LIVE WEIGHT PRODUCTION IN EXTENSIVELY-MANAGED BEEF BREEDING HERDS

Geoffry Fordyce[a], Michael McGowan[b], Kieren McCosker[c] and David Smith[d]
[a] The University of Queensland, Centre for Animal Science, Queensland Alliance for Agriculture and Food Innovation, Brisbane, 4072, Australia; g.fordyce@uq.edu.au
[b] The University of Queensland, School of Veterinary Science, Gatton 4343, Australia.
[c] Department of Primary Industry and Fisheries, PO Box 1346, Katherine 0851, Australia.
[d] Department of Agriculture Forestry and Fisheries, PO Box 976, Charters Towers 4820, Australia.

Summary
Extensively-managed beef breeding herds are usually located in moderate-low nutrition environments. Management must focus on what is achievable within that environment and implement practices that result in high-value live weight production that covers input costs. It is suggested that achievable weaner production per cow (average weaner weight x lactation rate) closely matches achievable steer growth in the same environments and is a very useful guide in formulating management and analysing costs and benefits of options. Live weight production ratio and operating margin are primary beef business targets. If either is below achievable levels, assessment of the many performance indicators that can be measured in cattle, and an understanding of what influences performance, will lead to practical solutions. These concepts are discussed in this paper.

Introduction
Beef business in northern Australia is conducted in mostly arid and semi-arid tropical environments where average annual rainfall is low, variation between years in rainfall distribution is very high, long periods without rainfall are experienced on a regular basis and long hot summers are an annual occurrence. There is a large range in land types, but these can be broadly classed as either downs or forest. Downs are naturally non-forested flat expanses with black soil. In northern Australia, most areas have low elevation and the proportion of hilly areas is low. In this region, northern forest areas have low-fertility soils, in contrast to central and southern forest that generally have high-fertility soils, with northern downs soils intermediate. This paper explores the principles involved in achievable production from breeding cows in this situation. Successful implementation is planned by assessing expected responses and costs, which are also discussed.

A significant problem within the Australian cattle industry is poor communication created by highly variable meanings for many terms. The most abused term is weaning rate. In view of this, we have defined key language used in beef cattle breeding herd production research (Table 1).

Achievable production and performance
To have the right answers, the right question must be asked. Typically, in response to questions about whether a beef breeding business is efficacious, answers are usually based on performance. We contend that the answers should be based on production, which is not usually specifically measured. There is a clear distinction between production and performance. Production is the amount of live weight produced and its value. Performance measures, eg, reproduction, growth, survival, behaviour or carcass variables contribute to production. Another major difference is that income to beef producers is directly related to production, whilst performance indicators have quite variable relationships with income.

Table 1. Definitions used in northern Australian research (McGowan *et al*. 2014a)

Terms	
Cattle year	Twelve month period ending at a natural point in livestock transactions and handling, usually after the last weaning muster in north Australian beef business. It must be at the same time each year within each business.
Maiden heifer	Heifer prior to first mating.
Heifer	Young cohort of female cattle up to the time the majority commence first calving.
Cow	Female cattle older than heifers.
First-lactation cow	Lactating cow during the period when the majority of her cohort is experiencing their first lactation, ie, their first year after transition from a heifer.
Adult equivalent	AE = 454 kg (1,000 pound) animal. This differs from the technical definition which is energy required to sustain a non-pregnant 454 kg animal at maintenance.
Performance	
Pregnant within 4 months	Lactating cow that has reconceived within 4 months of calving, which is required for cows to wean calves in consecutive years.
Annual percent pregnant	Percentage of mated cows that conceive within a one-year period ending on 30 September, ie, expected to calve within a July-June year.
Reproductive wastage	Percent of pregnant cows that fail to wean a calf.
Missing	A measure that sums cow mortality, cows that lose their individual identification and cows that are relocated without record.
Weaning rate	Cows weaning a calf as a percentage of mated cows, calculated as annual percent pregnant x (1 – reproductive wastage).
Lactation rate	Cows weaning a calf as a percentage of closing numbers (number of cattle at the end of the cattle year) within a group.
Production	
Weaner production	Lactation rate multiplied by average live weight of weaners.
Live weight production	Annual net LWP per cow (present at the end of the cattle year) = Average live weight of cows at the end of the measured period x (1 – mortality rate) + Average weight of weaners produced - Average live weight of cows at the start of the measurement period.
Live weight production ratio	Annual net LWP / Average live weight of cattle in the paddock over a cattle year (The latter represents feed intake and = Average cow live weight over the year + Average weight due to weaners over the year) eg, a live weight production ratio of 0.35 = 35 kg net increase in live weight for every 100 kg of cattle grazing that paddock on average over a one year period.
Business	
Operating margin	The return per kilogram of live weight sold minus the cost of producing a kilogram of live weight, expressed as $/kg.

