Calf ALIVE

SYMPOSIUM

Friday 24th – Saturday 25th November 2017

Capella, Queensland's Central Highlands

Organising committee: Dave Smith (Chairman), Kiri Broad, Lyn Coombe, Byrony Daniels, Geoffry Fordyce, Michael McGowen, Jarud Muller, Kylie Schooley, Nigel Tomkins

Secretariat: Jackie Kyte Conference & Event Specialist Pty Ltd - jackie@jackiekyte.com.au; 0409 564 729

Contents

Program

Chair: ***Geoff Murrell, General Manager Northern Australia Operations, Paraway Pastoral Company***

Day 1

12:00	**LUNCH**	
13:00	Welcome	
13:15	Kieren McCosker	*The prevalence of calf loss across northern Australia*
13:30	Tom Kasari	*The makings of a strong week-old calf*
14:30	Jarud Muller	*Hydration in newborn calves in the tropics*
14:45	Dan Lynch	*What calf loss costs*
15:00	**SMOKO**	
15:00	Michael McGowan	*Managing infectious and non-infectious causes of calf loss*
16:00		*Open questions to speakers*
19:00	**DINNER**	*"All hell breaks loose": tribute to Dr Peter O'Rourke*

Day 2

08:30	Frank Garry	Causes and management of calf loss in north America
09:30	Dahlanuddin	*Reducing calf loss through management in Indonesia*
10:00	**SMOKO**	
10:30	Kieren McCosker	*Defining the level of calf loss and identifying causes in your own herd*
10:50	Kylie Schooley	*What producers can do about calf loss*
11:10		*Open questions to speakers*
12:00	Michael McGowan	*Close*
12:10	**LUNCH**	

Objective

Create awareness within the beef producer and RD&E communities of recent advances in Australian and international calf loss research, offer practical advice on ameliorating loss, and discuss the issues with well-known national and international practitioners in the field of calf loss minimisation and beef herd productivity.

Background

Calf loss in beef breeding herds is a global problem causing reduced live weight production and lower profitability from cattle ownership, and is also associated with diminished welfare of both people and animals. The incidence in south-east Asia averages 20-30%. In the northern forest of Australia, median loss averages 15-20% over vast areas. Large studies in recent times have shown the major risk factors to be very different to that which cause calf loss in intensive or temperate-region cattle systems, and are primarily nutritional and environmental, with infectious diseases being an irregular primary cause. Interventions that improve milk delivery to neonatal calves and prevent primary infectious diseases are expected to reduce rates of loss. This symposium will bring together many specialists to discuss the opportunities available to manage cows for low reproductive wastage and high productivity, the consequences of which will be better returns for time and money invested by both smallholders and large-scale producers in the tropics.

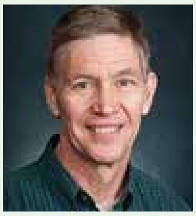
What is a symposium?

The word is derived from the Greek words of *sun* = together and *potēs* = drinker, and therefore denoted a drinking party. A modern definition is a meeting to discuss a particular subject; but we still love the old definition.

Speakers

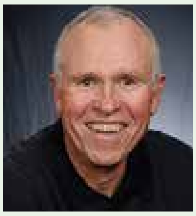
Dr Dahlanuddin
dahlan.unram@gmail.com

Dahlan is highly-respected for his leadership in improving beef systems in Indonesia. His work has resulted in major transformations to cow productivity in eastern Indonesia.



Dr Frank Garry
Franklyn.Garry@ColoState.edu

Dr Frank has studied neonatal calf survival in the USA. He is currently at Colorado State University where Johne's Disease control, causes of mortality in adult cattle, livestock worker education, and calf health management are his primary research interests.



Dr Tom Kasari
tom.kasari@agrivetsolutions.com

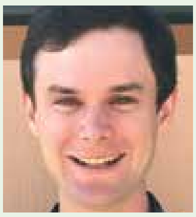
Dr Tom has considerable research experience in the health and physiology of newborn calves. He currently works for the US Department of Agriculture as a veterinary epidemiologist.

Dan Lynch
danlynch@bigpond.com

Dan and his family have beef breeding operations in the NT's Top End and the southern Gulf where, through a 'rest and rotation' strategy, he has increased cow annual live weight production from 9 to 29 kg/ha. He has advocated strongly for calf wastage research over many years.

Dr Kieren McCosker
kieren.mccosker@nt.gov.au

Based in Katherine (NT) as a Beef Production Scientist, Kieren did a PhD in the Cash Cow project. Kieren has research interests across all aspects of beef production systems.



Jarud Muller
Jarud.Muller@daf.qld.gov.au

Jarud is a young DAF (Qld govt) scientist based at Charters Towers. He has a keen interest in beef cattle reproduction and has conducted some innovative research on calf survival.

Geoff Murrell

geoff.murrell@parawaypastoral.com

Geoff has worked on and managed large north Australian beef enterprises. He is General Manager Northern Australia Operations, Paraway Pastoral Company Ltd.

Kylie Schooley

schooley@bigpond.com

Kylie's family has a beef business in SE Queensland (Cheltenham). She is a cattle vet with a practice in Chinchilla.

Dr Peter O'Rourke – *Dinner Speaker*

Peter O'Rourke worked as a biometrician with Department of Primary Industries (1967-94) to provide statistical advice on design of studies, research planning and data analysis for agricultural research. His special interest and passion was the north Australian beef industry. In 1992 he joined the Beef Industry Program to provide strategic leadership and to liaise with industry. His PhD in 1994 developed models for reproductive management of beef herds in north Australia.

Peter joined the Public Health program at University of Queensland in 1994 and QIMR Berghofer in 2006. Here he leads statistical consultancy and research collaboration in medical and public health research. However his interest and active role in beef cattle research for north Australia persists after first beginning 50 years ago.

The Australian contingent were all participants in the Cash Cow project and are now in the Calf Wastage team, the balance of whom are:

Wendy Brodie	*Redland Park, Mackinlay*
Bec Comisky	*Melton Grazing, Alpha*
Alister McClymont	*Burleigh, Richmond*
Tim Schatz	*NT DoR, Darwin*
Geoffry Fordyce	*QAAFI, Charters Towers*
Dr Luis Silva	*QAAFI, Brisbane*
Prof Nigel Perkins	*UQ, Gatton*
Dr Tamsin Barnes	*UQ, Gatton*
Dr Simon Quigley	*UQ, Gatton*
Dr David McNeill	*UQ, Gatton*
Dave Smith	*DAF, Charters Towers*
David Mayer	*DAF, Brisbane*
Dr Bruce Hill	*DAF, Brisbane*
Dr Lee Allen	*DAF, Toowoomba*
Dr Ben Allen	*USQ, Toowoomba*
Prof Roger Hegarty	*UNE, Armidale*

Recent Publications

Burns, B.M., Fordyce, G. and Holroyd, R.G. (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**:1-22.

