. 13 and No.14 cohorts

	No.13					**No.14**		
Weight range	Mar 14 Ylg	Sep 14 Ylg	Feb 15 Mate	Mar 15 Mate	Jul 15 PD	Jun 14 Wean	Jul 15 Ylg	Jun 16 PD
0-200 kg	102	66	Sub sample of 30 weighed	0			41	
200-225 kg	73	96		2			38	
225-250 kg	20	50		24	2		18	
250-275 kg	20	23		65	21			
275-300 kg	12	12		60	47			
300-350 kg	9	6		73	86			
350-400 kg		1		9	26			
>400 kg				3	3			
Total number	236	254		236	185		97	
Av live weight	214	223	262	291	317	150	205	389

The number of heifers in three separate cohorts at pregnancy diagnosis and their average live weights and pregnancy rates are shown in Table 5.

Table 5. Live weight and pregnancy data from all heifers at pregnancy testing

Mating	Cohort	Total		Pregnant			Empty
		Number	Av Wt (kg)	Number	Rate	Av Wt (kg)	Av Wt (kg)
2014	No.12	354	396	248	70%	402	383
2015	No.13	565	321	191	34%	344	309
2016	No.14	383	391	238	62%	405	367
	Total	1,302	362	677	52%	387	335

A clear and consistent relationship between live weight at pregnancy diagnosis and pregnancy was established (Fig. 5). For the Mt Oweenee herd, a post-mating target weight of 400 kg is needed to achieve a pregnancy rate of 75%. Although weight distribution and overall pregnancy rates varied considerably between years, pregnancy rates within weight classes remained relatively stable.

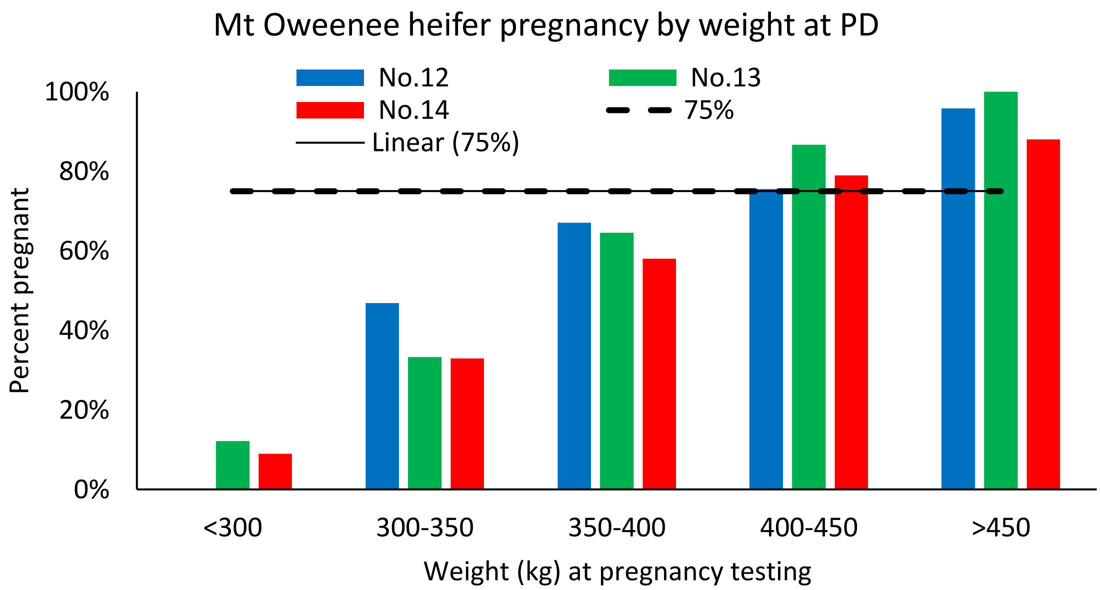


Fig. 5. Pregnancy by weight category after mating for each heifer cohort at Mt Oweenee

A logistic regression analysis showed the relationship between proportion pregnant and weight was highly significant ($p<0.001$), with no effect of either breed or year group. The relationship is shown in Fig.6. For more detailed statistical information see Appendix 9.3.
The equation was:

Logit (p) = -7.702 (se 0.499) + 0.02160 (se 0.00138) x weight

[where p = proportion pregnant and logit p = log (p / (1-p))]

Equivalently,

p = e(-7.702 + 0.02160 x weight) / (1 + e(-7.702 + 0.02160 x weight))

[where p = proportion pregnant]

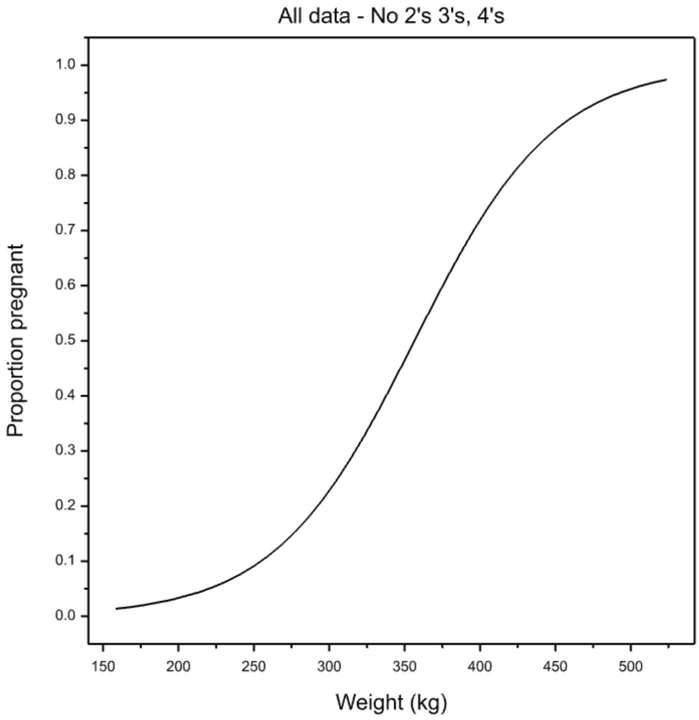


Figure 6. Relationship between Proportion pregnant and Weight at PD (for all data from No.12's, No.13's and No.14's)

4.3 Summary of pre-mating scanning

Pre mating scanning only occurred in year 1 (No.12 heifers) when only half had either cycled (29% with a CL, 8% pregnant) or were nearing puberty (22% with a large follicle). An attempt at scanning was made with the No. 13's in September 2014 on one of the agistment properties however, these heifers were substantially underweight and in backward body condition. After scanning the first thirty (with no sign of any ovarian activity) we ceased scanning and recorded weights only. By December 2014 the No.13 heifers were agisted across another two new agistment properties, also suffering drought, and were unable to be mustered due to the difficult logistics of coordinating musters and the poor condition of the heifers. Drought conditions continued throughout 2015 and No.14 heifers were not weighed or scanned at 18 months of age (September) or premating (December 2015) due to the logistical reasons cited above.

The No.12 cohort weights, measured, a month prior to mating in December 2013, showed a clear linear relationship (R^2=0.95) with puberty (Fig. 7) with a live weight of about 340 kg to achieve 80% of heifers at or near to puberty.

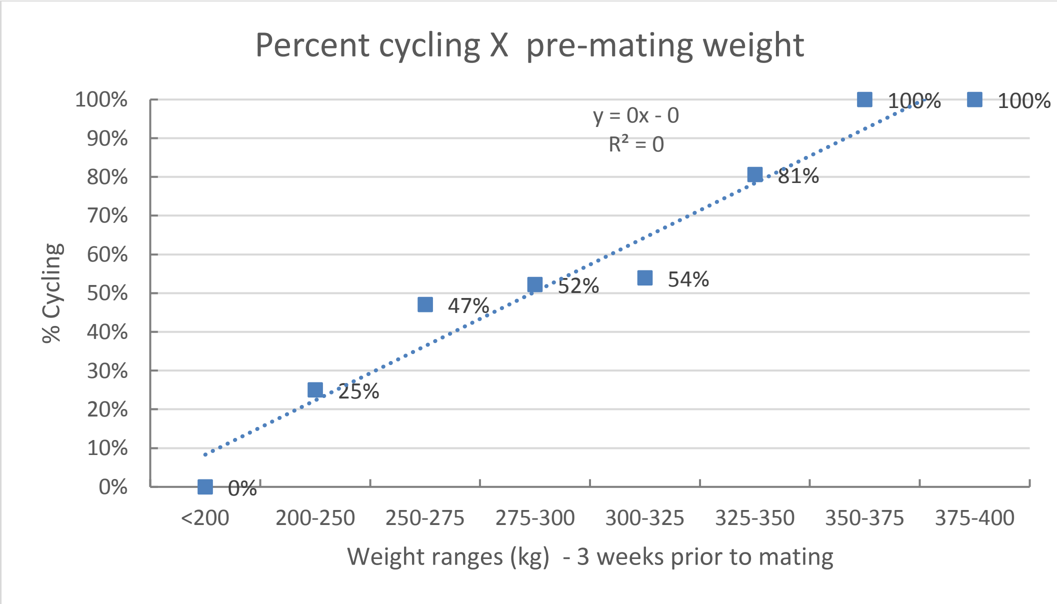


Fig. 7. Relationship of pre-mating live weight with the percentage of heifers that had cycled or had a large ovarian follicle

A spreadsheet model, based on *Bos indicus* content and mature cow weights that predicts heifer weight at puberty has been developed using research data. This was to be tested on the producer group's own herds for further validation in commercial situations however drought conditions precluded this further testing.