When developing management, or assessing a beef business, production that occurs or is expected should be gauged against what is achievable. If production is inadequate, then key performance indicators will indicate the facets of the business causing the problems. The major production measure is live weight production ratio which is a measure of live weight production from feed utilised (Table 1). Both weaner

production and live weight production per cow are good indicators of live weight production ratio.

Though it is not usual to calculate production from breeding cow herds, it can easily be done through simple herd performance records and analyses of these (see later). In a large north Australian study involving 78,000 cows, we have shown that achievable annual weaner production per cow is similar to achievable annual steer growth in the same environment. From a sub-set of 37 businesses, average weaner production (kg) = 0.92 x average annual steer growth (kg; estimated by the owners) + 9.5 (McGowan *et al*. 2014a).

In a more detailed study using over 2,000 Brahman and tropical composite cows, average annual live weight production ratios remain constant to 6.5 years of age, after which slow decline occurs (G Fordyce, unpublished data). Live weight production per cow increased with cow age to 6.5 years after which it declined. This appears a function of the changing contributions of cow growth and changes in average weaner weight.

Across a range of environments where average annual steer growth ranges from approximately 120 kg to 250 kg, the achievable live weight production ratio varies from approximately 0.20 to 0.36 kg live weight/kg cattle/year, respectively (Table 2). The 75th percentile was selected as the achievable level in distributions within land type, reflecting underlying nutrition and other inherent environmental influences. The selected level takes account of higher levels occurring randomly, due to uncontrollable events, because of very good management, good seasonal conditions or because of over-investment to achieve the outcome. Average performance and production of well-managed breeding cows in a detailed study (G Fordyce, unpublished data) was similar to the 75th percentile level across the four land types in the large cow study (McGowan *et al*. 2014a), thus providing further confidence that this level is the correct choice. Of considerable concern in this study was the large variation in production which was mostly a consequence of variations in seasons and management. Achievable production will vary between years with variation in the quality and quantity of pasture available to cattle. Once again, expected achievable steer growth is probably the best guide.

As for production, herd performance is highly variable across and within environments (Table 2). The data shown provide good indicators of achievable performance, except for missing cattle with which mortality is directly related. The relationship of cow performance to production is variable (Table 3), although cow survival, growth and reproductive performance are all significant contributors to live weight production.

Breeding herd performance and production

Pregnancy rates in heifers are primarily affected by the proportion that have reached puberty. Live weight is the best predictor of puberty in heifers. The expected average live weight at puberty is ~60% of mature cow weight in *Bos taurus* breeds (Freetley *et al*. 2010), but closer to 70% of mature cow weight in *Bos indicus* breeds (G Fordyce, unpublished data). The coefficient of variation for weight at puberty is ~13% (Johnston *et al*. 2009). Mature live weight is of non-pregnant cows aged 5 years or more in moderate body condition (3 on a 1-5 scale).

Early age at puberty, thus a high probability of pregnancy in maiden heifers, may not be of benefit to a business if the expected annual live weight gain of non-pregnant heifers is similar to live weight production of breeding heifers because of lower costs associated with non-breeding cattle. For example, Fordyce *et al*. (2009) showed that supplementing heifers to reduce age at puberty is not recommended unless a high

pregnancy rate is achieved by maiden mating at one year rather than 2 years of age. That is, a majority of heifers is closer to mature size and need to wean calves to sustain high live weight production. In some of the very low growth environments of northern Australia, 3-year-old maiden mating is a usual practice and business profitability may not necessarily be improved by strategies that achieve pregnancies at 2 years of age.