Bunter KL, Johnston DJ, Wolcott ML and Fordyce G (2014). Factors associated with calf mortality in tropically adapted beef breeds managed in extensive Australian production systems. *Animal Production Science* **54**:25-36.

Fordyce G, Holroyd RG, Taylor J and Kirkland PD (2013). *Neospora caninum* and reproductive wastage in extensive Queensland beef herds. *Australian Veterinary Journal* **91**:385-390.

Fordyce G, McGowan MR, McCosker K and Burns BM (2014). Reproductive wastage in extensively-managed beef cattle. *In:* Proceedings of the 28th World Buiatrics Congress, Keynote lectures, 27 July to 01 August 2014, Cairns. pp.94-100. ***(FULL PAPER PROVIDED)***

Fordyce G, McGowan MR, McCosker K and Smith D (2014). Live weight production in extensively-managed beef breeding herds. *In:* Proceedings of the 28th World Buiatrics Congress, Keynote lectures, 27 July to 01 August 2014, Cairns. pp.87-93.

Fordyce G, McMillan H and McGrath N (2014). Accelerating healing of calf frontal sinuses exposed by dehorning. Final Report, Project B.AWW.0227, Meat and Livestock Australia, Sydney. http://www.mla.com.au/Research-and-development/Final-report-details?projectid=15464

Fordyce G, Olchowy TWJ and Anderson A (2015). Hydration in non-suckling neonatal Brahman cross calves. *Australian Veterinary Journal* **92:** 214-220.

Fordyce G, McGowan MR and Johnston D (2016). Mating outcome effect on live weight production and efficiency of beef cows. Proceedings of the World Buiatrics Conference, 4-7 July 2016, Dublin. p 543.

Fordyce G, McGowan MR, Smith D, McCosker K, Schatz T, Perkins N, McNeill D (2016) Discussion paper: Candidate management interventions to reduce foetal and calf loss in beef herds in northern Australia. Project B.GBP.0001, Meat and Livestock Australia, Sydney.

Hutchinson, L., Fordyce, G., Corbet, N. and Grant, T. (2011). Brahman teat and udder score changes during lactation. *In:* Proceedings, Northern Beef Research Update Conference, 1–2 Aug 2011, Darwin. p 115.

Kirkland, P.D., Fordyce, G., Holroyd, Taylor, J. and McGowan, M.R. (2009). Impact of infectious diseases on beef cattle reproduction: Investigations of pestivirus and *Neospora* in beef herds in eastern Australia. Final Report, Project AHW.042, Meat and Livestock Australia, Sydney.

Lane J., Jubb T., Shepherd R., Webb-Ware J. and Fordyce G. (2015). Priority list of endemic diseases for the red meat industries. Final Report, Project B.AHE.0010, Meat and Livestock Australia, Sydney. http://www.mla.com.au/Research-and-development/Search-RD-reports/RD-report-details/Animal-Health-and-Biosecurity/Priority-list-of-endemic-diseases-for-the-red-meat-industries/2895

McBryde K, Pilkington R, Fordyce G, Smith DR and Limburg N (2013). Measuring milk yield in beef cattle. *In:* Proceedings, Northern Beef Research Update Conference, 13–14 Aug 2013, Cairns. p.177.

McGowan MR, McCosker K, Fordyce G, Smith D, O'Rourke PK, Perkins N, Barnes T, Marquet L, Morton J, Newsome T, Menzies D, Burns BM and Jephcott S (2014). North Australian beef fertility project: Cash Cow. Final Report, Project B.NBP.0382, Meat and Livestock Australia, Sydney. http://www.mla.com.au/Research-and-development/Final-report-details?projectid=15462

McGowan MR, Fordyce G, Smith D and McCosker K (2016). Managing liveweight production from beef breeding herds. *In:* Proceedings of the 29th World Buiatrics Congress, Keynote lectures, 04-07 July 2015, Dublin. pp 87-90. ***(FULL PAPER PROVIDED)***

Muller J, Fordyce G and Anderson A (2016). Are neonatal beef calves getting enough to drink in northern Australia? Proceedings of the Australian Society of Animal Production, Adelaide. p89.

Smith D, Fordyce G, Perkins N, McGowan MR (2016) Objective prioritisation of RD&E for calf loss research in northern Australia. Report for Project B.GBP.0001, Meat and Livestock Australia, Sydney.

REPRODUCTIVE WASTAGE IN EXTENSIVELY-MANAGED BEEF CATTLE

Geoffry Fordycea, Michael McGowanb, Kieren McCoskerc and Brian Burnsa

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[b] The University of Queensland, School of Veterinary Science, Gatton 4343, Australia.

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Summary

This paper complements a comprehensive review of reproductive wastage in northern Australia by Burns *et al.* (2010) by providing outcomes from recent research that has added considerably to our understanding of the risk factors. Recent research has involved a large number of cattle on a large number of extensive beef properties, where herd sizes usually exceed 1,000 breeding cows. High variability in foetal and calf loss in northern Australia has been demonstrated. A high incidence of elevated reproductive wastage occurs, especially in the tropical northern forest region where 40% or greater loss has been recorded. Loss associated with reproductive disease, primarily BVDV and *Campylobacter,* was confirmed. Animal factor effects previously associated with reproductive wastage were quantified. Of greatest significance was a range of nutritional, environmental and management risk factors having large impacts on calf survival, either directly or as a result of cow mortality. This research has provided the basis that will enable beef producers to attain achievable levels of reproductive wastage, thereby increasing business productivity and profitability.

Introduction

Foetal and calf loss between confirmed pregnancy and weaning is a major problem in northern Australia, with the average exceeding 15% in tropical forested areas (McGowan *et al.* 2014). A high proportion of loss occurs within a week of birth. Reasons for loss are multiple. Although the specific causes of the majority of loss remain unconfirmed, recent research indicates that the primary causes are not infectious diseases, but are nutritionally related.

Burns *et al.* (2010) conducted a comprehensive review of foetal and calf loss in north Australia. This paper provides additional information and perspective from more recent research and the business impact in extensively-grazed beef cattle in northern Australia. For the purposes of this review, terms are defined in Table 1.