4.4 Summary of NIRS and P status

4.4.1 NIRS

The frequency of NIRS dung sampling decreased as heifers moved onto various agistment properties mostly due to the long distances between properties. The analyses (Figures 8, 9) demonstrate the typical seasonally dry periods from June until December with low crude protein and digestibility indicating a response from urea based supplements. The No.13 heifers were moved to two agistment properties in June 2014. More detail (Appendix 9.1). The graphs below show results from the No.12 heifers and No.13 heifers on the basalt agistment property.

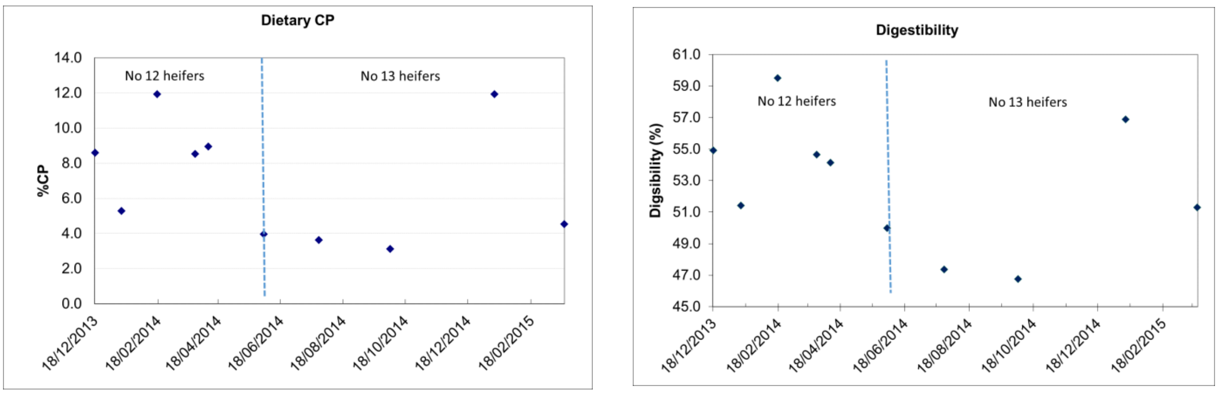


Fig. 8. NIRS estimates for dietary crude protein and digestibility of Mt Oweenee heifers. The No. 13 heifers were on the basalt agistment property.

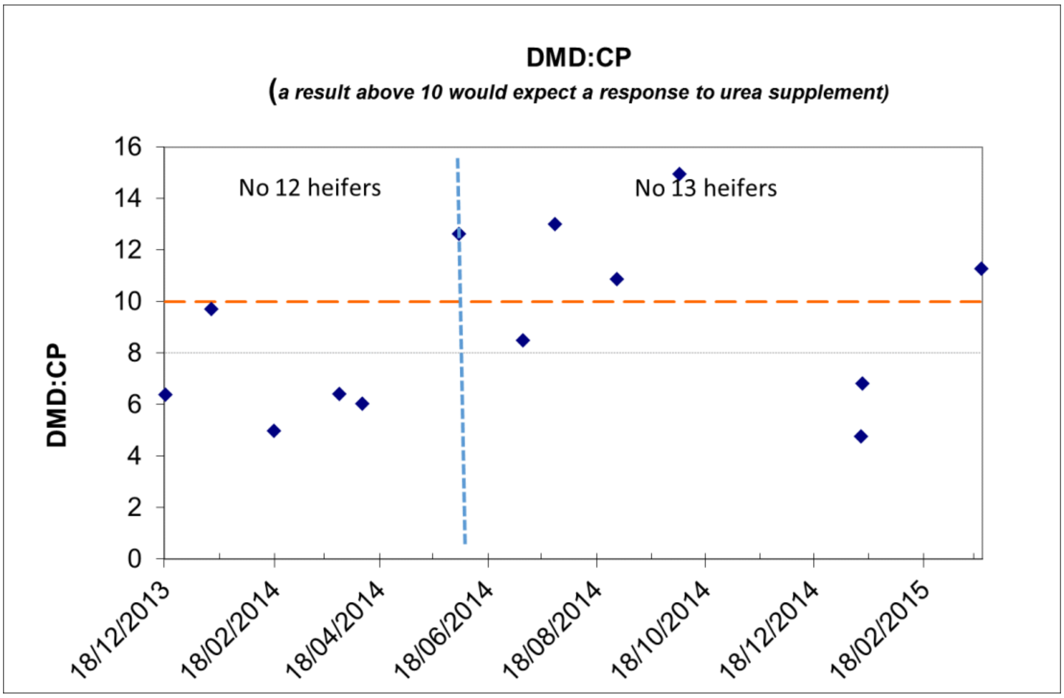


Fig. 9. NIRS estimates for the ratio of dry matter digestibility (DMD) to crude protein (CP) of Mt Oweenee heifers. A value above 10 indicates there should be a good response to feeding urea supplement. No.13 heifers were on urea-medicated water from June to December 2014 on the basalt agistment property.

4.4.2 Phosphorus

Young growing cattle require phosphorus for bone and tissue growth and younger pregnant and lactating cattle need it to support the foetus and milk production, in addition to their own growth. Cattle that are phosphorus deficient will suffer poorer growth (30-40 kg/year) and low reproductive rates (10-30% lower weaning rates) (Jackson et al., 2012). To achieve a phosphorus status of 'adequate', blood inorganic phosphorus should be >50 mg/L in growing cattle (<35 mg/L is classed as deficient) (Jackson et al., 2012).

In March 2014, prior to agistment, the No.13 yearling heifers were sampled by tail bleeding for blood inorganic phosphorus as part of P Screen analysis. The results indicated 70% of the samples were adequate and 30% were marginal for phosphorus with average P_i of 63 mg/L. Faecal phosphorus was 2.68 mg/kg DM and faecal nitrogen was 1.52% of DM. At the basalt agistment property, the cattle were on medicated water with phosphorus included.

In March 2015, the No.14 yearling heifers, still grazing at Mt Oweenee, were sampled for blood inorganic phosphorus as part of P Screen analysis. The results showed an average P_i level of 46.4 mg/L (range 37.5-53.9) indicating a marginal to adequate status. The faecal nitrogen was 1.49% of dry matter at the time of sampling. This suggests that phosphorus supplementation for young cattle grazing these particular paddocks should be considered in future.

4.5 Summary of reproductive disease status

4.5.1 Vibriosis

Bulls were vaccinated for vibriosis annually as part of routine management; no testing was carried out.

4.5.2 Pestivirus (BVDV)

No.12 and No.13 heifers in December 2013 and September 2014 were negative (AGID) for BVDV antibodies. The No.14 heifers tested in September 2016 (ELISA test), well after mating, showed a moderate level of exposure (54%); however, the test could not indicate the timing of the infection. Given the pregnancy rate result in relation to live weight, the disease was assumed to have been spread post-mating.

4.6 Bull management

Each year bulls underwent a full BBSE. Physically-sound bulls with scrotal circumference above breed average were used. Mating commenced in mid-January and bulls removed at pregnancy diagnosis in early May.

In year 1 (No.12 heifers), four bulls mated to the 354 heifers equated to only 1% of heifers (Option B, Table 6). This was based on only half of the group cycling at the beginning of mating and a 2.5% bulls to cycling female ratio. No adverse effects were noticed in pregnancy rates; with rates similar to preceding years (65-70%) in the absence of reproductive disease. In subsequent years Mt Oweenee elected to maintain this comparatively low bull ratio of about 2% bulls: females. This approach was used across the whole herd with no apparent negative effects on pregnancies, but a very positive effect on reducing costs (Table 6). This is a one off saving but very significant.

Table 6. The financial impact of reduced bull to female mating ratios

	Option A	Option B
Number of bulls mated	12 (~4%)	4 (1%)
Capital cost @ $3,000/bull	$36,000	$12,000
Net annual bull cost ($434/yr)	$5,207	$1,736
Bull cost per pregnancy	$21	$7

4.7 Monitoring, evaluation and reporting (MER)

Monitoring and evaluation was based on a pre and post project survey of the producer group members. Eight businesses completed the pre project survey and six of those original businesses completed the post project survey a summary of the results is in Table 7.

Table 7. MER plan and outcome.