Table 2. Medians and interquartile ranges for cow herd performance and production in selected northern Australia beef businesses (McGowan *et al*. 2014a) Note: 75th percentile is the achievable level

Annual measure	Southern Forest	Central Forest	Northern Downs	Northern Forest
Pregnant within 4 months of calving (%)	67 (40-81)	68 (52-78)	66 (52-75)	15 (7-25)
Pregnant (%)	85 (76-92)	85 (79-92)	80 (75-90)	66 (55-73)
Reproductive wastage (%)	6 (2-10)	7 (5-10)	10 (5-15)	13 (10-19)
Weaning rate (%)	76 (62-88)	77 (69-87)	72 (57-78)	53 (44-62)
Missing (%)	8 (3-13)	8 (2-11)	7 (4-10)	11 (6-16)
Live weight production (kg/cow)	188 (156-250)	197 (143-255)	141 (129-189)	89 (71-122)
Weaner production (kg/cow)	191 (164-240)	195 (161-220)	163 (135-183)	93 (74-112)
Live weight production ratio (kg/kg cattle)	0.28 (0.23-0.35)	0.30 (0.20-0.37)	0.23 (0.21-0.29)	0.14 (0.04-0.20)

Table 3. Amount of variance in production explained (var) by each measure of performance and the change in performance per unit change in production from univariable analyses (McGowan *et al*. 2014a)

	Live weight production ratio (kg/kg cattle)		Live weight production (kg/cow)		Weaner production (kg/cow)	
Annual measure	var	/0.01	var	/10 kg	var	/10 kg
Pregnant 4 mths after calving	0.18	5.8%	0.43	5.7%	0.57	6.3%
Pregnant	0.27	2.8%	0.40	3.9%	0.61	4.5%
Pregnancy-weaning calf loss	0.16	-1.8%	0.20	-2.7%	0.34	-3.6%
Cow mortality	0.42	-0.9%	0.18	-2.1%	0.11	-3.4%
Average weaner weight	0.56	5.1kg	0.70	7.1kg	0.69	8.2kg
Cow live weight change	0.26	5.6kg/yr	0.29	9.9kg/yr		

Performance of cows should not be judged as adequate unless it is also apparent that production is sub-optimal. A popular paradigm is that non-pregnant lactating cows have low productivity. Using the principle described above that weaner production is on average equivalent to yearling steer growth in the same environment, if weaner live weight exceeds annual average yearling growth, the deficit will be reflected in cow body condition loss (or mortality). In addition, poor-condition, non-pregnant cows weaning a calf will regain weight and condition as a “bank” for subsequent weaner production.

An accompanying paper (McGowan *et al*. 2014b) describes in considerable detail risk factors associated with the ability of lactating cows to re-conceive and these are summarised in Table 4. Almost all of these factors directly or indirectly affect nutrition of the cow. A vast amount of detailed research on folliculogenesis has shown that, to achieve early-lactation conception, this 5-month process must start well before calving, and at all stages is sensitive to nutrition (Scarramuzzi *et al*. 2011). Nutritional influences on cows are mostly expressed as body condition or changes in body condition, thus emphasising its importance as an assessment criterion in managing conception rate.

An accompanying paper (Fordyce *et al*. 2014) describes in detail the risk factors associated with reproductive wastage, some of which are summarised in Table 4. In northern Australia, reproductive wastage is predominately related to nutritional and environmental factors with some impacts of reproductive disease and animal attributes.