Northern Australia and beef breeding cattle

Northern Australia is transected by the Tropic of Capricorn. Summer temperatures are high. Winters are warm in the north and cooler in the south. Frosts are common in inland areas south of the Tropic of Capricorn. Australia is relatively dry with 50% of the country having a median rainfall of less than 300 mm per year and 80% less than 600 mm (Anon 2014). A north Australian 'wet' season, when most rain falls and grass grows, generally occurs from December through March. The remainder of the year is called the 'dry' season. Annual average evaporation exceeds 2 metres and is double this in some situations.

Cropping in northern Australia is mostly restricted to the north-eastern seaboard of Queensland and the eastern half of sub-tropical Queensland (central and southern forest regions; Table 1). Outside the large areas of desert in WA and the NT, beef production predominates, with wool production occurring in some areas of Queensland. Of the ~26 million Australian beef cattle, over half are located in this northern region and 45% in Queensland (Anon 2012). Management systems for beef cattle herds in northern Australia are described as extensive. Cattle diets are almost exclusively pasture. Stocking rates are low and in some areas are as low as one cow per 150ha (Tothill and Gillies 1992). Management groups of 500 to 1,000 cattle are common. The majority of cows is continuously mated with peak calving occurring late in the calendar year. Seasonal mating is usually between 3 and 7 months where suitable cattle-control infrastructure is available. Cattle handling for husbandry is infrequent and is typically twice annually in April-July and August-September (Bortolussi *et al.* 2005).

While median weaning rates for much of northern Australia are low, performance is higher in the eastern half of Queensland south from the Tropic of Capricorn where there more fertile soils predominate (Table 2). The high incidence of low weaning rate is primarily a consequence of low annual pregnancy rates. Instances of high combined foetal and calf loss occurs in all areas, but is almost always high in the northern forest.

Table 1. Definitions of terms used

Term	Definition
Northern Australia	Queensland, the Northern Territory and the northern half of Western Australia.
Beef CRC	A 2000-2011 genetics project in which >2,000 females, their steer siblings and bull progeny were monitored. Females were monitored at 4 sites in Queensland representing the main country types.
Cash Cow project	A north Australian project in which ~78,000 cows were monitored on 72 commercial beef businesses for between 2-4 years.
Northern Downs	Downs (naturally non-forested, black soil plains) areas of western Queensland, the Barkly Tableland, and the Kimberley region.
Northern Forest	Non-downs northern dry tropical areas, north of ~21OS (Bowen to Karratha).
Central Forest	Forested areas associated with the Brigalow areas of Queensland.
Southern Forest	Non-downs areas outside the Brigalow country of central and southern Queensland.
Prenatal loss	Abortion, calculated as a percentage of pregnant cows.
Perinatal loss	Calf death within 48 hours of birth, calculated as a percentage of pregnant cows.
Postnatal loss	Calf death between 2 days after birth and programmed weaning, calculated as a percentage of pregnant cows.
Neonatal mortality	Calf death within one week of birth, calculated as a percentage of pregnant cows.
Cows missing	Annual incidence of cows experiencing mortality, tag loss and unrecorded relocation.
Cow mortality	Annual incidence of cow death, with most deaths associated with death of a foetus or suckling calf.
Reproductive wastage	Death of a foetus, calf or cow between confirmed pregnancy diagnosis and weaning, and calculated as a percentage of pregnant cows.
Lactation rate	Calves weaned as a percentage of cows retained after weaning the previous year.
Weaning rate	Percentage of pregnant cows * (1 – Reproductive wastage).

Table 2. Annual performance of north Australian beef cows with 25 to 75 percentile range (McGowan *et al.* 2014)

Country type	Pregnant	Missing	Foetal/Calf loss	Weaning
Southern Forest	85% (77-92%)	9%	6% (2-10%)	76% (62-88%)
Central Forest	85% (78-92%)	10%	7% (4-10%)	77% (69-87%)
Northern Downs	83% (74-91%)	7%	10% (5-15%)	72% (57-78%)
Northern Forest	66% (55-74%)	15%	13% (10-19%)	53% (44-62%)

Table 3. Recent reports of foetal and calf wastage in north Australian beef cattle herds, excluding Beef CRC and Cash Cow projects

Measure	Level	Sth forest	Central forest	Nt downs	Nth forest	Data source #
Prenatal loss	Target				5%	a
Perinatal loss	Target				4%	a
Postnatal loss	Target				3%	a
Reproductive wastage	Target				12%	a
Prenatal loss	Range	0-9%	0-12%	8%	1-12%	b
Perinatal loss	Range		3-12%	2-12%	3-8%	b
Postnatal loss	Range		0-5%	9-10%	3-16%	b
Reproductive wastage	Range		7-10%	21%	3%	b
Reproductive wastage	Range			12-39%		c
Reproductive wastage	Average			13%	8%	d
Reproductive wastage	Range				0-29%	e
Cow mortality	Range				0-10%	e
Cow mortality	Range				1-28%	f

a: Holroyd 1987; b: Burns *et al.* 2010; c: Schatz and Hearnden 2008; d: Fordyce *et al.* 2013; e: Fordyce *et al.* 2009; f: Henderson *et al.* 2013

Incidence of reproductive wastage

The review of Burns *et al.* (2010) and reports from recent relatively-small projects show there is considerable variation in reproductive wastage in northern Australia and that there has been a paucity of specific information in this area (Table 3). Field work for two large projects has recently been completed and provides a much more detailed understanding of the variation in reproductive wastage (Table 4). In the Cash Cow project, the 25th percentile was taken as the practical achievable level for reproductive wastage. Large variation in loss was demonstrated above this level across the region. Schatz and Hearnden (2008) reported an average reproductive wastage of 22%, and up to 39% of first-lactation cows in large Northern Territory herds (>4,000 cows monitored) failing to lactate in the year after pregnancy diagnosis.