Areas of focus	Project targets	Project achievements
Inputs Establish and maintain a PDS producer group to assist with monitoring and interpretation of results from the host property.	1. One host property 2. Six producer group properties	One host property (Mt Oweenee) was established and monitored. The PDS producer group was extended to 11 properties with a total area of 318,000 ha and approximately 40,000 cattle.
Outputs 1. Define the reproductive status of the monitor property 2. PDS group meetings and open industry field days 3. Feedback and newsletter articles	1. Pregnancy rate and pre/post mating live weight, disease status for vibriosis and pestivirus 2. Two field days held and three PDS group meetings 3. Two Northern muster articles and one Feedback article	The significant relationship between pregnancy rate and live weight was established. Pre mating weights were only completed in the first year due to drought conditions. Three annual group meetings were held on property at pregnancy testing and two field days were held at the end of the project. Two additional meetings were held. Two Northern Muster newsletter articles, one Friday Feedback article and one radio interview were completed. One NBRUC abstract /poster was published.
Changes in knowledge, attitudes and skills KASA changes in understanding heifer management, in particular the importance of live weight	Improved understanding of the heifer live weight and the effect on puberty	The post project audit show improvement from pre to post project in: - Knowledge in recent and past heifer research (40%) - Bull selection (30%) -Effect of live weight (13%). An average post project score of 4.5/5 for understanding an optimal live weight is required to reach puberty was recorded.
Practice changes *Describe the practice changes that you are expecting to achieve by the end of your project:*	Use live weight as a diagnostic tool to understand heifer pregnancy	Group members either agreed or strongly agreed (score 4 or 5/5) that they planned to record heifer weights, profile future

		heifer mobs for reproductive diseases and use scrotal size when selecting bulls
Benefits *Describe the benefits that you are expecting to achieve as a result of the project:*	Improved understanding of a diagnostic approach to understanding heifer performance	An understanding of using live weight, test for main diseases and appropriate bull management to analyse heifer performance was achieved.
General observations	Project learnings ○ As a general rule, to consistently achieve high heifer pregnancy rates, live weight during the mating period will need to be higher than general industry expectations. Reproductive disease may cause intermittent crashes. Management, in particular nutrition and growth patterns, is the major cause of low performance. ○ The fundamental principle of on property studies made the project relevant and accepted by producers • *What were the barriers and enablers to change* ○ Barriers include mis or ambiguous information and some paradigms of what is possible, however the enablers in this process were open question and answer discussions; uncomplicated, straightforward presentation and interpretation of results and having access to specialists in this field on hand. • *Where are the research gaps, if any?* ○ This issue of breed was not adequately covered in this project. Recent preliminary CRC data mining seems to show the negative impact of increasing Brahman content on heifer pregnancy when joined below their target body weight. • *Any unintended/unexpected benefits or consequences?* ○ The practical use of lower bull ratios and bull selection using BBSE including a scrotal circumference x live weight chart was quite popular.	

Additionally, a post field day survey was completed by 30 producers and showed a substantial gain in knowledge from an average score of 3/7 to 5.3/7 and 79% indicated they were likely (5) or highly likely (7) to make changes to their business (Appendix 9.4).

4.8 Communications

PDS group meetings were generally held in conjunction with the main animal recording activities with the exception of one training day on basic economic options analysis techniques and a field day. It was difficult to hold group meetings during the peak of the drought (2015) and contact was maintained through reports via email. Two field days open to industry held in the final year (May and December 2016) attracted 52 producers from 27 properties (Table 8).

Table 8. Producer group meetings and field day activities

Date	Activity	Participants
December 2013	Pre mating weight and ovarian scan No. 12	10 (six properties)
May 2014	Pregnancy testing No.12	10 (six properties)
September 2014	Weighing and scanning No.13	7 (four properties)
December 2014	Discuss drought conditions and managing the No.13 group	10 (five properties)
February 2015	Options analysis training	6 (three properties)
March 2015 – April 2016	Contact maintained via email and telephone updates	
May 2016	Pregnancy testing No.14 (open field day - results)	12 (8 properties)
December 2016	Open field day (results and repro diseases)	40 (19 properties)

At the final field day, themed around reproductive diseases, 40 producers attended at Mt Oweenee cattle yards and were briefed on the heifer live weight study, potential impacts of reproductive diseases (in particular vibriosis and pestivirus but also leptospirosis), gains to be made with better bull management and other breeder management practices including weaning and phosphorus were discussed. Thirty evaluation sheets were completed. Knowledge before the day was rated (1 lowest - 7 highest) for pestivirus and vibriosis. Knowledge improvement (scores 4-7) increased from 21%-93% (pestivirus) and 45%-100% (vibriosis). The potential for practice change was also pleasing with 79% scoring likely to highly likely to implement changes as a result of the day. The majority of these changes were testing to understand the status for pestivirus and vaccinating bulls for vibrio although there was indication from some that considering heifer weight prior to joining may occur.

5 Discussion

5.1 Summary

Typically heifer management in northern Australia includes segregating weaned females until mating at approximately two years of age, although some extensive areas do not have the infrastructure or control to successfully segregate young females from bulls to control their first mating. In general, live weight of heifers is not known and a 'mate all heifers' strategy is commonplace and recommended. Diagnosis for lower than expected heifer pregnancy rates are difficult without supporting data, especially live weight and sometimes reproductive disease status. This demonstration validated the importance of heifer live weight during their first mating.

Although this study was complicated by serious drought conditions and animals being relocated to several properties, it confirmed the original hypothesis that low heifer live weight during mating was the primary cause of sub-optimal pregnancy rates. The value of this work was re-enforced by the project's producer group members' comments on the practical nature and 'real life' scenarios that the project endured while still remaining focussed on the outcome (proving the hypothesis). On-property demonstration projects can often be compromised by the lack of replication, extreme weather events and variation on planned management. Frequently, a consequence of these variables result in inconclusive outcomes as incorrect or inadequate data was collected. Having a specific, focussed question to answer minimises this risk.

The evidence collected over the three years clearly demonstrated the negative effect of low live weight during mating on heifer pregnancy. A logistic regression analysis showed the relationship between proportion pregnant and weight was highly significant (p<0.001). The effect of breed type (with limited phenotypic data) was not significant (p>0.05) nor was year group and therefore not used in the statistical model. For this herd, live weights of at least 400 kg need to be attained by the end of mating to achieve higher than 75% pregnancy rates. This finding is very consistent with previous research results (Fig. 10). Although live weight and percentage pubertal data were only obtained in the first year prior to mating, it suggested weights of around 340 kg are required pre-mating at have least 80% of animals at or near to puberty. This aligns with other research, in particular Johnston et al., (2009) who indicated average weight at puberty in Brahmans and Tropical composites was 334 kg; the range was 90 kg either side of this for 95% of heifers.

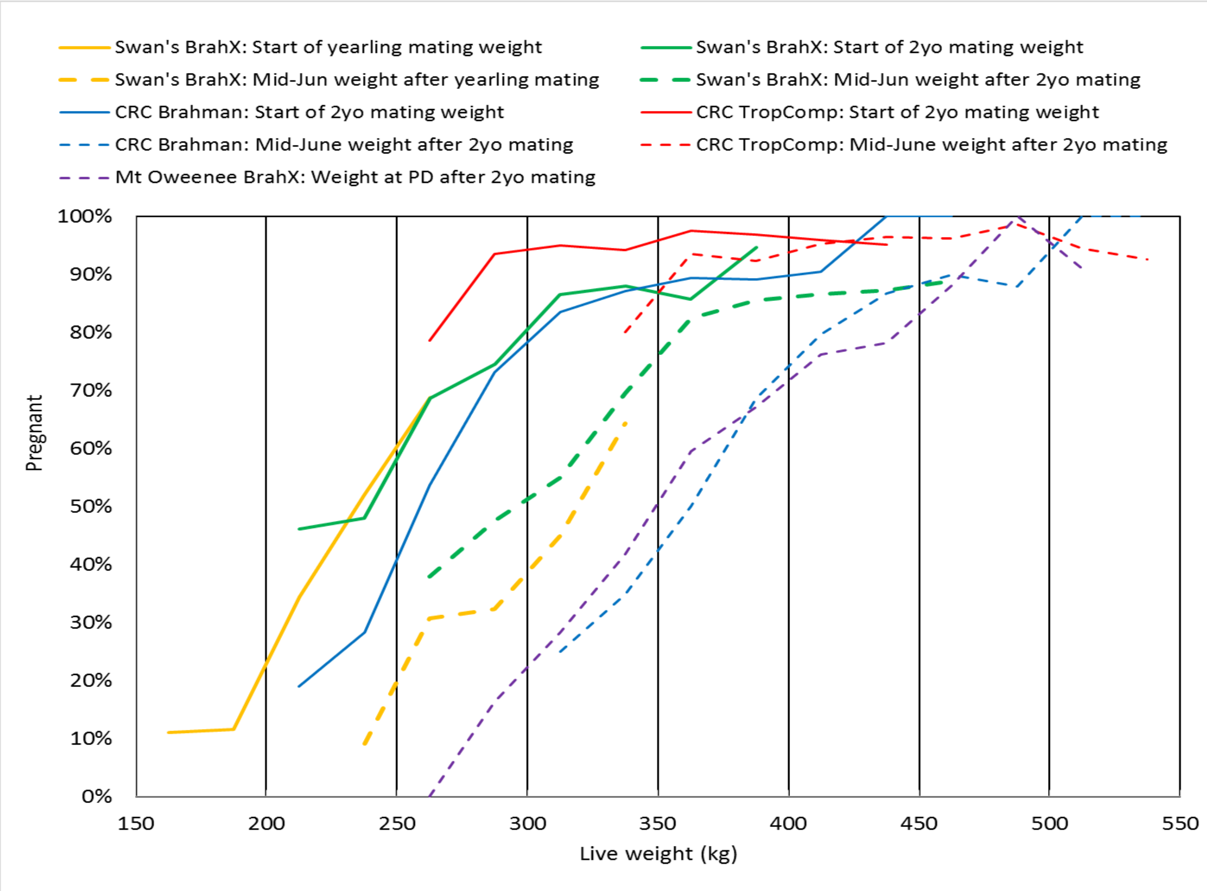


Fig. 10. Pregnancy rates in relation to live weights pre-mating and in June after mating of yearling and two-year-old heifers at Swan's Lagoon (~½ Brahman cross: 1987-93 cohorts), in the Beef CRC (Brahman and Tropical composites: 2000-03 cohorts) and at Mt Oweenee (~¾ Brahman cross: 2012-14 cohorts).

