final report

Project code: B.NBP.0664.A

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Date published: October 2013

ISBN: 9781925045529

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Determining property-level rates of breeder mortality in northern Australia: literature review

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

Abstract

Estimation of breeder mortality in northern beef herds is difficult because of problems in sourcing accurate data describing both deaths and the overall breeder population. Estimates range from less than 3% to around 12% per annum with higher mortality rates likely in older cows and under drought conditions. Caution is urged in interpreting many reports based on survey information or producer opinion because these are likely to over-estimate weaning rates and under-estimate mortality rates. The combination of conditions most likely to increase mortality risk is poorer conditioned cows that are heavily pregnant or in early lactation during the late dry to early wet seasons. A range of management options are presented that can help to reduce breeder mortality on those properties where mortality is relatively high. Further effort is recommended to better characterise breeder mortality and to incorporate consideration of breeder mortality into benchmarking and strategic management options for producers in the future.

Executive summary

This literature review highlights the difficulties in sourcing accurate data to describe mortality in breeding cows on northern beef properties and the use of a variety of alternative and indirect measures to estimate breeder mortality.

The review describes approaches used to estimate breeder mortality and provides estimates from properties and regions across much of northern Australia. Major factors influencing breeder mortality are identified along with management strategies for minimising their potential to adversely impact upon breeder deaths.

There is a small number of more detailed studies that have collected data on breeder mortality from observations conducted on northern beef properties. A number of studies have collected retrospective property records or have used surveys to collect producer estimates of breeder mortality rates. A number of reports have used indirect methods based on sales data in combination with estimates of breeding populations to estimate mortality rates in breeders. Other studies have used herd modelling software generally in combination with records either from producers or from other sources (sales, abattoir or animal movement records) to generate estimates of mortalities in breeders.

There is considerable variability in estimated breeder mortality rates between properties and regions within northern Australia. There are undoubtedly individual properties where the combination of environmental, animal and management factors are able to produce relatively low breeder mortality rates (under 3%). Across much of northern Australia, the literature reviewed in this report from the last two decades suggest that typical annual breeder mortality rates are likely to be between 2 and 12% per annum with higher mortality rates expected in cows aged 10 years or older (15 to 20% or higher) and in severe drought conditions (>20%).

There is relatively little available information to characterise the causes of breeder mortality in detail. The major combination of conditions likely to increase mortality risk is poorly conditioned cows that are heavily pregnant or in early lactation during the late dry to early wet seasons. There is an age associated increase in mortality risk that is likely to occur in cows older than 8-10 years, though this is expected to vary between animals and properties, and individual cows that are able to maintain good dentition and body condition may be able to remain productive past 10 years of age.

Where breeder mortality is high there is strong evidence to suggest that strategic investment should be directed at reducing breeder mortality before attempting to improve other performance measures such as weaning rates. Where breeder mortality is relatively low it may not be useful to direct further investment into reduction of mortality. A range of management factors is discussed that have the potential to reduce breeder mortality.

It is recognised that breeder mortality is only one of many performance measures that can be used to assess enterprise performance and guide strategic decisions. Further effort is recommended to better characterise breeder mortality and to incorporate consideration of breeder mortality into benchmarking and strategic management options for producers in the future.

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1 Introduction

Breeder mortality is defined as deaths in female cattle of breeding age or in cattle that are eligible to be joined.

A number of sources have identified mortality in breeding females as an important driver of production and economic performance in extensive, northern beef properties [8,37,45,47,48,54,62]. Death of a breeding female is often associated with loss of a calf as well, given that mortality risk is higher for females that are heavily pregnant, calving or that have a young calf at foot. Death of calves in association with the breeder in turn act to reduce the number of animals available for replacement heifers as well as for sale. Breeder mortalities impact on the number of calves born, number of calves that survive to weaning, the need for retention of heifers to replenish breeder numbers, and the number of animals (steers and cull females) available for sale.