Table 4. Raw data for reproductive wastage in the Beef CRC project (9,678 pregnancies in >2,000 cows) and the Cash Cow project (23,166 pregnancies)

Calves	Measure	#	Southern forest	Central forest	Northern downs	Northern forest
Brahmans - Beef CRC ##						
All	Repro wastage	Av		12.7%	27.8%	11.4%
	Cow mortality	Av		0.7%	0.4%	0.8%
	Prenatal loss	Av		2.7%	3.1%	3.4%
Singles	Perinatal loss	Av		3.7%	14.5%	2.5%
	Postnatal loss	Av		5.5%	9.7%	4.5%
	Wean	Av		87.0%	71.7%	88.5%
Twins	Peri & Peri	Av		0.1%	0.0%	0.1%
	Post & Post	Av		0.0%	0.0%	0.0%
	Peri & Wean	Av		0.2%	0.3%	0.0%
	Post & Wean	Av		0.1%	0.1%	0.1%
	Wean & Wean	Av		0.1%	0.0%	0.1%
Tropical composites - Beef CRC ##						
All	Repro wastage	Av	8.8%	9.2%	20.8%	
	Cow mortality	Av	0.6%	1.1%	1.0%	
	Prenatal loss	Av	4.0%	2.6%	3.5%	
Singles	Perinatal loss	Av	2.5%	2.9%	11.1%	
	Postnatal loss	Av	1.8%	2.6%	5.0%	
	Wean	Av	90.9%	90.4%	78.9%	
Twins	Peri & Peri	Av	0.0%	0.0%	0.1%	
	Post & Post	Av	0.0%	0.0%	0.1%	
	Peri & Wean	Av	0.1%	0.2%	0.1%	
	Post & Wean	Av	0.1%	0.2%	0.0%	
	Wean & Wean	Av	0.1%	0.1%	0.2%	
All breeds - Cash cow project						
First	Repro wastage	Med	8.9%	10.2%	14.9%	16.4%
			3.9-13.6%	3.7-17.7%	7.3-20.0%	10.8-19.1%
Second	Repro wastage	Med	4.6%	7.3%	4.7%	9.5%
			0.7-7.1%	3.5-11.3%	4.3-9.3%	5.4-13.6%
>Second	Repro wastage	Med	4.6%	6.2%	6.9%	13.5%
			2.2-8.5%	3.8-9.1%	3.3-14.7%	9.4-19.2%
All	Missing cows	Med	8.3%	7.9%	6.6%	10.6%
			3.3-12.5%	1.8-11.2%	3.8-9.8%	5.8-15.9%

A: Average; Med: Median with interquartile range; ## Excludes one year of data from the northern downs site where Vitamin A deficiency was associated with 41% calf loss

Variation in established pregnancy per oestrus cycle has rarely been reported for this region. Preliminary data analyses from 24 mating groups of tropically-adapted cattle at 4 sites across Queensland revealed a range of 40%-70% during 12-week mating periods (Fordyce *et al.* 2005). Given the low incidence of infectious disease in the study herds, the median rate of approximately 60% pregnant per oestrus cycle in this investigation is currently considered the achievable level for beef herds in north Australia.

Cow mortality has not been usually cited as a component of reproductive wastage. Fordyce *et al.* (1990) reported that mortality risk increased between conception and weaning, and that almost all pregnancies and calves were lost from cows that died following a prolonged dry period. The incidence of cow mortality (Tables 3 and 4) is highly variable and high in many situations, especially in the northern forest. Based on the incidence of missing cows, the incidence of mortality may be at least 3% higher in the northern forest than elsewhere (Table 4). A recent study of cow mortality in 45 large north Australian beef herds in northern forest and northern downs regions reported a median breeding cow mortality rate of 6% (Henderson *et al.* 2013).

Infectious reproductive diseases and reproductive wastage

There are a limited number of recognised infectious diseases that contribute to calf loss in northern Australia. Foremost among these is BVD. McGowan *et al.* (2014) reported that the average percent cattle pregnant within 4 months of calving was 57%, 43% and 34% in north Australian herds with <20%, 20-80% and >80% of cows sero-positive to BVDV, respectively; about a third of herds were within each sero-prevalence category. This result confirms a large impact of the virus on fertilisation failure and or embryo loss in this region. High prevalence of recent BVDV infection in cows sampled in early-mid pregnancy was associated with almost 10% higher foetal and calf loss than in herds with a low prevalence of recent infection (P<0.001; Table 5). Both Kirkland *et al.* (2012) and Morton *et al.* (2013) also reported a low proportion of cattle herds having recent BVDV infection and confirmed the large impacts of foetal and calf loss associated with recent infection. Both groups reported that half the herds they studied had 0-30% sero-positive animals, indicating high susceptibility to the virus.

Table 5. Reproductive wastage (%) associated with herd exposure to common infectious reproductive diseases in the Cash Cow project (McGowan *et al.* 2014)

Disease	Herd prevalence		Herd distrib (%)		% reproductive wastage
	Level	Criterion	2009	2011	(confid interval)
BVD	Low	<10% AGID 3+ #	42	64	11.5 (6.5-16.4)
	Mod	10-30% AGID 3+	31	27	12.1 (7.0-17.2)
	High	>30% AGID 3+	28	9	20.8 (12.5-29.2)
C.fetus sp. *veneralis*	Low-Mod	<30% vaginal mucus Ab	98	89	12.9 (8.4-17.4)
	High	≥30% vaginal mucus Ab	2	11	19.9 (10.8-29.0)
Neospora caninum	Nil	0% sero-positive	19	24	12.6 (3.5-12.2)
	Low	0-20% sero-positive	55	53	12.0 (5.9-18.1)
	Mod-High	≥20% sero-positive	26	23	15.9 (7.0-24.9)

Agar gel immuno-diffusion

Recent data from >37,000 cattle that were mostly 1-2 years of age showed there is very little variation in >1% BVDV antigen prevalence across Australia (Dr Peter Kirkland, Elizabeth McArthur Agricultural Institute, NSW, personal communication). Modelling that uses an understanding of BVDV epidemiology in Australia (McGowan *et al.* 1993a; McGowan *et al.* 1993b; Kirkland *et al.* 1990) suggests that, depending on the relative prevalence of BVDV strains with varying abortigenic effect, weaning rate is conservatively estimated to be lower by between 1% and 4.5% as a result of between 3% and 7% of cows being infected in early pregnancy each year. Each percentage unit reduction in weaning rate equates to >40,000 calves in northern Australia. Modelling of available data suggests that, irrespective of the virus's effect on pregnancy, >100,000 persistently-infected calves are born annually in north Australia.

N.caninum infection was not associated with increased reproductive wastage in north Australian beef herds in two large recent studies (Fordyce *et al.* 2013; McGowan *et al.* 2014). However, there was a non-significant (P=0.5) trend for herds with a moderate to high seroprevalence to have a higher predicted mean percentage foetal/calf loss than those with either nil or a low seroprevalence in the latter study (Table 5). These findings contrast sharply with studies of the impact of *N.caninum* infection of dairy cattle on the Atherton Tableland in northern Australia (Landmann *et al.* 2011) and elsewhere in the world. The reason for this difference is not apparent, but one could speculate that because wild dogs have been shown to be a carrier of this organism (King *et al.* 2012) and are common across the beef breeding regions of northern Australia, exposure of young heifers to pastures contaminated with faeces from wild dogs may result in them becoming immune to infection (Williams *et al.* 2009).