This study also confirmed reproductive disease (vibriosis and pestivirus) and bull sub-fertility were not the major influence on heifer pregnancy results in this PDS but still need to be managed appropriately according to the level of risk involved. This evidence is supported by previous research (Cash Cow: (McGowan et al., 2014); Bull Power: (Holroyd RG et al., 2000)).

5.1.1 Impact of live weight on heifer pregnancy

High expectations of heifer performance is quite widespread within the industry. Often forgotten is that cattle of most breeds have been bred to be larger over the past decades. This has positive implications for sale animals, but some potential problems in other areas such as heifer puberty, which is directly related to mature animal size. These large animals mean the heifer weight for puberty has also increased which, in low productivity environments such as the forested areas of northern Australia, often means heifers will not reach a threshold live weight to trigger puberty until late in the second wet season (close to the end of, or after mating). Any growth setbacks prior to mating, especially in their first dry season post weaning will preclude many from attaining the required live weight to trigger puberty at two years of age (Fordyce 1988). This study confirmed a pre-mating weight of 340 kg was required to achieve high pregnancy rates, but with only one year of data. This pre-mating weight is also known as a Critical Mating Weight (CMW) which is defined in various ways. As conception rates of at least 60% per cycle can be expected in the absence of infectious disease, at least two fertile cycles of 18-24 days are required to achieve 90% pregnant. This infers a more useful target mating weight is to have heifers reach sufficient live weight to achieve a potential third ovulation before the end of mating, i.e., reach puberty within 6 weeks of the end of mating (Fordyce 2006). This target weight is primarily a function of breed and the cow herd's mature live weight. Average weight at puberty is ~60% of mature cow weight in British cattle and closer to 70% of mature cow weight in Brahmans, depending on Bos indicus content (G. Fordyce , 2017 Pers Comm.). Puberty will be closer to 60% of mature live weight with less Brahman and in herds selected for earlier age at puberty. The data in this study recommends an end of mating weight of at least 400kg to achieve at least 75% pregnancy rates. This target, although after the event, is a practical measure that can be targeted by nutritional management from weaning and used for diagnostics to help discriminate causes of low heifer pregnancy rates.

This data was specific to one herd, however it appears to validate other research data. It is recommended that on other beef properties managers need to build their own set of heifer weight and pregnancy data to understand what is achievable for their current phenotype.

5.1.2 Reproductive disease

Vibriosis and pestivirus are generally the most prevalent and detrimental reproductive diseases in northern Australia (McGowan et al., 2014). It is common for industry to assume disease is the main cause of poor heifer performance whereas this study counters this view. Neither disease was found to be causing significant impacts on heifer performance for the three study years. This result supported the hypothesis that low live weight at mating is the most consistent cause of low heifer pregnancy rates

It is recognised however, that diseases can enter the herd periodically with catastrophic results. Relatively simple strategies can reduce the impact of these two diseases. Where bull biosecurity is good, annual vibriosis vaccinations for all bulls is recommended. Where there is a high likelihood for stranger bulls to enter the herd, vaccinating the heifers as well as bulls may be advised.

For pestivirus, ensure all purchased bulls are certified virus-free. In the female herd where the virus status is unknown, test 10-20 cows that have been on the place all their life for antibodies – if positive, then the disease is endemic; if not, you will have a high risk situation where biosecurity and vaccination protocols may be recommended by a cattle vet. If endemic, test 10-20 18-month-old heifers each year to see if the age group is naturally protected; if not, vaccinate.

5.1.3 Bull management

Ensuring sound bulls were used for each heifer mating was critical to eliminate them as a causal factor for low pregnancy. An important part of bull management is mating at a realistic ratio. Common practice is a bull: female ratio of 4% (4 bulls per 100 females). This project proved a ratio as low as 1% could be used without penalty to pregnancies, but can improve business outcomes greatly by significant cost reductions and eliminate most bull problems (fighting etc.), especially where the joining period is >2 months. (Appendix 9.2). The Bull Power project research (Holroyd RG et al., 2000) recommended a bull ratio of no more than 1 bull to 40 cycling females.

Mt Oweenee heifer pregnancy rates have been approximately 65-70% for many years, and this did not change when fewer bull were used. Reducing the bull ratio to 2.5% of cycling females appeared to have had no negative impact on pregnancies, but achieved a long-term saving of $14 per pregnancy in addition to a major short-term capital saving by not having to purchase replacement bulls. Mt Oweenee is now applying this strategy across the entire cow herd which is now mated at no more than one veterinary tested bull to 50 females (2% bulls). This simple practice change, resulting in large short term and longer term costs savings has been well received by both the producer group and wider industry. This was an unintended, but welcome result.

Longer term fertility improvement for the herd through sire selection is also recommended. Where available, Estimated Breeding Values (EBV) for days to calving may be used as an aid for calving earlier in the season, resulting in larger weaners and therefore well grown heifers as they enter their first dry season. In addition, giving preference to bulls with average or better scrotal size for their breed and a high percentage of normal sperm should sire more fertile female progeny.

5.1.4 Pre/post project audit

At the beginning of the project the producer group members completed an online survey. Critical baseline data indicated almost 90% did not consider their heifers' performance was at an acceptable level, hence the interest in this project. Nobody considered they had the diagnostic tools to identify heifer performance issues and 75% did not consider live weight a critical performance measurement. Most (87%) did not consider disease was a major factor and this was supported by the same percentage not vaccinating for vibriosis or leptospirosis. Pregnancy testing was routine annually for 75% and there was a marginal increase by the end of the project, however weighing prior to mating was not routine (25% weighed annually) which remained unchanged at the end of the project. Most of the producer group did not mate all of their heifers and this remained relatively unchanged. Half of the respondents had their bulls examined by a vet and this had increased to 80% by the end of the project.

Knowledge gains in heifer management were substantial. Knowledge of past research work improved (40%), bull selection (30%), and the use of a diagnostic approach (44%). The producer group indicated there was intent of practice change with either agreeing or strongly agreeing that plans would be in place for testing and understanding the disease status of their herd for pestivirus and vibriosis and using scrotal size as a tool when selecting bulls and five out of six respondents agreed to plan to start weighing heifers in the future. These weights will most likely be post mating at pregnancy diagnosis rather than an additional pre mating muster.

6 Conclusions/recommendations

The major findings and recommendations are summarised in Fig. 11 below and was the product of the final field day. The relevance to the group is succinctly summarised by the following feedback from a producer group member's post project survey comment. "This project brought together community members in a positive environment. It promoted not only the growth of knowledge but also kick-started a community into approaching research with an open mind and continuing to interact on a social level in tough times. This has been of great importance to these people and has assisted in the development of a positive relationship with the Department of Agriculture and Fisheries."

Issue	***Facts***	***Management***
Pestivirus	• The virus is spread by direct contact with a carrier • Carriers are created when infected at 30-100 days of pregnancy • Half the carriers are dead by weaning, and half of whatever remains alive dies each year • If there are antibodies in the herd, it is causing abortions and mortalities	• Ensure all purchased bulls are virus free; note - vaccinated or antibody-free does not mean they are not carriers • Test 10-20 cows that have been on the place all their life for antibodies – if so, then the disease is endemic; if not, you will have a high risk situation • If endemic, test 10-20 18-month-old heifers each year to see if the age group is naturally protected; if not, vaccinate • If the herd is free, get cattle vet advice on biosecurity
Vibrio	• An STD caused by a bacteria carried by bulls in their prepuce & carried by some cows for many months • The bacteria is introduced at mating • The main impact is infertility and early embryonic loss ie impacts on pregnancy rates – especially in maiden heifers. • Cash Cow showed it can cause up to 10% calf loss in infected herds	• Vaccinate all new bulls with 2 shots before first mating and then all bulls annually, whether you think you have the disease or not • Vaccination is painful, so use good technique • A cattle vet may test vaginal mucus antibody if there is a raging infertility problem and may recommend heifer vaccination
Bulls	• Myths (BS) abound on bulls • Semen quality is repeatable but very sensitive to stress • At 4% bulls, most get an average of only 1 mating per day when they can comfortably do 10 or more • Cows and bulls find each other for the job; hills, rivers, wets, etc. don't get in the way	• Only introduce bulls to your herd if they have passed a cattle vets soundness exam; they only need a basic exam in years after that • Don't test bulls that have experienced stress in the previous 2 months • Give preference to bulls with average or better scrotal size for their breed and weight • Bulls with high normal sperm and high scrotal size sire more fertile female progeny • Mate no more than 1 bull per 40 ***cycling*** females, which can reduce to 1% bulls when not all females are cycling; but do not have less than 2 bulls in a paddock – fewer bulls = less $/calf

Heifers	• Average weight at puberty in Brahmans varies with selection pressure but was found to be 334 kgs for Brahmans in the CRC herds and was 330 kgs for Tropical Composites. • Typically live weights at PD of 400 kg or more to should be targeted to get high pregnancy rates.	• Use multiple strategies to target 400 kg or better at 2.5 years of age; examples: select bigger weaners; wet season phosphorus; good-quality pastures • Breed heifers from bulls low EBV's for Days to Calving or were from dams that got back in calf early as a first calf cow. • Select bulls with high scrotal circumference for breed and weight, and at least 70% normal sperm • Where heifers are well-controlled, use standard measures to minimise the risk of sub-fertility caused by pestivirus or vibrio •

Fig. 11. Summary of key findings

7 Bibliography

Burns, B. M., et al. (2010). A review of factors that impact on the capacity of beef cattle females to conceive, maintain a pregnancy and wean a calf—Implications for reproductive efficiency in northern Australia. Animal Reproduction Science 122(1–2): 1-22.