Different benchmarking exercises conducted in northern Australia have reported that breeder mortality is either one of the key benchmarks used for assessing performance[26,39,49], or the single most important driver of gross revenue per livestock unit in central Australia[45].

An immediate consequence of this assertion is the follow-on suggestion that priority be directed to measures specifically aimed at identifying or measuring breeder cow mortality and at intervening to reduce breeder cow mortality where it is a problem.

Although mortalities on many well-managed properties are considered likely to be relatively low (<2 to 5%), in some regions and on some properties breeder mortality may be considerably higher. Even where health and nutritional management are adequate, there may still be opportunities to achieve even lower levels of breeder-cow mortality if ‘at risk’ animals can be successfully identified and more effectively managed. An important indicator of improved management in extensive beef herds in northern Australia is considered to be a reduction in breeder cow mortality, associated with higher numbers of surplus females and consequent increased sale of females. This also leads to the ability to apply better selection pressure on the breeder herd including strategic decisions such as culling older or unproductive females[37].

This review is an attempt to summarise current knowledge on the topic of breeder cow mortality in extensive beef production areas of northern Australia and to inform the management of a concurrent project collecting information and production data from selected properties across several regions in northern Australia to describe breeder cow mortality in these regions.

2 Measuring breeder mortality

2.1 Direct estimation of breeder deaths

Estimation of mortality rates involves counting of both numerator (deaths) and denominator (animals at risk of dying) over a defined time period such as an annual cycle.

Obtaining accurate counts of both total cattle numbers and cattle deaths from northern, commercial beef herds is problematic, because of a range of management and environmental issues including:[14,39,49,51,71]

- Variable quality of herd records where breeder numbers and total herd numbers may be unreliable or absent.
- Infrequent observation or mustering of cattle on many extensive properties providing little opportunity to observe evidence of mortalities or identify problems as they occur.
- Difficulties in obtaining a clean or complete muster meaning that accurate counts of the number of animals on the property may be difficult or impossible to obtain or maintain.
- The combination of large paddock and property areas, challenging terrain, seasonal extremes in rainfall, and lack of fencing may mean animals are not observed or mustered because they have moved or are inaccessible but not dead.
- Climatic extremes (drought, flood) and market forces (variability in pricing, market access) mean that cattle numbers on any one property may vary considerably from year to year as producers shift cattle onto or off a particular property to respond to external forces or because one property may be part of a larger structure with animals moving from one place to another.
- Significant numbers of breeders are occasionally lost as a result of extreme conditions (drought, fire, and flood) or potentially due to sporadic disease outbreaks.

Brown et al[7] reported that estimates of mortality rate were likely to be more imprecise than any other production measure because of difficulties in recording accurate animal counts.

There are instances where accurate animal records are available. A number of commercial properties invest considerable efforts and resources in maintaining accurate animal records. In some cases, more intensive recording systems may be implemented as part of a particular research project or on a research station[52]. Under these conditions it may be possible to collect detailed information to allow accurate description of breeder mortality rates. It is expected that this situation may be more likely to occur on properties that muster or handle animals multiple times per year, that have effectively fenced paddocks and that strategically invest in accurate record keeping systems. There have also been surveys and field studies that have attempted to collect information on breeder mortality from commercial properties, with differing levels of discussion around data availability, accuracy and variability.

Collecting accurate records on animal numbers and mortalities represents a significant and ongoing challenge for northern beef properties. The bovine Brucellosis and Tuberculosis Eradication Campaign (BTEC) has been credited with contributing to general improvements in management of northern beef properties through the 1980s and 1990s[40]. Since then there have been ongoing improvements in infrastructure (fencing, water supply and pasture improvement) and these have been accompanied by improvements in livestock management and mustering efficiency[5,6,37]. However, the relatively large areas and low stocking rates for northern pastoral land still mean that it is difficult to monitor cattle effectively. An illustration of these challenges is seen in the recent description of activities employed in a study of cattle morbidity and mortality that included the use of paddock patrols on horseback and motorbike using specific purposedesigned transects to ensure paddock coverage, combined with helicopter surveillance[43].