Campylobacteriosis has primarily been associated with embryo loss (Clark 1971), which usually occurs prior to the typical time for foetal ageing of commercial beef herds. However, in a large north Australian study, high prevalence of vaginal mucus samples positive for antibodies to *C.fetus sp.veneralis* had no impact on percent pregnant within 4 months of calving, but was associated with 7% higher reproductive wastage than in herds where the prevalence was low to moderate (Table 5). The contribution to reproductive wastage of *Tritrichomonas fetus,* which also is reported to cause abortions, was not measured in the study. This effect of campylobacteriosis requires further study, part of which is to develop practical and efficacious diagnostic tests of clinical infection.

Although leptospirosis is recognised as a cause of calf loss (McGowan 2003), the incidence of this effect in north Australian beef herds is not well established. In a large recent project, vaccination against leptospirosis *(L.pomona and L. hardjo)* was associated with a 3.4% reduction in reproductive wastage (McGowan *et al.* 2014). Only 3/27 herds in 2009 and 0/41 herds in 2011 had evidence of recent infection with *L.pomona* (≥10% with a MAT titre ≥800). The three herds in which 10-30% of cows had evidence of recent infection tended to have higher (+6%) reproductive wastage than herds with a low prevalence of recent infection.

Professional opinion is that botulism is a highly prevalent disease across north Australia (Sackett *et al.* 2006). The disease is associated with deficient appetites, which is a common occurrence in north Australia; vast areas have low soil and pasture phosphorus (McCosker and Winks 1994). The incidence of clinical disease which has a high mortality rate, has not been quantified in the region. Deaths due to botulism in unvaccinated cattle will be associated with reproductive wastage where the affected animal is either pregnant or lactating.

Environmental, nutritional and management influences on reproductive wastage

The large effects of a range of environmental, nutritional and management risk factors in north Australia on reproductive wastage, including through causing cow mortality has recently been quantified (Table 6). These data emphasise that the overall effect of these risk factors on reproductive wastage in northern Australia is just as high, and higher in many cases, that that due to disease and animal effects.

Other than infectious diseases, predation and dehorning, calf death is likely to be the outcome of either the cow not providing enough milk, or the calf unable to suckle effectively (low vigour). When ambient temperatures are not high, non-suckling calves lose about 7% of their weight daily, which is equivalent to about 2.5 litres of milk daily (Fordyce *et al.* 2014b). When calves lose 15% of their weight, they need intervention to survive. When ambient temperatures approach 40OC, calves can lose this weight in one day, that is, neonates need at least 5 litres daily. Many cows may not be able to provide this if they have inadequate tissue reserves or are nutritionally-stressed. This is a likely outcome for many of the risk factors listed for reproductive wastage. Fordyce *et al.* (1996) reported daily milk yield of first-lactation Brahman cross cows in mid-lactation of 3.6 kg. McBryde *et al.* (2013) found average milk yields of 3.3 kg/day from moderately-conditioned Brahman cows with a trend for milk yield to increase by 1 kg/day per unit increase in body condition score (5-point scale). These reports highlight the potential loss of calves that can occur when nutritional stress is experienced or when the temperature-humidity index is elevated.

Post-natal loss of calves due to dehorning (Bunter *et al.* 2014a) may be reduced through simple methods that reduce associated haemorrhage (Fordyce *et al.* 2014a).

Losses associated with predators are counter-intuitive. Wild dogs are prevalent across all north Australian beef production areas. McGowan *et al.* (2014) and Allen (2014) both reported that when producers took typical measures to reduce wild dog populations in northern Australian beef herds are more likely to be associated with an increase in calf predation than a decrease. Allen (2014) has suggested this is due to poison-baiting impacts on dog behaviour which causes them to target non-preferred species when they would usually native prey.

Table 6. Increases in reproductive wastage and cow mortality in recent north Australian studies due to risk factors other than infectious disease when compared to reference values in analyses

Risk factor		AV Effect	#
Cow and calf factors on reproductive wastage			
Previously failed to lactate in the year after diagnosed pregnancy		3.5%	a
Birth weight < 29 kg where population average ±sd is 33.5 ±5.9 kg		8%	b
Teat score 5 (1-5 scale) = Bottle teats		20%	b
Udder score 5 (1-5 scale)		6%	b
Hip height > 140 cm = Large mature size		3.5%	a
Environmental, nutritional and management factors on reproductive wastage			
THI* >79 for > 15 days in the expected month of calving		4-7%	a
Low-protein dry-season feed, ie, CP:DMD ratio < 0.125		4%	a
Vit A deficiency after consecutive low-rainfall years on treeless plains		≤25%	b
Low herd phosphorus status and low-growth tropical environment		10%	a
Low herd phosphorus status and BCS <3.5 ## mid-pregnancy		3.5%	a
Mustering within 2 months of calving month:	mature cows	2%	a
	first-lactation cows	9%	a
Wild dog predation considered a problem, irrespective of regular control		5%	a
Dehorning		2%	b
Mustering efficiency < 90%		9%	a
Factors affecting breeding cow mortality rate			
Dystocia when calving at 2 years without strategic nutritional support		5-10%	d
Cows > 11 years of age		6%	c
Low-growth tropical environment		7%	a
Pasture available < 2 tonnes/ha in the early dry season		5.5%	a
No rainfall within 30 days of 50 mm at the end of the dry season		4%	a
Body condition score < 3 (1-5 scale) mid-pregnancy		3-8%	a
No dry season segregation based on foetal age		10%	c
No wet season phosphorus supplementation		1%	c

Source – a: McGowan *et al.* 2014; b: Bunter *et al.* 2014a; c: Henderson *et al.* 2013; d: Fordyce *et al.* 2009; ## Body condition score on a 1-5 scale; * Temperature-humidity index (Hahn *et al.* 2009)

Dead cows provide very little milk and have a negative impact on herd live weight production (no reference available so we hope it is true). Mayer *et al.* (2012) derived a model to predict cattle mortality rates using data from multiple north Australian databases with observed annual mortality rates of 3% in pre-breeding age cattle and 11% in breeding-age cattle. Their modelling found that survival is a complex relationship between body condition score, dry season weight change and age. This supports the analysis of Fordyce *et al.* (1990) that identified the major risk factors for higher cow mortality to be aged > 8 years, lower body condition and more advanced reproductive status (conception to weaning); the latter is associated with higher energy demand, thus greater weight loss during the dry season.