Fordyce, G. (2006). Practical strategies to reach target mating weight in northern Australian heifers. In 'Proceedings of the Australian cattle veterinarians conference, 16–19 November 2006, Port Macquarie. pp. 142–152. (Australian Association of Cattle Veterinarians: Brisbane)

Fordyce, G. Holroyd, RG; James, TA; Reid, DJ (1988). The effect of post-weaning growth on the fertility of Brahman cross heifers. Proc. Aust. Soc. Animal Production 17: 396

Fordyce, G., et al. (2014). Live weight production in extensively-managed beef breeding herds. WBC 2014: XXVIII World Buiatrics Congress, Australian Veterinary Association.

Freetly, H. C., Kuehn, L. A. & Cundiff, L. V. 2011. Growth curves of crossbred cows sired by Hereford, Angus, Belgian Blue, Brahman, Boran, and Tuli bulls, and the fraction of mature body weight and height at puberty. Journal of Animal Science, 89, 2373-2379.

Holroyd R G , Bertram J. D., Burns B M , De Faveri J , D'Occhio M J , Doogan V J , Fordyce. G. Fitzpatrick L A , Jayawardhana G A , McGowan M R and Miller R G (2000). Bull selection and use in northern Australia (Bull Power) DAQ.104. NORTH SYDNEY NSW 2059, Meat & Livestock Australia.

Jackson, D., Rolfe, J., English, B., Matthews, R., Dixon, R., Smith, P., MacDonald, N. & Partridge, I. (2012). *Phosphorus management of beef cattle in northern Australia*. North Sydney, NSW, 2059. Meat & Livestock Australia.

Johnston, D. J., Barwick, S. A., Corbet, N. J., Fordyce, G., Holroyd, R. G., Williams, P. J. & Burrow, H. M. (2009). Genetics of heifer puberty in two tropical beef genotypes in northern Australia and associations with heifer- and steer-production traits. *Animal Production Science,* 49**,** 399-412.

Schatz, T. J. and M. N. Hearnden (2016). The effect of weight and age on pregnancy rates in Brahman heifers in northern Australia. Animal Production Science

McGowan, M., Fordyce, G., O'Rourke, P., Barnes, T., Morton, J., Menzies, D., Jephcott, S., and K. McCosker, Smith, D., Perkins, N., Marquart, L., Newsome, T., Burns, B., (2014). Northern Australian beef fertility project: Cashcow. Final report. North Sydney, NSW, 2059. Meat & Livestock Australia

8 Acknowledgements

Without the outstanding contribution and cooperation from Doug, Zoe, Ingrid and Georgina O'Neill of Mt Oweenee station this project would not have been possible. Thanks also to the producer group who provided input and support to the project.

9 Appendix

9.1 Additional NIRS results

Table 9. NIRS results for the No.3 heifers while at Mt Oweenee (Bluewater paddock) and the agistment property Amelia Downs. The basalt region, including Amelia Downs, is well known for low diet quality during the dry season, but equally can respond with high nutrition during a normal wet season.

Paddock	Date	Diet N	Diet CP	Faecal N	DMD	DMD:CP	Non Grass	Ash
Blue water	18/12/2013	1.38	8.6	1.53	54.9	6.4	14.9	17.1
Blue water	13/01/2014	0.85	5.3	1.23	51.4	9.7	15.6	14.9
Blue water	17/02/2014	1.91	11.9	1.99	59.5	5.0	15.2	18.4
Blue water	26/03/2014	1.37	8.5	1.52	54.6	6.4	16.1	14.1
Blue water	8/04/2014	1.43	9.0	1.52	54.1	6.0	15.7	15.9
Amelia Downs	1/06/2014	0.63	3.96	0.86	50.0	12.6	14.9	18.0
Amelia Downs	25/07/2014	0.58	3.64	0.77	47.4	13.0	13.5	24.1
Amelia Downs	3/10/2014	0.50	3.13	0.90	46.7	15.0	14.0	21.8
Amelia Downs	13/01/2015	1.91	11.9	2.03	56.9	4.8	17.2	21.6
Amelia Downs	22/03/2015	0.73	4.54	0.92	51.3	11.3	14.0	19.2

9.2 NBRUC paper

Reduced costs when using recommended bull to female mating ratios

Dave Smith [A], Geoffry Fordyce [B], Timothy Moravek [A], Doug O'Neill [C]

[A] DAF, Charters Towers 4820; [B] QAAFI, UQ, St Lucia 4072; [C] Mt Oweenee, Charters Towers 4820

Introduction

The Bull Power project (Holroyd *et al*. 2000) concluded that multiple-sire mating using tropically-adapted bulls that are reproductively sound at a rate of 2.5% of cycling females will not jeopardise herd fertility under most conditions in extensive parts of northern Australia where it is still common for producers to use 4-5% bulls. An opportunity to assess the recommended mating ratio arose within a heifer productivity demonstration study north of Charters Towers (Qld).

Methods

Pre- and post-mating monitoring of 334 two-year-old Brahman and crossbred heifers grazing a 2600 ha undulating paddock included pre-mating ovarian scanning and live weight. All bulls used had passed a full BBSE including sperm morphology, had above breed average scrotal size for their weight and were vaccinated against vibriosis. Heifers were sampled for BVDV antibody. Four-month mating commenced in mid-January 2014. Rather than using previous practice of a bull:heifer ratio of ~4% (Option A, Table 1), 2.5% bulls to cycling heifers was used.

Results

Average pre- and post-mating heifer live weights were 291 kg (190-389 kg) and 397 kg (298-512 kg), respectively. Pre-mating (December) ovarian scanning indicated 51% of heifers were cycling or about to cycle, with the expectation that more heifers would cycle as they grew. Bulls mated equated to only 1% of heifers (Option B, Table 1). No adverse effect on pregnancy rates occurred with 70% achieved, similar to preceding years: 65-70%. Nil pestivirus activity was recorded.

Table 1. The financial impact of reduced bull power.

	Option A	Option B
Number of bulls mated	12 (~4%)	4 (1%)
Capital cost @ $3,000/bull	$36,000	$12,000
Net annual bull cost ($434/yr)	$5,207	$1,736
Bull cost per pregnancy	$21	$7

Discussion and Conclusion

Reducing the bull number to mate 2.5% of cycling females appeared to have had no negative impact on pregnancies and a saving of $14 per pregnancy. The business also realised a major short-term saving through reduced capital expenditure on bulls ($24,000) by being able to reduce their bull herd without risk. In addition, a significant reduction in bulls fighting and broken fences associated with an ease in handling were noted. This demonstration supports recommendations from the Bull Power research and where implemented can achieve substantial short- and long-term savings in business costs.

References

Holroyd RG, Bertram J, Fitzpatrick LA, Fordyce G, McGowan MR, Jayawardhana G, Miller R, Doogan VJ and De Faveri J (1998) Bull selection and use in northern Australia (Bull Power). Final Report, Project DAQ.104, Meat Research Corporation, Sydney.

9.3 Statistical analysis

Relationship between pregnancy diagnosis and weight

(Mt Oweenee PDS)

Summary

The aim of the analyses was to determine the relationship between the proportion of pregnant cattle and their weight at the time of pregnancy diagnosis, within the cattle monitored in the PDS run at Mt Oweenee station. Data available included pregnancy diagnosis, weight at the time of the pregnancy diagnosis, the year cohort (No. 12's No. 13's and No. 14's) the date of weight measurement and the breed (Brahman x, Charbray x or Drought x).

Breed had no significant ($p>0.05$) effect on the relationship between proportion pregnant and weight. A generalised linear model with a binomial distribution and a logit link showed there was a significant ($p<0.001$) relationship between proportion pregnant and weight. The relationship was:

$$p = e^{(-7.702 + 0.02160 \times \text{weight})} / (1 + e^{(-7.702 + 0.02160 \times \text{weight})})$$ where p = proportion pregnant.

Data

Data used in the analyses included pregnancy status (pregnant or not pregnant) and live weight at the time of pregnancy testing. Data was available from three year groups (No. 12's, 13's or 14's). Measurements for the different year groups were made on different dates. Breed (Brahman x, Charbray x or Drought x) was recorded for No. 12's and 13's only, although it was considered not entirely reliable data. This was because breed was assessed visually by different people and they each may have had a different interpretation of what breed should be assigned to the animal. Many animals did not have a breed recorded (or breed was just recorded as 'bought'). Numbers of observations appear in the table below (Table 1).

Table 1 - Count of Animal ID Number

Year Brand	Date *(Date of preg test & weight measurement)*	Breed			No breed available	Total
		Brahman x	Charbray x	Drought x		
No. 12	6/05/2014	24	97	175	57	353
No. 13	19/07/2015	17	74	62	32	185
	28/07/2015	8	13	14	23	58
	3/09/2015	22	94	160	46	322
No. 14	22/06/2016				383	383
Total		71	278	411	541	1301

Notes: One extra record with no id number and no weight at pregnancy test has been excluded from the table.