Table 4. Average effect of risk factors on cow performance in north Australian beef herds (from McGowan *et al*. 2014a)

Risk factor Compared to reference values	Pregnant within 4 months of calving	Foetal & calf loss [a]	Missing cows
Body condition < 3 in mid-dry season	- 6-22% - NOT northern forest	+ 3.5% if P deficient	+ 3-8%
Lost body condition over lactation	- 8%		
<2 t/ha pasture early dry season			+ 5.5%
>30 d 1st - 2nd wet season rainfalls			+ 4%
Northern forest [b]	- 59%	+ 7%	+ 7-9%
Northern downs [b]	- 23%		
High risk of phosphorus deficiency	- 1-24%	+ 10% in NF[h]	
DS[c] pasture CP:DMD[d] <0.125		+ 4%	
WS[e] pasture CP:DMD[d] <0.125	- 7.5%		
High THI in calving month [f]		+ 4-7%	
Calving July-September	- 20-50%		
Mustering efficiency <90%		+ 9%	
Mustering around calving		+ 9% - L1[i]	
		+ 2% - mature	
First-lactation	- 5-16%		
Not lactating previous year		+ 4-8%	
Hip height >140 cm	- 5%	+ 3.5%	
≥50% *Bos indicus*	- 15%		
High seroprevalence of BVDV [g]	- 14-23%		
High prevalence of recent BVDV		+ 8%	
High prevalence of vibrio antibody		+ 7%	
Wild dog presence		+ 5%	

a: Add cow mortality to these losses; b: Compared to Southern forest;
c: Dry season; d: Crude protein (%) to dry matter digestibility (%) ratio, an indicator of protein adequacy; e: Wet season; f: Temperature-humidity index (Hahn *et al*. 2009) >79 for more than half the month; g: Bovine Viral Diarrhoea Virus or Pestivirus;
h; Northern forest; i: First-lactation.

Annual cow mortality, primarily in the dry season, is a substantial contributor to diminished live weight production of north Australian beef breeding herds. A recent study (Henderson *et al*. 2013) reported a median annual cow mortality rate of 5.7% for 33 extensively-managed herds (~125,000 breeding cows) in Australia's semi-arid tropical regions. This result is consistent with other reports over the past 30 years or more. The research was able to show several risk factors associated with higher

annual cow mortality: aged >11 years (+6%), no dry season segregation (+10%), and no wet season phosphorus supplements (≤1%). Fordyce *et al*. (1990) previously showed lower body condition, being more advanced in the reproductive cycle, and aged >8 years to be predictive of lower dry season survival probability for cows. McGowan *et al*. (2014a) were unable to demonstrate a major effect of stage of reproduction on missing cows, but did show increases due to limited available pasture and low body condition. In addition, losses were higher in the poor-nutrition northern forest regions (Table 4).

Implementing effective management of breeding beef cattle

Based on the presence of any known factors that affect cow growth, conception, reproductive wastage and mortality, the potential impact of management changes can be assessed using whole herd modelling. Targeted management could include attention to feed quantity and quality, suckling periods, cattle control, morbidity and mortality agents, sub-optimal cattle and personnel skills.

Management practices have a hierarchy of importance. The efficacy of any practice is enhanced by effective implementation of more fundamental practices. The most important and most basic management is to provide adequate feed to readily satisfy voluntary feed intake (pasture utilisation), ready access to clean water and to have cattle under control. If these conditions are not met, then most higher-order management is rendered less efficient.

A herd management plan must be built around available nutrition. The task of a beef producer is to maximise availability of pasture and its quality, and then manage cattle to most efficiently transform available feed into high-value saleable live weight. Breeding female cattle and bulls should be managed to minimise supplementation. Effective supplementation augments good management. It should not be used to correct management errors. It is suggested that breeding herd production responses to supplementation and to other strategies that improve nutrition may be partially gauged by their potential impact on annual steer live weight gain (including the effect on mortality) in the same environments.

After implementing the basics, weaning as part of managing the suckling period, is the most important husbandry practice used and requires astute implementation. It is suggested that the potential production of a breeding herd, based on annual steer growth is a guide to appropriate weaning management. For example, in a low-nutrition environment, well-managed steers may grow 120 kg per year. Therefore, if a beef producer wishes to wean 60 calves from every 100 cows kept each year (60% lactation rate), then the average weaning weight should be 120 / 0.6 = 200 kg. If a higher lactation rate is required, then the timing of weaning should be altered to achieve lower average weaning weights. If calves are weaned too heavy for a situation, excessive cow body condition is lost, lactation rate will drop, cow mortality rate may increase and business costs are likely to increase with no extra return available.