Animal factors and reproductive wastage

Reproductive wastage is lowly repeatable as cows that experienced it in one year will only have a 3.5% higher chance of wastage in a subsequent year (McGowan *et al.* 2014; Table 6), independently of other animal effects including udder and teat score and effects of birth weight (Bunter *et al.* 2014a). Mature size will contribute to repeatability as tall cows were shown to have higher loss than short and medium-height cows in northern Australia (McGowan *et al.* 2014). It is hypothesised that being tall is associated with a higher probability that energy is diverted away from milk production towards the cows itself in order to sustain its own survival.

Bunter and Johnston (2014b) also showed that reproductive wastage in tropical cattle in northern Australia is lowly heritable as previously reported for USA Brahmans (Riley *et al.* 2004). However, large teats and udders which are phenotypically and genetically correlated with calf loss are highly heritable (Table 6; Bunter and Johnston 2014b). This research was unable to discern a specific effect of common breeds used in northern Australia on calf loss. This contrasts to the report from the USA where Brahman calves had a higher incidence of low vigour at birth than Brahman cross calves with a trend to high mortality (Riley *et al.* 2004).

Both the repeatability and heritability elements of reproductive wastage may also be partially related to factors that affect calves' ability to acquire adequate milk for survival. In their review, Burns *et al.* (2010) reported that behavioural influences on reproductive wastage were another potential contributor to repeatable and heritable calf loss.

Other than *in utero* infections such as with BVD, reasons for low calf vigour that may affect their ability to access milk and utilise nutrients are unclear. Riley *et al.* (2004) reported this trait to be heritable in Brahmans. Yates *et al.* (2012) in their review suggested that heat stress may also cause this outcome, in association with reduction in birth weight.

Dystocia is not commonly associated with calf loss in tropical cattle in north Australia. However, Fordyce *et al.* (2009) reported the large effects of dystocia in cows calving at two years of age (Table 6) when nutritional management did not adequately counter foeto-pelvic disproportion. The true extent of the effects of dystocia on calf viability and survival are unknown as this has been an extremely difficult aspect to study under extensive management conditions. Riley *et al.* (2004) has previously reported that dystocia in Brahman and Brahman cross cows reduces vigour of their calves at birth and increases mortality rates.

Unknown causes of reproductive wastage

Although there appears to be considerable variation in pregnancy rate per oestrus cycle in north Australian herds as a consequence of variation in fertilisation rates and embryo mortality, no research in the region has yet identified non-infectious causes for this variation.

Burns *et al.* (2010) reported that in northern Australia, the majority of reproductive wastage events had no discernable aetiology. The large epidemiological study of McGowan *et al.* (2014) has demonstrated the large impacts of environmental, nutrition, and management factors on reproductive wastage as discussed above. Although calf hydration appears to be a key element, the specific pathophysiology that results in calf death has not been explained in most cases; therefore, the exact manner of loss is not resolved. This reduces the ability to develop and apply remedial management. The likely role of aberrations in cow and calf behaviour contributing to loss is high and has previously been reported by Brown *et al.* (2003). Overcoming these behavioural effects relies on a better understanding of how this occurs.

Impact of reproductive wastage in north Australia

The loss of a foetus or calf reduces lactation rate and causes loss of annual net live weight production per cow, especially when associated with cow mortality. Economic herd modelling of herds in the region has shown that a 1% reduction in lactation rate and a 1% increase in mortality rate are independently associated with reductions in herd gross margins per adult equivalent (450 kg) of approximately AUD$1 and AUD$2, respectively (Niethe and Homes 2008). In a typical business that can sustain 3,000 adult equivalents, where management changes can increases lactation rate by 5% and decrease mortality rates by 2%, inputs to achieve these outcomes of up to AUD$27,000 are likely to be viable options. The effect of substantial reproductive wastage that is occurring above achievable levels has impacts on business that can be calculated in a similar manner for individual businesses.

Specific opportunities to remediate reproductive wastage are indicated by the risk factors associated with loss. However, further research is required to confirm the effects of management changes as much of the research has been of an epidemiological nature and not controlled testing of cause-and-effects. Further, many of the risk factors identified do not provide a direct indication of specific strategies, which must be developed through further research.

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MANAGING LIVEWEIGHT PRODUCTION FROM BEEF BREEDING HERDS

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Introduction – asking the right question

Too often when the question is asked, 'How is your beef breeding herd going?' the answer is a performance measure such as the proportion of cows pregnant or calves weaned. However, profit is primarily a function of live weight production, its value, and the cost of production. Therefore, the question should be 'How many kilograms of live weight do you produce annually from this management group (herd) of breeding females per hectare?' For example, if the farmer puts 100 tonne of cows in a paddock after completing pregnancy diagnosis of the herd then 12 months later how many tonnes of beef have been harvested from the herd (includes calves weaned and any cows and bulls sold). The role of veterinarians consulting to beef breeding farms should be to develop management strategies to improve herd live-weight production and identify opportunities to reduce cost of production. However, beef cattle farmers typically use veterinarians only to conduct pregnancy diagnosis, breeding soundness examination of bulls, and investigate outbreaks of disease or lower than expected reproductive performance.

Measuring live weight production and fertility of beef herds

Annual pregnancy diagnosis and foetal aging, assessment of lactation status at branding and weaning, and weighing a representative sample of cows and weaned calves provide the data required to define liveweight production and fertility of breeding herds. Transrectal foetal ageing enables estimation of month of conception and calving, which when conducted in two consecutive years enables the interval from calving to conception to be estimated. Assessment of lactation status after the expected period of calving enables determination of the incidence of foetal and calf loss. Summarising the data in the form of predicted month of calving histograms informs decisions on when to conduct branding or weaning, and enables the veterinarian to identify potential causes of reduced performance (Figure 1).