Breed effect *(No. 12's & 13's only)*

Analysis

Breed was investigated to determine if it influences the pregnancy versus weight relationship. When testing for a breed effect, data from only No. 12's and No. 13's were used as only these animals had a breed recorded (n total =755 as 5 of the 760 animals had missing weights in data file). All animals with no breed or a breed recorded as 'bought' were excluded.

The outcome for each animal 'pregnant' (coded as 1) or 'not pregnant' (coded as 0) was analysed using a generalised linear mixed model with binomial distribution and logit link. The binomial totals were '1'. This allowed for estimation of the proportion pregnant. The random effects considered were Year_group/Date. The fixed effects were Weight*Breed (equivalent to Weight + Breed + Weight.Breed).

The random components were found to be negligible, so they were excluded from the model and a simpler generalised linear model was fitted. A with binomial distribution with a logit link was used. Significance of effects were tested by Wald statistics when dropping them from the model. All analyses were conducted using GenStat v 18.

Results

The component of variance for Year_group was zero and the Year_group.Date component range included zero (component=0.146, se=0.171), thus, the random components were removed from the model. In the GLM model including terms Weight*Breed, the interaction term Weight.Breed was not significant (p=0.334), as determined by the Wald test when dropping the term from the model. The interaction was dropped from the model and just main effects of Breed and Weight fitted. The Wald test indicated the main effect of breed was not significant (p=0.961).

There was no significant difference between breeds in their proportion pregnant versus weight relationship, thus breed was not required to be included in the overall model using all years of data.

Relationship between proportion pregnant and weight

Analysis

The outcome for each animal 'pregnant' or 'not pregnant' was initially analysed using a Generalised Linear Mixed Model (GLMM) with binomial distribution and logit link. The random term was Year and the fixed term was Weight. The random term were negligible Random term (component=0.003 and s.e.=0.019). Although this error term could technically be left in the model, as the range included zero, the random term was excluded for simplicity. Thus, the binomial response 'pregnant' or 'not pregnant' was analysed using a generalised linear model with a logit link.

Results

Combining data from all years, the relationship between proportion pregnant and weight was highly significant ($p<0.001$). The equation was:

$$\text{Logit}(p) = -7.702\ (\text{se } 0.499) + 0.02160\ (\text{se } 0.00138) \times \text{weight} \qquad \text{[Figure 1]}$$

[where p = proportion pregnant *and* logit p = log (p / (1-p))]

Equivalently,

$$p = e^{(-7.702 + 0.02160 \times \text{weight})} / (1 + e^{(-7.702 + 0.02160 \times \text{weight})})$$

[*where* p = proportion pregnant]

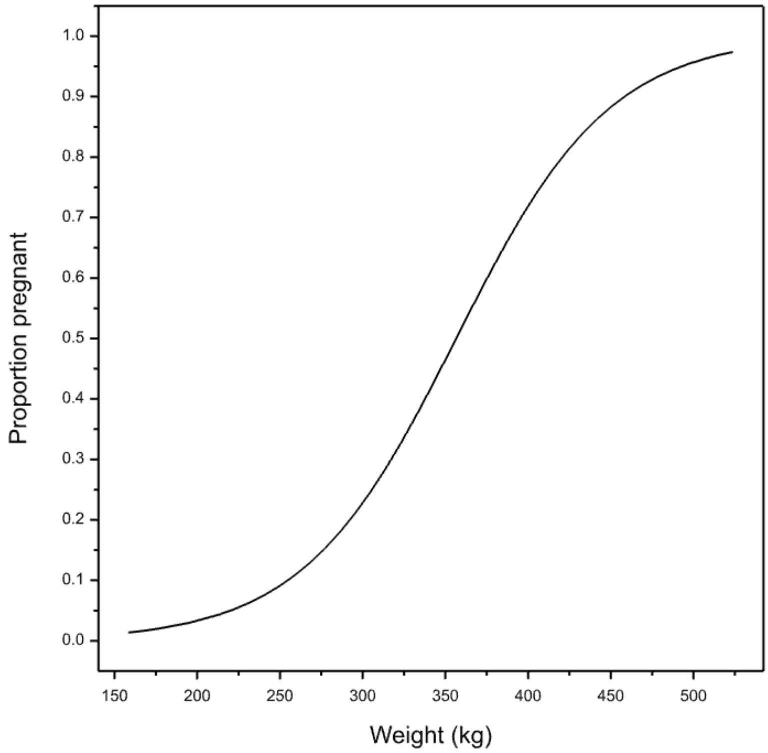


Figure - 1. Relationship between proportion pregnant and weight (for all data No. 12's, No. 13's and No. 14's)

Report prepared by:

Angela Anderson
Senior Scientist (Biometry)
Dept of Agriculture and Fisheries
angela.anderson@daf.qld.gov.au

7 February 2017

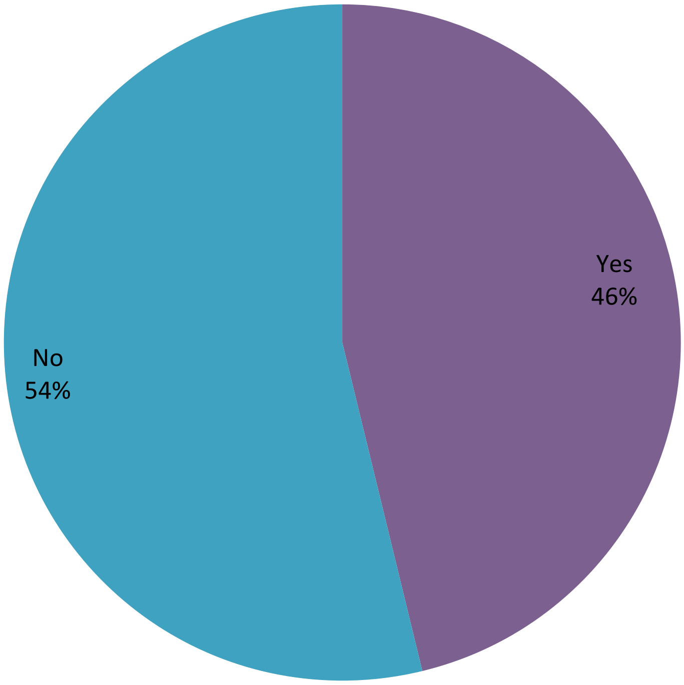
9.4 Final field day evaluation

Report Heifer PDS Field day - Managing Repro Diseases (15 December 2016)

Response Statistics

	Count	Percent
Complete	30	100
Partial	0	0
Disqualified	0	0
Total	30	

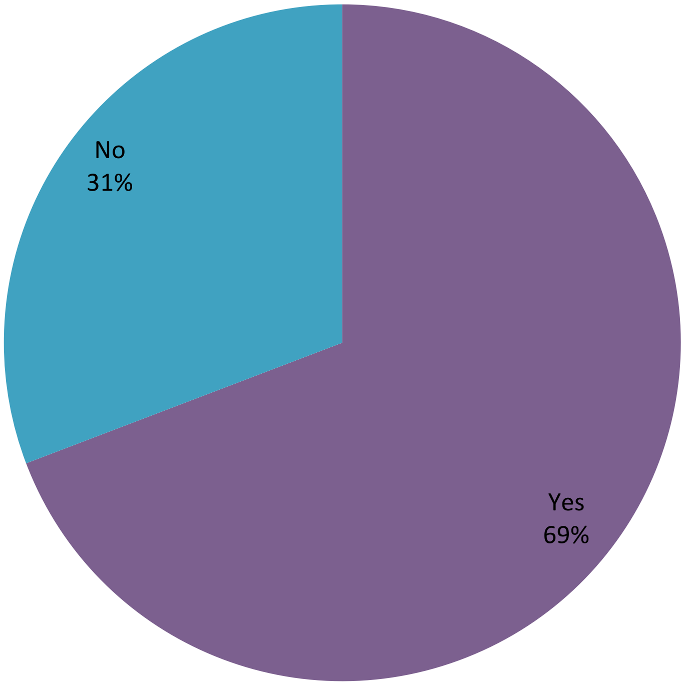
Is management of pestivirus an important part of your business?



