FACTORS AFFECTING THE EFFICIENCY WITH WHICH BEEF COWS BECOME PREGNANT AFTER CALVING IN NORTHERN AUSTRALIA

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Introduction

Approximately half of Australia's beef breeding herds are located in northern Australia which includes the state of Queensland, the Northern Territory and the northern part of the state of Western Australia. This is a subtropical-tropical region with a characteristic wet and dry season dominated by a summer rainfall pattern. Soil fertility is highly variable with most areas north of the Tropic of Capricorn being considered at least marginally phosphorous deficient. Many areas in central and southern Queensland have moderate to high fertility soils. Beef cattle graze either improved tropical pastures or native pastures that vary considerably in dry matter digestibility and crude protein content according to season. In northern Australia, approximately 85% of beef cattle have some *Bos indicus* content to enable them to better cope with high environmental temperatures, low quality pastures and internal and external parasitism, in particular cattle tick (*Rhipicephalus microplus*) and buffalo fly (*Haematobia irritans exigua*) infestation. Property and paddock size vary markedly across this region (12 to 16,000,km^2 and 17 to 71,000ha, respectively; McGowan *et al*. 2014) and stocking rates are typically one adult equivalent to 5-30 ha but in some areas decrease to 150 ha. Cattle are typically mustered (brought together from the paddock into a cattle yard) twice a year for branding, weaning and other husbandry such as pregnancy diagnosis (PD), usually in the late wet-early dry season and then again in the mid-dry season. Helicopter mustering is now commonly used on most extensively managed properties. Approximately two-thirds of cow herds in the dry tropical rangelands (Northern Forest country type; Figure 1) of northern Australia are continuously mated, whereas in areas with higher soil fertility and more intensive management herds are control mated, typically for periods of 3 to 7 months.

Infrequent mustering, rarely identifying either sires or dams of calves, and extended mating are major challenges to studying cow reproductive performance in northern Australia. However, foetal ageing at pregnancy diagnosis enables both the month of conception and calving to be estimated.

Schatz and Hearden (2008) and McCosker et al. (2011) provide data on the reproductive performance of heifers in this region, and an indication of what is an achievable level of performance. The factors affecting the loss of either the foetus or calf between conception and weaning in northern Australia beef herds has recently been reviewed by Burns *et al*. (2010). Fordyce (2006) provides an excellent review of the management strategies that will enable producers to significantly improve the performance of heifers in this region of Australia.

This paper will focus on factors affecting the percentage of lactating cow that become pregnant within 4 months of calving. Data are drawn from a large recently completed study that sought answers to two fundamental questions:
(i) Why do some breeding herds or management groups have good reproductive performance, and others significantly poorer performance?
(ii) Why do some cows readily conceive and wean a calf, while others either take significantly longer to conceive and/or fail to wean a calf?

Approximately 78,000 cows managed in 165 management groups located on 72 commercial beef cattle properties distributed across the major beef breeding regions of northern Australia (Figure 1) were selected and then monitored for 3 or 4 consecutive years (2008-11; McGowan *et al*. 2014). This study determined the levels of reproductive performance that are commercially achievable, and considered the impacts of some 83 different environmental, nutritional, management, animal and infectious disease factors on performance. The location of co-operating properties was classified according to four broad country types on the basis of perceived annual live weight production potential. Properties with forested land types and fertile soils in central and south-east Queensland were differentiated into those outside (Southern Forest) and within the Brigalow forest region (Central Forest). In northern and western areas, land types predominated by treeless black soil native grasslands (Northern Downs) were separated from forested land types with low-fertility soils (Northern Forest). Using data provided by the co-operating property owners the estimated median annual steer growth for the Northern Forest, Northern Downs, Central Forest and Southern Forest was 100kg, 170kg, 180kg and 200kg respectively.