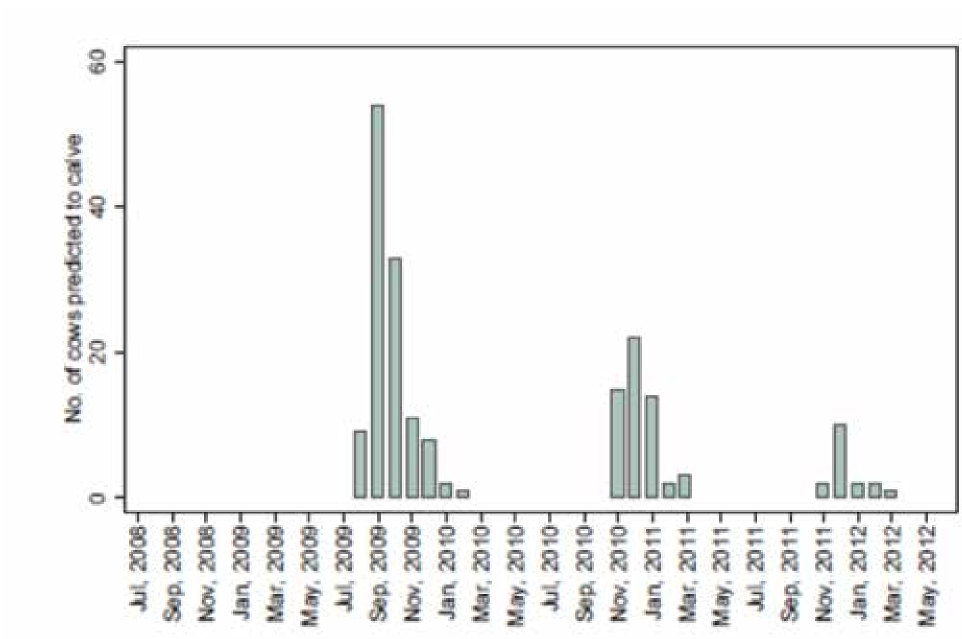

Figure 1. Calving pattern for a group of heifers that were monitored for 3 years in a herd which had a defined mating period. Note the shift to the right in month of calving which reduces the opportunity for late calving females to reconceive.

Relatively simple paper-based recording systems have been developed by Fordyce *et al.* (2014a) that enable live weight production and performance of beef breeding herds to be monitored. However, adoption of these recording systems has been highly variable with many extensive rangeland farmers in particular, still unable to accurately count the number of females on their farm or the number of calves weaned annually. The development of electronic identification (EID) systems to enable crush/chute-side and remote electronic data capture can be effective in monitoring the production and performance of extensively managed beef cattle (McGowan *et al.* 2014a; Swain and Friend 2013).

Operating herd management software using a ruggedized laptop and an electronic enter pad connected to an EID reader mounted to the crush/chute and electronic scales mounted under the crush/chute enables capture of 12 to 20 pieces of data on cattle at typical processing rates of 60 to 100 animals per hour (McGowan *et al.* 2014). Currently, the major limitations of this system are loss of EID tags from cattle, estimated at about 8% within 3 years of insertion in a tropical rangeland environment (McGowan *et al.* 2014a), and the inability to complete data analysis on the day of data capture. Cloud-based systems will allow real-time assessment of individual management information through viewing and recording farm data from any location using many devices (eg, laptops, phones, tablets). This will also enable interconnectivity for external on-the-fly data analyses that could validate data plausibility and estimate individual and management group production and performance indices.

Predicting live weight production that can be sustainably achieved by breeding cattle

Beef breeding herd management varies considerably across the world, but the fundamental principles remain constant. A key principle is to know what level of live weight production a specific feed resource, usually native or improved pasture, is capable of sustaining. In a large study of factors affecting the reproductive performance of commercial beef breeding herds in northern Australia (McGowan *et al.* 2014a) farmers/managers were asked estimate average annual growth of yearling steers if they grazed the pastures grazed by the heifers and cows enrolled in the study. Mean annual steer growth varied from 100 to 200kg associated with large differences in soil fertility and vegetation type. One easily measured estimate of live-weight production from breeding herds/management groups is weaner production (kg/cow = total weight of calves weaned / the number of cows retained for calving and then mating in the next year). McGowan *et al.* (2014a) demonstrated that commercial weaner production was on average equivalent to annual estimated steer growth. Research is currently being conducted in northern Australia to further investigate whether routine grazing of a sample of representative yearling steers in each paddock grazed by cows and heifers can be used to estimate the expected average weaner production from these paddocks. Clearly, because of the often marked variation in seasonal weather conditions this approach will need to be conducted over at least three years to obtain a reasonable estimate of average weaner production.

Beef farmers often aim to achieve a certain average weaning weight which may not take into account the feed resource(s) they have available for their cattle. For example, if the annual estimated growth of steers in a particular situation is 100kg and the average weight of calves weaned is 200kg, where does the additional 100kg come from? Clearly, it has to come from mobilisation of fat and protein reserves from the heifer or cows that produced these calves. In this low annual growth environment, these cows may lose 100kg during lactation (2 body condition scores - 1-5 scale), and as a consequence are unlikely to reconceive and have an increased risk of mortality. The farmer may then be forced into supplementary feeding to prevent cow mortalities; but then the question must be, 'is this intervention likely to be profitable'?

Farmers often want to know what level of production they should be aiming for. Although benchmarking herd or management group production causes angst amongst some economists, this is entirely valid if referenced against a measure of what the specific feed resource is capable of producing. An example of this approach is provided in Table 1.

Table 1: Annual weaner production from management groups of cows in northern Australia against estimated annual average steer growth (McGowan *et al.* 2014a)

Mean annual steer growth (kg)*	No. of herds	Weaner production (kg/cow)		
		25th percentile	Median	75th percentile
200	33	164.0	191.0	240.0
180	33	160.7	194.6	220.1
170	29	134.9	163.0	182.6
100	59	74.0	93.3	112.4

*Estimated growth of steers grazing same pasture as cows

What are the major drivers of live weight production of a breeding herd

The concept of live weight production (McGowan *et al.* 2014a) is that over a one-year production cycle, a cow's production, if she remains alive, is the sum of her live weight change, and the weight of any weaned calf. The business makes money by selling the annual live weight produced either directly, or after transfer to another sector of the herd for value adding. This is equivalent to how any business measures productivity.

McGowan *et al.* (2014a) demonstrated that no single performance measure of a population of commercial beef breeding herds in northern Australia was predictive of annual live weight production. However, this is not surprising since no measure of fertility takes into account heifer/cow mortality or annual change in live weight. Using annual live weight production as a primary measure of "how a herd is going" encourages a more holistic approach to herd management. However, regardless of whether beef breeding herds are control mated or mated continuously, key drivers of live weight production are the percentage of lactating cows pregnant within 4 months of calving (estimates the proportion of cows likely to wean a calf in consecutive years), the annual total percentage of pregnant cows, the percentage of foetal and calf loss between confirmed pregnancy and weaning, average weight of weaned calves, live weight change of heifers/cows and percentage heifer/cow mortality.