An economic analysis of various options for a beef business is the most effective process to derive best practice management. Decisions are based on what is achievable, full business analysis, costs of options, expected performance and production impacts on targeted herd sectors and the time taken to achieve financial return on options. This process requires reliable herd models that are able to consider the types of options available. The primary output variables that need to be optimised are live weight production ratio and operating margin. Unfortunately, herd models require reliable input data. If the input is unreliable, the calculated output is likely to be equally unreliable. Our experience in northern Australia is that a very low proportion of beef producers keep sufficient records to enable calculation of current production, herd

performance and business performance. In view of this, a standardised simple herd performance recording system has been developed.

Business monitoring
Practical monitoring of a business provides information necessary for effective management decisions.

Environmental conditions, especially rainfall and temperature.

Pasture. Practical systems are available to estimate available pasture for feed budgeting purposes at strategic times (Aisthorpe *et al*. 2004). Pasture protein and digestibility can be derived from NIRS of faecal samples (Coates and Dixon 2008). Pasture and land condition monitoring is an integral part of managing pasture production from healthy rangelands.

Body condition. As well as assessment during annual reproductive assessments, subjective assessment of distribution of scores within lactation status in management groups can be conducted regularly.

Reproductive performance. Foetal ageing, especially of cows that have been lactating, provides data for estimation of pregnancy rates within 4 months of calving, expected calving distribution and determination of those cows with the highest potential earning capacity if retained in the breeding herd. A combination of lactation status and calf counts from cows previously diagnosed as pregnant is required as part of measuring reproductive wastage.

Strategic assessments for evidence of risk factors. These include disease agents, specific soil or plant nutrient deficiencies and animal genetic merit.

Annual summary of business income and costs by cattle, labour depreciation and variable costs.

Animal data for age x gender groups: Annual herd description (number and average live weight) at the end of the cattle year plus weights and values at any branding, weaning, spaying, purchase or sale as they occur.

The animal data described above, especially when recorded over several years and combined with a business financial summary, enables calculation of key performance indicators using various software, most of which has been developed by beef business advisers. Operating margin, a key index, is also calculable. It explains a very high percentage (82%, Phil Holmes, pers comm) of the variation in beef business profitability. Table 5 shows an example of one such analysis and exemplifies the complexity in conducting and understanding beef business. If an accurate understanding of current production and performance is not available, then errors may be made in formulating management.

Table 5. Example of average performance and production over four years calculated for a north Australian beef herd

Measure	Value	Measure	Value	
Branding rate	74%	Herd size	4,656	AE
Branding rate – RC[#]	91%	Females mated	2,524	females
Weaning rate	72%	Weaner production	183	kg/cow
Lactation rate	90%	Herd LWP	144	kg/animal
Heifers as replacements	86%	Breeding cattle LWP	138	kg/animal
Average herd change	5%	Steer LWP	176	kg/animal
Mortality: Weaned female	1.9%	Herd LWP ratio	0.33	kg/kg
Mortality: Yearling heifers	1.9%	Breeding cattle LWP ratio	0.31	kg/kg
Mortality: Heifers 2-3 yrs	2.3%	Steer LWP ratio	0.39	kg/kg
Mortality: Cows	5.2%	Income	$1.43	/kg
Mortality: Spays		Cost of production	$0.95	/kg
Mortality: Male weaners	1.9%	Operating margin	$0.48	/kg
Mortality: Yearling males	2.3%	Labour	$0.30	/kg
Mortality: Males 2-3 years	5.7%	Mortality effect on sales	-$0.23	/kg
Mortality: Mature males	8.3%	Income	$241	/AE
Mortality: Bulls	1.0%	Variable costs	$4	/AE
Sold: Male weaners	4%	Gross Margin	$237	/AE
Sold: Male yearlings	3%	Overhead costs	$155	/AE
Sold: Males 2-3 years	71%	EBIT	$83	/AE
Sold: Mature males	27%	Labour	$50	/AE
Female / Total sales	48%	Bull costs	$24	/weaner

Retained cows, as is used in calculation of lactation rate

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