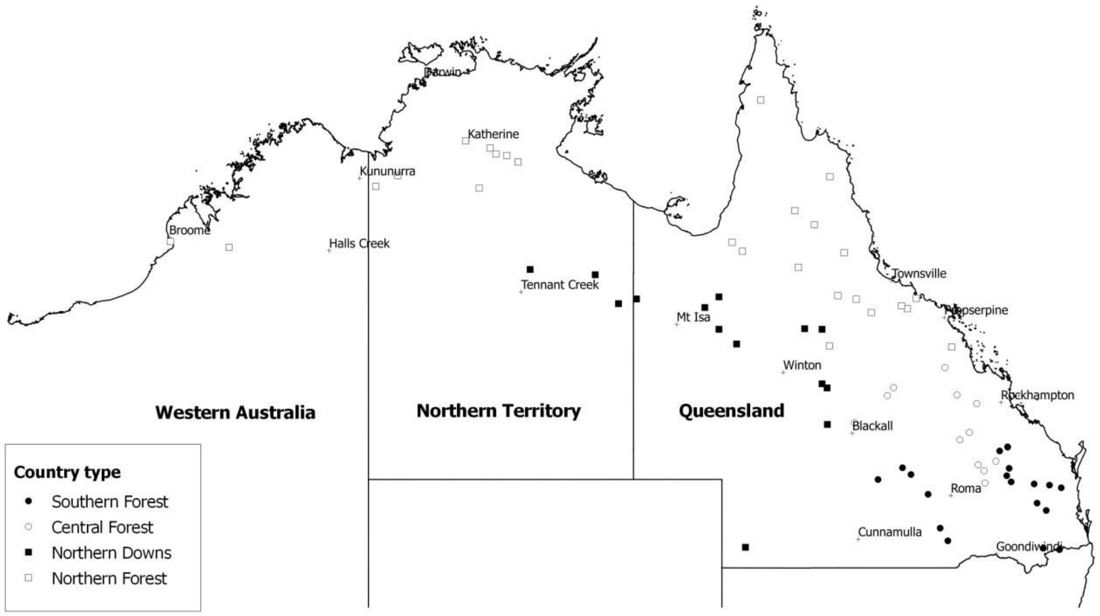

Figure 1. Location of commercial beef cattle properties enrolled by country type in an epidemiological study* of factors affecting reproductive performance in northern Australia

*** McGowan *et al*. 2014**

Measuring the efficiency with which cows become pregnant after calving
A practical measure of reproductive efficiency is the percentage of calving cows likely to wean a calf in consecutive years. An often quoted target of reproductive efficiency is a 12 month inter-calving interval. If a cow is to achieve an inter-calving interval of 12 months, and assuming a 9.5 months gestation (typical of *Bos indicus* genotypes), then she has to become pregnant within 2.5 months of calving. Analyses of data (Fordyce pers. comm) from a large beef breeding study conducted in northern Australia (Johnston *et al*. 2009) indicated that despite 'best practice management' only a low percentage of cows (about 10%) in this environment maintain a 12 month inter-calving interval over their breeding life.

Use of mean inter-calving interval as a measure of reproductive efficiency is problematic as it does not tell us what proportion of the herd is weaning a calf in consecutive years, and it can be influenced by management decisions such as culling of late conceiving cows and re-mating of non-lactating cows. Further, as parturition is not commonly observed in commercial breeding herds, calving interval must be based on the results of foetal ageing (determination of the stage of pregnancy typically by manual palpation, but increasingly by use of ultrasonography) conducted at the time of the annual pregnancy diagnosis muster. McGowan *et al*. (2014) reported that amongst a group of experienced cattle veterinarians, foetal age tended to be overestimated by approximately 0.5 months when the true foetal age was <5 months, and underestimated by approximately 1.0 months when the true foetal age was ≥5 months. As the direction of these errors was not consistent the estimated inter-calving interval for a cow with an actual inter-calving of 12 months could range between 11 and 13 months. Further, analysis of data (Fordyce pers comm) from a large beef breeding study conducted in northern Australia (Johnston *et al*. 2009) indicated that for those cows that calved in the same three month period ('calving window') in consecutive years, the percentage of cows conceiving within 2, 3, or 4 months of calving was 17%, 64% and 90%, respectively.