Value	Percent	Count
Yes	46.2%	12
No	53.8%	14
	Total	**26**

Statistics	
Total Responses	26.0
Skipped	4.0

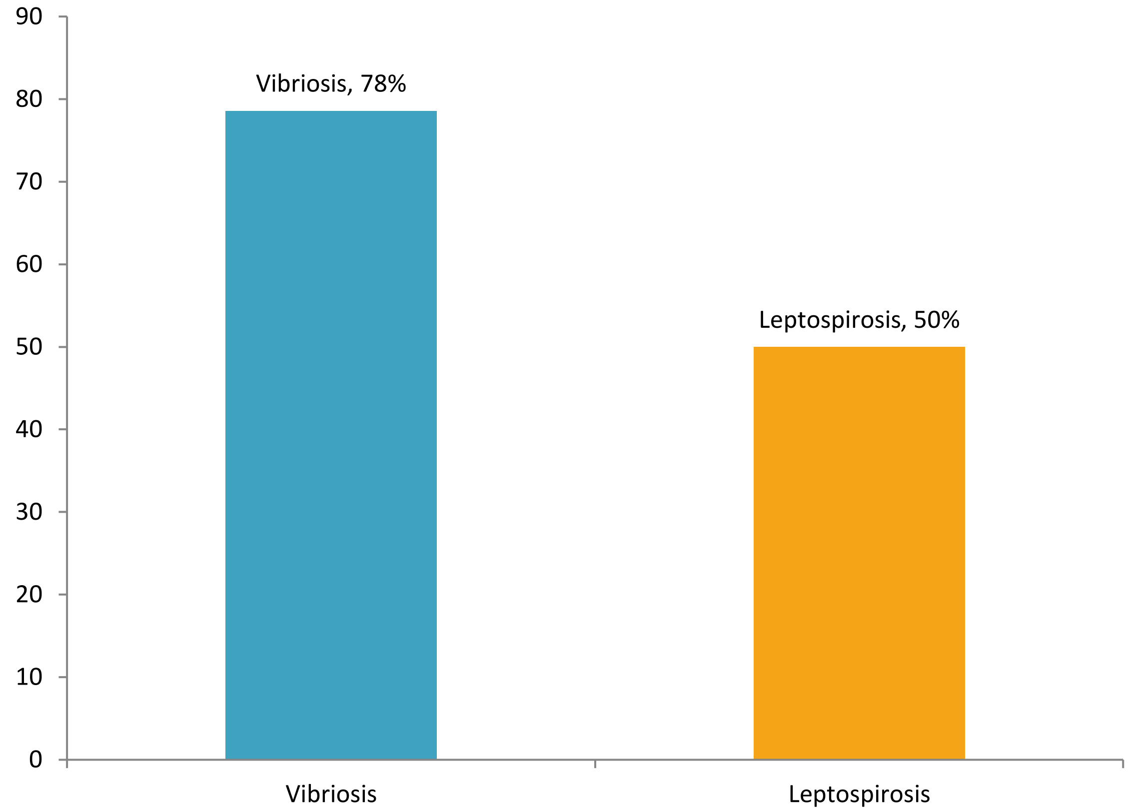
Is management of vibriosis an important part of your business?



Value	Percent	Count
Yes	69.2%	18
No	30.8%	8
	Total	**26**

Statistics	
Total Responses	26.0
Skipped	4.0

Do you already vaccinate for the current reproduction diseases?



Value	Percent	Count
Vibriosis	78.6%	11
Leptospirosis	50.0%	7

Statistics	
Total Responses	14.0
Skipped	16.0

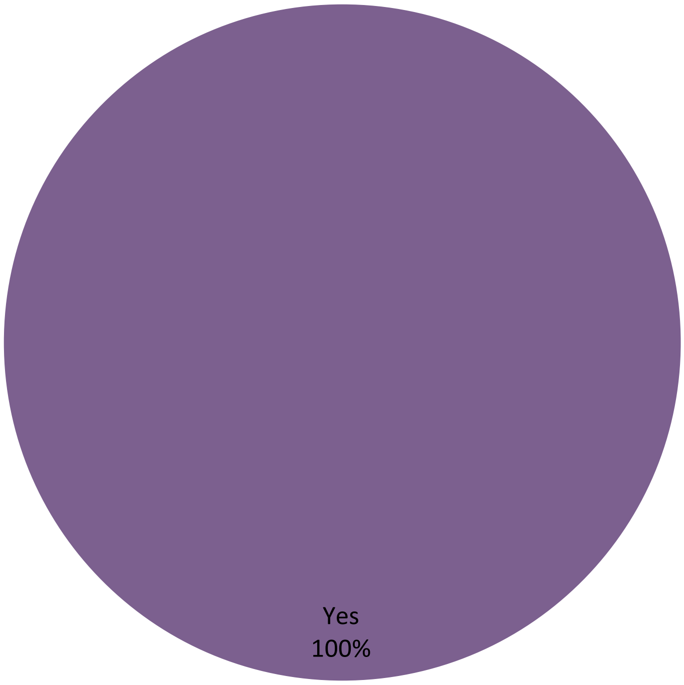
How would you rate your knowledge of these reproduction diseases before today? (1=low)

	1	2	3	4	5	6	7
Pestivirus	5	13	5	2	2	1	1
Vibriosis	3	9	4	5	4	4	0

On a scale of 1-7 how would you rate your knowledge of reproduction diseases after participating today? (1=low)

	1	2	3	4	5	6	7
Pestivirus	0	1	1	6	8	12	2
Vibriosis	0	0	0	5	9	12	4

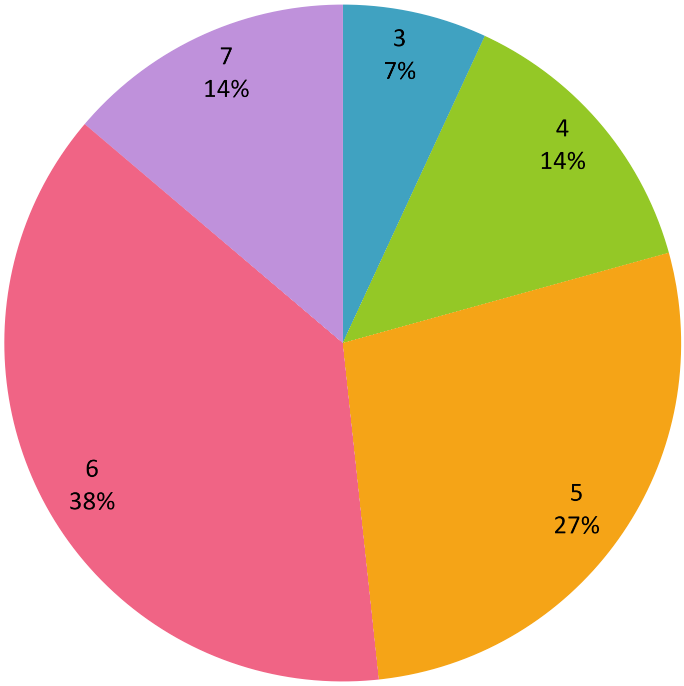
Do you have better understanding of a process to manage reproductive diseases?



Value	Percent	Count
Yes	100.0%	27
	Total	**27**

Statistics	
Total Responses	27.0
Skipped	3.0

How likely (on a scale of 1-7) are you to make any changes to the way you manage your business / property as a result of what you have learnt today?



Value	Percent	Count
3	6.9%	2
4	13.8%	4
5	27.6%	8
6	37.9%	11
7	13.8%	4
	Total	**29**

9.5 BoM Drought report

Australian Government

Bureau of Meteorology

RAINFALL DEFICIENCY REPORT

To support the Australian Government Drought Concessional Loans Scheme

AGENCY REFERENCE:

n/a **BUREAU ID:**

1a7bb0467fa7 **DATE**

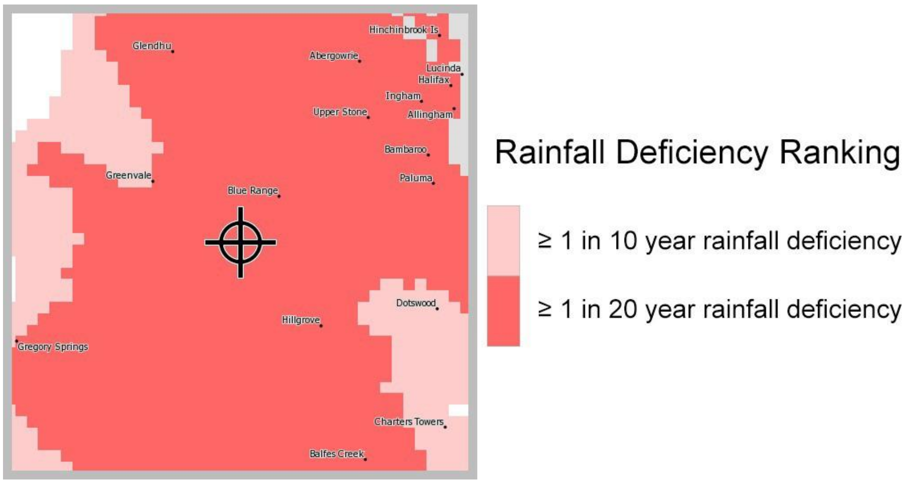
PRODUCED: 15/11/2016

REPORT VALID UNTIL: 14/01/2017 (60 calendar days from the date report produced)

REPORT FOR LOCATION: -19.2635° 145.3601°

PERIOD ASSESSED: 01/10/2014 to 30/09/2016

PERIOD OF LOWEST PERCENTILE RAINFALL: 01/10/2014 to 31/12/2015 LOCATION HAS EXPERIENCED A 1 IN 20 YEAR RAINFALL DEFICIENCY: YES LOCATION HAS EXPERIENCED A 1 IN 10 YEAR RAINFALL DEFICIENCY: YES



Coloured areas on the map show regions which have experienced a rainfall deficiency, which is equivalent to or worse than either a 1 in 20 year rainfall deficiency event (red) or a 1 in 10 year rainfall deficiency event (pink) for the lowest rainfall percentiles recorded for every grid cell over all of the 91 potential periods assessed within the two year assessment period from 01/10/2014 to 30/09/2016.

Notes

Rainfall deficiency is used to describe the situation where there has been less rainfall over a given period (in this case any period between 12 and 24 months in the latest two year period), when compared with similar periods over the whole historical record (since 1900).
A 1 in 20 rainfall event is an indication of how many times such low rainfall would be likely to occur at a location in a 20 year period: so for every 20 years you could expect to get low rainfall like this just once. This is also, more accurately, known as being below the 5th percentile (or within the lowest 5% of rainfall records). Similarly a 1 in 10 rainfall event is used to show where rainfall is below the 10th percentile (or within the lowest 10% of rainfall records).