Developing management strategies to increase live weight production and reduce cost of production

It does not matter whether you are consulting to breeding herds of 5 cows or 150,000 cows, the critical influence of nutrition on reproductive performance is the same. Too often undue emphasis is placed on investigating infectious diseases and trace element deficiencies rather than focussing on body condition of heifers and cows in the last trimester of pregnancy and first 3 months of lactation. The major factors affecting the percentage of cows becoming pregnant within 4 months of calving and percentage of pregnant females failing to wean a calf in tropical rangelands typical of northern Australia have been described by McGowan *et al.* (2014b) and Fordyce *et al.* (2014b), and in many cases are remarkably similar to those identified as being important in more intensive temperate beef breeding regions of the world. The overall approach we recommend is after defining the likely factors affecting production and performance implement 'best practice' management strategies which are summarised as:

Manage the feed-base

You cannot make something from nothing. Cattle can only achieve net live weight production if energy and protein intake is above that required for maintenance. Beef breeding businesses are built on ready access to productive, palatable, nutritious pastures and good quality water. The principles of 'best practice' grazing management must be understood and implemented.

Key management practices

- Budgeting available feed to meet short and medium term cattle requirements
- Good grazing management to allow pasture recovery, eg, rotational grazing, or in tropical rangelands deliberate withholding of grazing of selected paddocks over the wet season
- Limit grazing distance from water to <2.5 km where possible
- Active pasture development and rehabilitation
- Fencing to control overutilization of preferred land types including riparian zones
- Use supplements that augment sound basic management. For example feeding supplemental phosphorous to late-pregnant heifers and first-lactation cows where risk of phosphorous deficiency is high. If good grazing management and lactation management practices are implemented then feeding of nitrogen supplements during the dry season in arid tropical rangelands may only be necessary during periods of severe drought.

Manage lactation

Cows have amazing capacity to meet their energy, protein and macro-mineral requirements from available pasture and mobilisation of their own body tissue reserves. However, where cattle draw down on their body tissue reserves (eg, during lactation) this must be followed by a period of re-alimentation in preparation for the next reproductive cycle. Thus the timing of weaning is critical because cows must have sufficient access to pasture of adequate quality to replenish body tissue reserves prior to the next calving event.

Key practices

- Manage weaning to conserve body condition of cows in preference to achieving high live weight weaners, ie, the decision on timing of weaning should be made on the basis of cow body condition, not an average weaning weight target.
- Use pregnancy diagnosis and foetal aging to segregate cattle for different nutritional management and efficient weaning. It is particularly important that heifers are managed as a discrete group until they are confirmed pregnant after calving for the first time. Also in continuously-mated herds identification of heifers and cows likely to calve at a time when pasture quality and quantity is very limited is critical to minimising cow and calf mortalities.
- Wherever possible mating should be controlled to ensure heifers and cows calve close to the time when the likelihood of significant improvement in seasonal pasture quantity and quality is high. Alternatively in continuously-mated herds use foetal aging to segregate cows into approximately 3-month calving periods which can be matched with feed available, handling and husbandry.

Manage cattle health & stress

This primarily involves implementation of evidence-based control strategies to prevent infectious causes of heifer/cow death (eg, clostridial diseases including botulism, babesiosis), clinical illness (eg, bovine ephemeral fever), subclinical disease (eg, external/internal parasites), and infectious causes of embryonic, foetal and calf loss (campylobacteriosis, trichomoniasis, bovine viral diarrhoea virus). Also breeding females and their offspring may be exposed to a wide range of environmental stressors which can severely impact on both survival risk of the calf and the dam.

Key practices

- A risk-based approach to control of infectious diseases should be used involving assessment of the immune status of the dams including determination of whether the herd or management group is endemically infected, and risk of introduction of infection.
- Provide protection from environmental extremes (floods, blizzards, heat wave), especially for young calves and their dams
- Where possible, avoid handling calves less than one month of age

Manage breeding

Bull fertility and genetics have a profound effect on business outcomes and herd productivity. Frequently the 'low hanging fruit' in a beef breeding business is the bull percentage used. In a study of bull selection and management McGowan *et al.* (2014a) found that approximately three quarters of farmers or managers used above the recommended 2-2.5% bulls. Bull costs per calf born are an important cost eg, if the average cost of replacement bulls is $4,000 and bulls are mated at 2% versus 4% then the annual costs per calf assuming a weaning rate of 80% are $14 and $27, respectively.

Key practices

- stablish a genetic improvement program to achieve long-term increases in fertility as well as improvements in traits such as carcass quality, and in harsh environments, adaptive traits
- Select replacement bulls that have passed a breeding soundness evaluation. Select physically-sound bulls with at least average scrotal circumference for breed and live weight, and greater than 70% normal sperm.
- Replacement bulls should be introduced to the farm at least 4 months prior to use. They should be vaccinated against known causes of death, illness and reproductive loss.
- Mate at no more than 2.5% sound bulls.
- Select bulls from dams that have weaned a calf from their first two mating opportunities.
- Bulls should be managed to ensure they maintain satisfactory body condition (at least BCS 2.5 - 1-5 scale). Treatments to control external and internal parasites are recommended as bulls generally carry higher burdens of both.
- Herd bulls should undergo at least a general physical examination and detailed examination of the external genitalia annually prior to mating and bulls should be considered for culling when they reach 8-9 years of age.

Initiating adoption of management changes – how successful have we been?

In preparing this paper we are very conscious that David Mossman, Basil Lowman and Keith Entwistle beautifully described the approach to improving reproductive performance in a series of publications in the '70's and '80's. However, adoption by farmers and managers of many of their recommendations has been disappointingly slow; eg, McGowan *et al.* (2014a) reported that in northern Australia only about a quarter of farmers/managers routinely used a breeding soundness examination including microscopic examination of semen to select replacement bulls. As veterinary advisors to beef breeding herds we have to accept that in many cases we have failed to effectively communicate how and why producers should adopt recognised 'best practice' recommendations. In some cases we focus only on the potential positive benefits of our recommended changes to management without equally acknowledging the potential negative outcomes. A good example of this is where a farmer adopts your recommendation on lactation management which results in a significant increase in the proportion of the herd becoming pregnant within 4 months of calving and thus contributing a weaned calf each year. If the farmer does not adjust his/her culling and selling strategies then there is a significant risk of overgrazing and degradation of the pasture. Further, too often we assume that the terms we use are universally understood by farmers yet there is clear evidence that in many cases there is considerable confusion amongst farmers, advisors and veterinarians; eg, the definition of weaning rate is highly variable.

Take home messages

- Understand what live weight production your client's beef breeding herd's feed resource is capable of sustainably supporting.
- Measure the actual production and performance of each breeding management group or herd you consult to.
- Understand the key drivers of live weight production from beef breeding herds.
- Understand how to cost effectively control the major factors affecting these drivers of live weight production

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