On many occasions limitations in data availability and quality mean that researchers may choose to omit reporting of breeder mortality estimates[6] or they may use estimation methods ranging from anecdotal opinion or self-reporting[39,55] to some form of indirect estimation based on available data relating to inventory or sales[37,47,71].

Under routine commercial operations cattle are generally mustered and handled once or twice yearly and occasionally more often[55]. Dead animals may be occasionally identified and recorded during paddock inspections or mustering, but mortalities are more typically defined by absence of individual animals from a number of consecutive musters of both the paddock(s) they are expected to be in and adjacent paddocks[7,44,51,66]. There appears to be variation in the number of consecutive musters that are used to define whether a missing animal is to be classified as dead with authors reporting two[12,44] and up to five[51,65] musters. Others report the use of up to three consecutive years of missed musters before a missing animal is classified as likely to be dead[66].

It is recognised that there are potential biases in the use of 'missingness' as an indicator of mortality. Missing animals may be still alive and not mustered because of isolation and challenging terrain or because they have moved into adjacent paddocks or territory. Animals may also be mis-identified because they have had ear tags incorrectly recorded or lost an ear tag. These animals may then be classified as missing when in fact they were not missing. It seems likely that 'missingness' might provide an over-estimate of mortality but this will depend on a range of factors operating at the individual property level and particularly the mustering efficiency (likelihood that all animals in a paddock will be mustered either in a single mustering round or over the course of one year). The use of lifetime unique animal identification and electronic ear tags through the current National Livestock Identification System (NLIS) provides an opportunity for better data collection and reconciliation of animal numbers on northern beef properties and may lead to better estimates of missingness and mortality in the future.

Figure 1 provides an illustration of a typical process for reconciling animal counts on an extensive beef property. Generally the closing counts from the previous year are carried over and form the opening count for the current year (expected number of animals on the property).

It is expected that there will be accurate counts of movements off the property (labelled as sales but including all movements off the property) and similarly movements of animals onto the property (labelled as purchases but including all incoming movements). The natural increase is represented by the number of females that are branded in a given year. If the opening count is adjusted by these counts, it produces an estimate of the closing count that assumes no deaths.

During the year it is also expected that counts of animals on the property will be estimated from mustering rounds that take place during the year. If the opening count is then adjusted based on the yard counts and animal movements (sales, purchases and brandings), it can produce a second closing count that incorporates a reduction in cattle numbers due to the effects of missing animals and deaths (including animals killed for rations as well as deaths due to any other reason). Further adjustment can be applied for rations and for animals that are missing but assumed to be alive, to produce an adjusted closing count (the number of live animals expected to be on the property at the end of the year). The difference between the opening count and the adjusted closing count should then provide an estimate of mortality over the year. This approach can be applied to different age classes of cattle on an individual property to generate opening and closing counts and mortalities for each age class of animal.