Based on these findings McGowan *et al*. (2014) recommended that a primary measure of reproductive efficiency for extensively managed beef herds or management groups) should be the percentage of lactating cows pregnant within 4 months of calving. The estimated foetal age at the date of the pregnancy diagnosis muster was used to calculate month of conception and predicted month of calving using an assumed gestation length of 287 days. Cows that had conceived within 108 days/3.5 months of calving (or ≤13 month inter-calving interval) were defined as being pregnant within 4 months of calving. Note cows that were not observed as lactating after being diagnosed pregnant the previous year were excluded from this analysis as by definition they will not wean a calf in consecutive years. This method used to calculate percentage of lactating cows pregnant within 4 months of calving is not affected by mating system and can be used in control and continuously mated herds.

A major reason for cows, particularly *Bos indicus* genotypes, failing to become pregnant within 4 months of calving is prolonged post-partum anoestrus. Johnston *et al.* (2014) reported that the mean lactation anoestrus periods (defined as the interval between commencement of mating and estimated day of first ovulation) for 1st lactation Brahman (*Bos indicus*) and tropical composite (tropically-adapted *Bos indicus* x *Bos taurus*) genotypes were 133.7 (SD=109.5) and 83.8 (SD=110.9) days, respectively; lactation anoestrus interval was highly (52%) and moderately (26%) heritable in these genotypes, respectively.

What is a commercially-achievable level of performance?
McGowan *et al*. (2014) have used the 75th percentile as the commercially-achievable level of performance for the measure percentage of lactating cows pregnant within 4 months of calving, by cow age class and country type, respectively (Table 1). Comparisons between the median and commercially-achievable levels of performance highlight the opportunities for improvement in reproductive efficiency of beef breeding cows in northern Australia.

Table1. Observed median and commercially achievable (in parentheses)* percentage of lactating cows pregnant within 4 months of calving by country type and cow age class

Age class	Country type			
	Southern Forest	Central Forest	Northern downs	Northern Forest
1st lactation cow	37% (80%)	49% (68%)	45% (69%)	11% (18%)
2nd lactation cow	66% (84%)	64% (74%)	62% (67%)	6% (45%)
Mature cow**	76% (88%)	77% (84%)	67% (76%)	16% (33%)
Aged cow***	80% (90%)	71% (88%)	71% (77%)	20% (28%)

*Performance of 75th percentile property
**Cows estimated to be 5-9 years old
**Cows estimated based on their year brand to be >9 years of age

Factors affecting the efficiency of cows becoming pregnant after calving

The estimated attributable risk of cows not becoming pregnant within four months of calving (from largest to smallest) were *country type, period of calving, cow body condition score at the pregnancy diagnosis muster prior to calving, change in cow body condition score between pregnancy diagnosis and weaning or branding, cow age class, average ratio of faecal phosphorus to metabolisable energy during the wet season, year observed, average ratio of dry matter digestibility to dietary crude protein during wet season (*McGowan *et al*. 2014).

Impact of country type

After adjustment for all other factors (see above) contained in the final multivariable model were taken into account, the percentage of lactating cows in the Northern Forest that became pregnant within 4 months of calving was estimated to be 36%, 47% and 59% (P<0.05) lower than that achieved by cows in the Northern Downs, Central Forest and Southern Forest, respectively. These very large differences were predicted despite the fact that the model contained many of the key nutritional and cow-level factors considered likely to also be having big impacts on performance. This finding highlights the importance of establishing achievable levels of performance according to country type, and also demonstrates that further work needs to be done to more precisely determine the cause(s) of this effect. There were also interactions between country type and body condition score at the time of pregnancy diagnosis, and between country type and cow age class which will be described below.