Rainfall deficiency data is calculated from the Bureau of Meteorology’s (the Bureau) national Australian Water Availability Project (AWAP) gridded rainfall dataset. The AWAP dataset provides a nationally consistent, long-term record of rainfall which includes observed rainfall data from 1900 to present. National rainfall deficiency datasets are produced on a monthly basis at an approximately five kilometre horizontal resolution. The Bureau analyses rainfall for all 91 potential periods, between 12 and 24 months long, in each two year assessment period for every individual grid cell across Australia. The analysis determines which grid cells have recorded a rainfall value at or below the 1 in 20, or 1 in 10 year rainfall deficiency thresholds.

The Bureau analyses rainfall for all 91 potential periods, between 12 and 24 months long, in each two year assessment period for every individual grid cell across Australia. The analysis determines which grid cells have recorded a rainfall value at or below the 1 in 20, or 1 in 10 year rainfall deficiency thresholds.

The map displays the lowest rainfall percentiles recorded for every grid cell over all of the 91 potential periods assessed.

Disclaimer

Generated: 2016-11-15 02:05:03 UTC

9.6 Tips and tools

Tips and tools - northern Australia heifer management – getting them pregnant.

Heifer pregnancy rates are notoriously low in northern Australia. The Cash Cow project showed the median pregnancy rate for maiden 2-year-olds in northern forest country to be only 67% (range 40-81%). The main causes of low rates, and the main strategies to cost-effectively achieve more pregnancies are:

- Low live weight during mating results in low pregnancy rates. Poor nutrition, particularly during the first dry season after weaning, sets back heifer skeletal and muscle growth dramatically and should be a focal point for management.
- Reproductive disease outbreaks cause dramatic losses.
- Targeted bull selection and management can reduce age of puberty of heifers and dramatically reduce mating costs.

The following are some more detailed facts and tips to cost-effectively increase heifer pregnancy rates.

Heifer live weight

Facts
• As a guide, weight at puberty in Brahmans is approximately 70% of mature cow weight; this percentage is less in crossbreds (60% in *taurus* cattle) - and when selected for young age at puberty. • Typically target weights at pregnancy diagnosis (end of mating) should be at least 400kg or more to get high pregnancy rates (see Fig. 1).

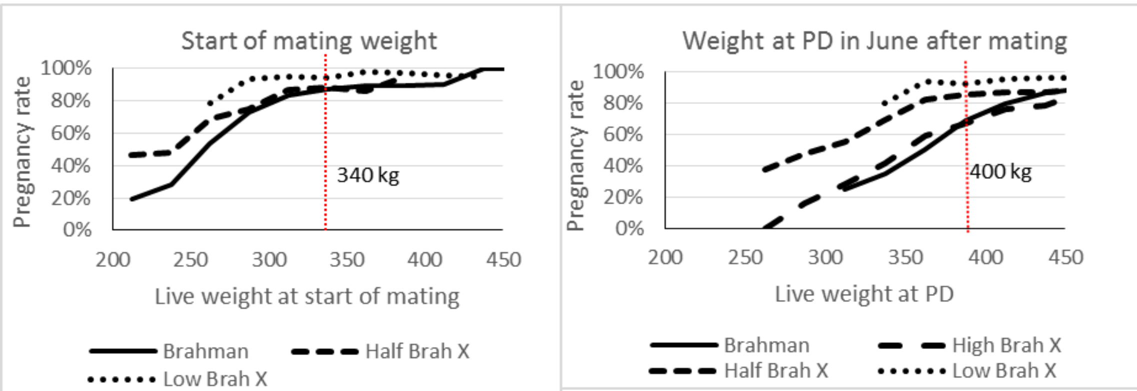


Fig. 1. For high pregnancy rates, the data from Beef CRC shows start of mating weights of at least 340kg for Brahman types and end of mating weights of at least 400kg. Tropical composites can achieve high pregnancies at lower weights. Note. The High Brah X after mating data is from a north Queensland commercial herd.

Management tips
• Determine the ideal time of joining for your herd according to seasonal conditions. The Green Date is a good tool to consider. • Use multiple strategies to target 400kg or better at 2.5 years of age; manage breeders to get pregnant early in the mating season to produce bigger weaners and then focus on good weaner growth in their first dry season. • Use wet season phosphorus supplement where appropriate and graze well managed, good-quality pastures, e.g., spelled paddocks. • Mate all heifers and leave culling till pregnancy diagnosis – use foetal aging to select those that got pregnant earliest in the mating period. • Where bull control is possible, yearling mating is not recommended unless at least 60% or greater pregnancy rates will be achieved.

Bull selection and management

Facts
• Myths abound on bulls. At 4% bulls, most get an average of only 1 mating per day when they can comfortably do many more. Fewer bulls significantly reduce business costs • No more than 1 bull per 40 ***cycling*** females is the maximum recommended, but no less than 2 bulls, irrespective of hills, rivers and paddock size. As all females won't be cycling at once, no more than 2.5% bulls per all females should be required. • Bulls with high scrotal circumference for their weight and breed sire heifers with earlier puberty. Those with high percentage normal sperm sire females with higher conception rates during lactation. • Select bulls for low Days to Calving EBV's OR where this information is not available, then choose bulls from dams that got back in calf within 3 months of calving as a first calf cow.

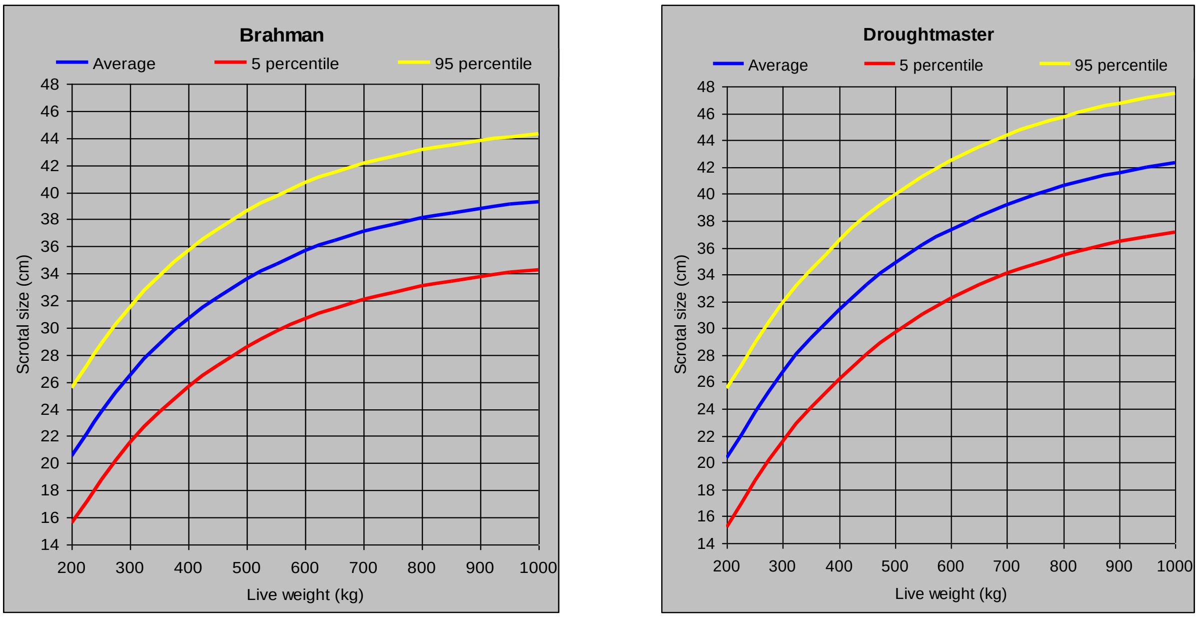


Fig. 2. Bull selection tool using the relationship between bull live weight and scrotal size. Choose bulls with above average (blue line) scrotal size to for to promote earlier puberty in heifer progeny.

Management tips
• Ensure all purchased bulls are pestivirus free; note - vaccinated or antibody-free does not mean they are not carriers. • Only use bulls that have passed a full BullCheck exam (BBSE); they only need a basic examination in years after that. • Give preference to bulls with average or better scrotal size for their breed and weight (the range for two breeds is shown in Fig. 2) and that have at least 70% normal sperm.

Reproductive diseases

Facts

• Disease can be an issue in reproduction performance, but often low heifer live weight will explain poor performance.
• If disease is suspected, the initial focus should be to diagnose:
  ○ Vibriosis (campylobacteriosis) and BVDV (pestivirus) are the main reproductive diseases of cattle in northern Australia
  ○ Trich (trichomoniasis) is also a devastating venereal disease but is not common
  ○ Leptospirosis requires specific risk factors to be a disease of concern

Management tips
• For vibriosis, vaccinate all new bulls with two shots before first mating and then all bulls annually, whether you have the disease or not. Where feral bulls are common, consider heifer vaccination in addition to bull vaccination. • For pestivirus test 10-20 cows that have been on the property all their life for antibodies – if test results are positive, then the disease is endemic; if not, you will have a high risk situation. If endemic, test 10-20 18-month-old heifers each year to see if the age group is naturally protected; if not, vaccinate. If the herd is free, get cattle vet advice on biosecurity. • Take cattle vet advice on control of other reproductive diseases.