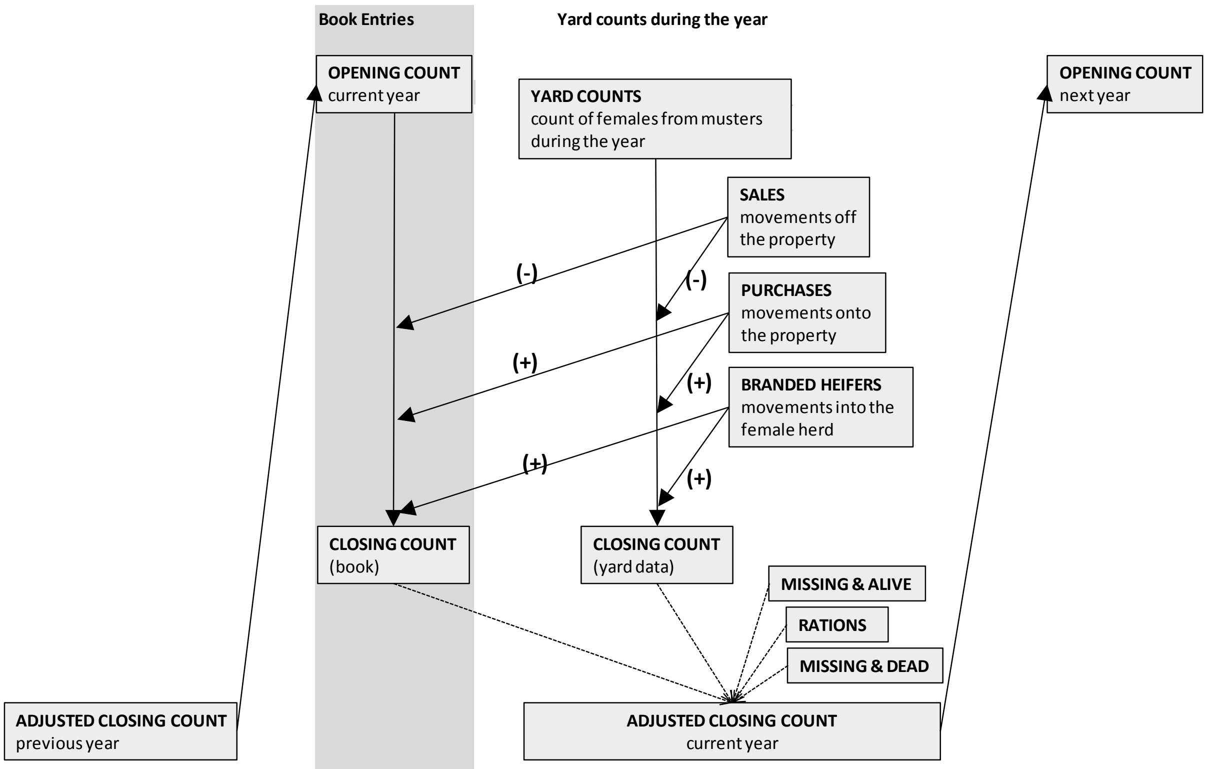

Figure 1: Conceptual diagram outlining the use of property records to estimate breeder mortalities[25].

2.2 Female sales data related to total sales

Indirect measures have been proposed for estimation of breeder mortality risk that are generally based on alternative data that may be more easily available and accurate than attempts to directly estimate deaths. These include calculation of:

- the proportion of annual female sales as a proportion of total annual sales[13,47,71];
- the sex turnoff difference (STD)[38];
- heifer retention rate or sales of surplus heifers[47]; and
- sales figures (turn-off) compared to weaning or branding figures}[13,37,47].

Female sales as a percentage of total sales has been promoted as a potential benchmark that can be used to estimate breeder deaths either at the individual property or aggregated / regional levels[37,47,48,71]. The approach was developed in part because sales data was considered to be widely available and accurate and because in extensive northern beef regions it was felt that female cattle were either retained for breeding or sold or died on the property. The approach is based on a number of assumptions including that about 50% of calves born each year will be expected to female; that in a steady state breeding operation, the number of young females retained to enter the breeding herd is expected to depend mainly on the number of deaths in the breeding herd; and, that expected deaths in young non-breeding females and young males are similar[37]. It is important to include all female sales in this estimate including calves, cull heifers, spayed heifers, fat cows and cull for age cows[47].

Wicksteed (1986)[71] estimated a female sales percentage for north Queensland of between 30 – 35%, which suggests an average female mortality rate of 10 – 12% per annum and that a female sales percentage of 45% or higher was associated with breeder mortality rates of 6% or less.

Wicksteed (1986)[71] proposed the use of a Breeder Performance Score (BPS) as a method of interpreting the female sales percentage. The BPS is simply a categorical score applied directly to interval ranges of the estimated female sales percentage, as shown in Table 1. This approach provided a simple, crude score that indicated whether a property might have a problem or not without attempting to produce a precise estimate of breeder mortality.