Impact of period of previous calving

Although there are recognised limits to the accuracy of current methods of foetal ageing, cows can be quite accurately assigned to 2 to 3 month calving periods. When all other factors were taken into account the estimated mean percentage of lactating cows pregnant within 4 months of calving for cows which had previously calved in July-September, October-November, December-January, February-March and April-June was 15%, 46%, 64%, 55% and 43%, respectively. This finding was independent of mating system and strongly indicates that strategies to ensure the majority of heifers and cows calve during the optimum calving period should be considered by producers. However, it is recognised thatin some areas (particularly in the Southern Forest) that calves born in July-Septemebr attract sufficient premiums to support continuation of this practice. In continuously mated herds removing bulls during the mid-dry season (at time of pregnancy diagnosis or last weaning) and then re-introducing them the following January, reducing the mating period to 7 months, will prevent the majority of out-of-season (July-September) calvings. Foetal ageing to segregate continuously-mated cows according to expected 3 month period of calving (Braithwaite and de Witte 1991) enables more precise timing of weaning in relation to expected calving time.

Impact of cow body condition score at the pregnancy diagnosis muster prior to calving
Body condition score (BCS using a 1 to 5 scale; McGowan *et al*. 2014) at the time of pregnancy diagnosis was a significant ($P<0.001$) determinant of the likelihood of lactating cows being pregnant within 4 months of calving. However, its associated effects were dependent on country type ($P<0.001$). The percentage of cows in poor body condition (BCS<2.5) at the time of pregnancy diagnosis the previous year that subsequently became pregnant within 4 months of calving was 7.8%, 13.7%, 18.1% and 21.6% lower ($P<0.05$) than cows in fair (BCS 2.5), moderate (BCS 3.0), good (BCS 3.5), and very good to fat (BCS 4-5) condition, respectively. However, the magnitude of the differences between body condition score categories was consistently much lower (average of 2% difference between BCS categories) for cows in the Northern Forest compared to those in the other country types. Part of the explanation for this difference is that except for cows in poor condition, most other cows in this country type lost condition between the mid-dry season muster (when pregnancy diagnoses were done) and the first annual weaning muster the following year.

Most of the publications reporting a significant relationship between cow body condition and reproductive performance have analysed the relationship between cow body condition at or near to calving and various measures of postpartum reproductive performance. In extensively managed herds it is often difficult to accurately assess cow condition near to calving, however the study of McGowan *et al*. (2014) has demonstrated that cows that were in good or better body condition at the time of pregnancy diagnosis (typically 3-4 months prior to peak period of calving) were subsequently significantly more likely to become pregnant within 4 months after calving than those in poor condition.

The most effective means of increasing the likelihood that cows will be in good body condition at the time of pregnancy diagnosis is to wean their calves before pasture quality deteriorates to sub-maintenance quality. In subtropical-tropical rangelands managing the majority of cows to calve just prior to or early in the wet season and subsequently timing weaning to occur near the end of the growing season will ensure most cows are in good condition prior to their next calving.

Impact of change in cow body condition score between the mid-dry season and weaning
When all other major factors were taken into account the percentage of lactating cows which became pregnant within 4 months of calving was 8% higher in cows that gained body condition between the time of pregnancy diagnosis the previous year (usually mid-dry season) and weaning of their calves the following year, compared to those cows that did not achieve a net gain in condition. There are a range of different management options involving strategic use of energy and nitrogen supplements prior to and after calving that can be utilised to improve cow condition but the cost effectiveness of these strategies must always be assessed (Holroyd and Fordyce 2001).

Impact of cow age class
The percentage of 1st lactation cows which became pregnant within 4 months of calving was predicted to be significantly lower than that for 2nd lactation cows, mature cows, and aged cows (>9 years of age); 4.9%, 12.6% and 16.1% lower, respectively. This pattern was consistent across country types except in the Northern Forest where 2nd lactation cows had a significantly lower percentage pregnant within 4 months than 1st lactation cows (3.2% lower). These findings are consistent with previous research and industry observations that in the Northern Downs and Northern Forest mature and aged cows have a higher likelihood

of becoming pregnant while lactating than first- and second-lactation cows. Further, and particularly in the Northern Forest where percentage of lactating cows pregnant within 4 months is low, selection of bulls reared from females that become pregnant while lactating for the first time will likely result in long term improvement in herd fertility (Barwick *et al*. 2014).