If the breeding herd is not being managed at a steady state then female sales as a percentage of total sales provide a potentially biased measure of breeder mortality. Selling additional females to reduce the size of the breeder herd has the potential to increase the % female sales and result in an under-estimate of breeder mortality. Conversely, retaining additional females to build up the breeding herd will reduce the % female sales and has the potential to over-estimate breeder mortality. Aggregating data from multiple years is likely to produce more accurate figures because it reduces the effects of single year fluctuations in inventory[71].

Table 1: Breeder performance score (BPS) based on sales data[71].

Branding rate (%)	Breeder deaths (%)	Female sales as percent of total sales (%)	Range in female sales (%)	Breeder Performance Score (BPS)
45	14	0	0-30	6
50	12	30	30-36	5
55	10	36	36-42	4
60	8	42	42-45	3
65	6	45	45-47	2
70	4	47	47+	1

The same underlying approach has been used to develop a measure called the sex turn-off difference (STD), defined as the difference between the number of male and female animals in the net turn-off from a herd[13,37,38].

The principle behind this approach is that if a property has an average turn off of 500 bullocks per year and 250 cull females, then the sex turn-off difference is 250. Under the assumptions above, this can be interpreted as an estimate of the annual mortality rate in the breeder population since 250 breeders must have died in order to require that this number of heifers be retained to enter the breeding herd. If there are appreciable deaths in the male cattle on the station, then the STD becomes a minimum estimate of female deaths[38].

One of the potential problems with this approach is that it produces a crude estimate of breeder deaths but it then requires a separate estimate of the total breeder herd in order to produce an estimate of breeder mortality rate. Many northern beef operations do not know the total number of breeding cows on their properties so estimation of the denominator adds further variability to the breeder mortality rate measure.

Analysis of Kimberley data on the number and sex of cattle turned off to abattoirs and to the live export trade for the five years from 1990 to 1994 indicated that the region's annual average STD was about 23,500 head[38]. Making various assumptions about total breeder populations and factors that may have been influencing general trends in breeder numbers (such as sales due to TB eradication), the authors estimated that annual breeder mortality across the Kimberley for this time period was likely to have ranged from 11 to 18%.

The authors pointed out that biases may be introduced to the STD estimates if substantial deaths occurred in the male population for any reason, if turn-off patterns for males changed during the course of the data collection process (sale of younger animals for example), or if there were increased female movements either into the breeding herd or off the property for any reason[37,38].

Subsequent authors have further developed the approach by using some form of herd modelling that allows measures of female (and male) turn-off to be combined with a range of other inputs relating to breeding herd structure and weaning rates in order to better understand the relationship between breeder mortality and percent female sales[26,47-49]. The approach may involve simplistic modelling using spreadsheets or more complex modelling using custom software such as Breedcow[27]. Assumptions concerning breeding herd structure and weaning rates can impact the relationship between percent female sales and breeder mortality as illustrated in Table 2[47].

Niethe and Quirk (2008) indicated that in the northern areas of Western Australia, female sales as a percentage of total sales varied widely between properties with a typical or mean value of around 39% while southern beef growing areas in eastern Australia may be achieving levels of more than 47%[49].

Table 2: Relationship between female sales as a percentage of total sales and breeder mortality rate at each of three different weaning rates. Adapted from[47].

Breeder cow mortality	Proportion of females turned off as percentage of total sales		
	50% weaning	*70% weaning*	*90% weaning*
2%	48%	48%	49-50%
5%	43%	45%	46-47%
10%	34%	39%	42%
15%	18%	31%	36%
20%	0%	17%	28%

Niethe and Quirk (2008)[49] have proposed a term called the Female Sales Index (FSI) as representing the percentage of females in the total annual sales figures for a property although the calculation is based on the same approach as used in the sex turn-off difference and the expression of female sales as a percentage of total sales. Figure 2 illustrates the variation in the FSI for properties in northern Western Australia.