Impact of average ratio of faecal phosphorus to metabolisable energy during the wet season
McGowan et al. (2014) used the average wet season ratio of faecal phosphorus to metabolisable energy (FP:ME determined from pasture dry matter digestibility derived by faecal near infrared reflectance spectroscopy; Jackson *et al*. 2012) to determine the risk of phosphorous deficiency adversely impacting on cow reproductive performance. First lactation, 2nd lactation, mature and aged (>9 yrs) cows considered to have a high risk of phosphorus deficiency adversely affecting performance (average wet season FP:ME < 500 mg P/MJ ME) had 24.3%, 0.8%, 4.1% and 9.5% lower percentage lactating cows pregnant within 4 months of calving than cows that were considered to have a low risk of phosphorus deficiency adversely affecting performance (average wet season FP:ME ≥500 mg P/MJ ME), respectively. These differences were all statistically significant except for 2nd lactation cows. The large difference in performance of 1st lactation cows is probably because the majority of these cows would still be undergoing skeletal and soft tissue growth at the same time as their foetus is undergoing mineralisation of its skeleton and subsequently they must lactate for periods of 4 to 7 months with accompanying significant losses of phosphorous in the milk they produce. The ability of this class of breeding female to meet any deficiency in phosphorous by mobilisation of body reserves is likely to be significantly less than that of older cows. These findings are consistent with previous reports (Miller *et al*. 1996) and highlight the likely significant improvement in performance to be gained by managing 1st lactation cows as a separate group and providing supplementary phosphorus where required.

Impact of year observed
Overall cows calving in 2009 had a lower (P<0.001) likelihood of being pregnant within 4 months of calving than those calving in 2011. Again this demonstrates that despite a very concerted attempt to measure all the major nutritional and environmental factors likely to affect cow performance there is a large and consistent effect of season on performance that is yet to be more precisely defined.

Impact of average ratio of dry matter digestibility to dietary crude protein during wet season
McGowan *et al*. (2014) used the DMD:CP ratio to estimate the adequacy of wet season pasture protein. The percentage of lactating cows which became pregnant within 4 months of calving was 7.5% lower in cows grazing pasture with an average wet season DMD:CP ratio of >8:1. This finding highlights the importance of implementation of pasture management and supplementation strategies that may increase availability of protein in the wet season (Holroyd and Fordyce 2001).

Conclusion
A practical measure of production from beef breeding herds is weaner production (kg of weaner per cow; Fordyce *et al*. 2014). McGowan *et al*. (2014) demonstrated that an important contributor to weaner production is percentage of lactating cows pregnant within 4 months of calving. Above are listed the major factors to consider first when investigating what may be contributing to lower than expected or lower than achievable percentage of lactating cows pregnant within 4 months of calving in subtropical-tropical rangelands similar to those in northern Australia.

Although a thorough understanding of the major factors affecting the efficiency with which cows become pregnant after start of mating or the commencement of the wet season is important, it is equally important to understand the major factors contributing to foetal and calf losses, which in northern Australia are commonly in excess of 15%. The accompanying paper by Fordyce *et al.* (2014) describes the major factors affecting the likelihood of pregnant heifers and cows subsequently weaning their calves.

To improve the reproductive efficiency of beef breeding cows in subtropical-tropical rangelands similar to northern Australia producers need to adopt two broad strategies which should be implemented in parallel. Implementation of an appropriately designed genetic improvement strategy based on the findings of Johnston *et al*. (2014) should result in a long term improvement in the percentage of *Bos indicus* genotype cows that ovulate and conceive whilst lactating. Being aware of the major factors affecting the percentage of lactating cows that become pregnant within 4 months of calving and implementing measures to control these factors should result in significant short to medium term improvement in the reproductive efficiency of cow herds. Fordyce and Holroyd (2003) provide details of the range of management practices that producers should consider utilising to improve the reproductive efficiency of their beef breeding herds.

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