$$FSI = \frac{Females\ sold + female\ rations}{Total\ sales + rations}$$

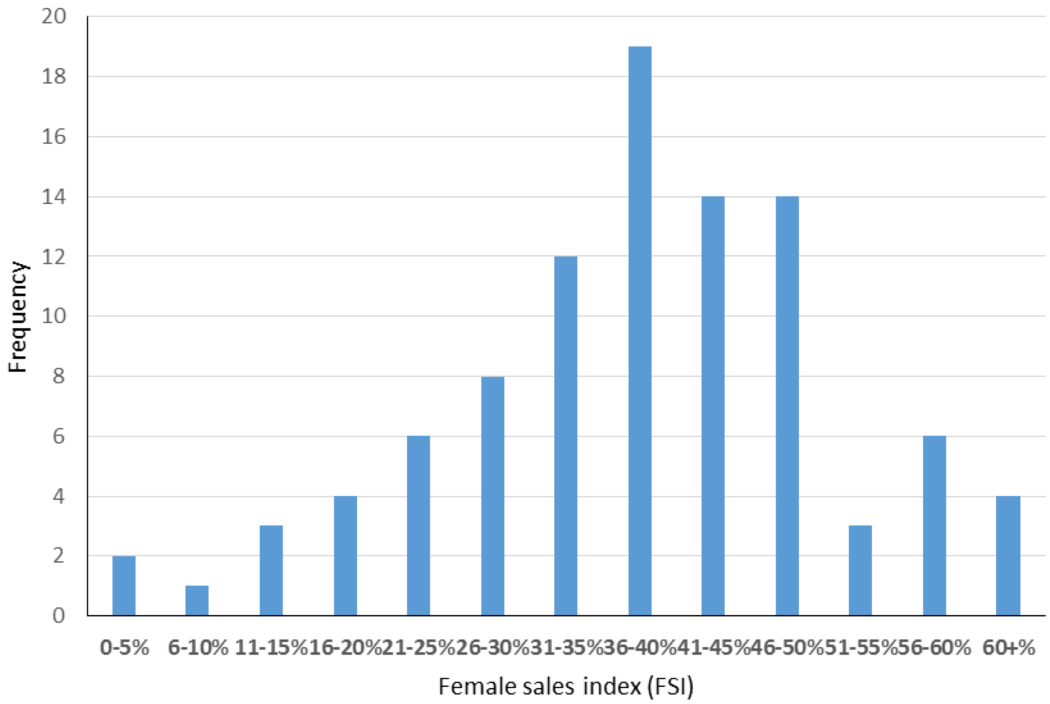

Figure 2: Variation in the Female Sales Index (FSI) calculated for properties in northern Western Australia[49].

2.3 Other indirect measures

Several performance measures have the potential to provide some indication of whether mortality may be an issue on a particular property (either mortality across all classes of stock or breeder mortality in particular).

Heifer retention rates are identified as providing indirect evidence to support assumptions about breeder mortality rates[49]. This is based on the general assumption that under a steady-state herd situation, increased heifer retention rates would be most likely to occur where breeder mortality is high. Under steady-state assumptions, heifer retention rate may be viewed as a direct estimate of mortality in older cows.

The retention rate of heifers for breeding is inversely related to the number of sales of cull/surplus heifers. The number of surplus heifers sold each year will depend on how many breeders are culled each year, the weaning percentage and the number of heifers required to maintain the breeder herd. In a stable herd, there should always be surplus heifers that are not required as replacements for the breeding herd. It is also true that the number of surplus heifers will be dependent on the average age limit at which cows are retained in the breeding herd before being sold. Herds which never sell surplus heifers are indicative of a high mortality rate in the breeders.

Data from branding and sales can be combined to produce estimates of loss between branding and turn-off[38]. If, for example, 4,000 calves are branded annually and 1,700 steers are turned off at two years of age, then one can assume that there were 2,000 male calves at branding (50% of the total) and therefore that male mortality between branding and turn off was 300 calves. These data can then be used to estimate an annual mortality rate of 150 male calves (from branding to turn-off)[38].

Sales or turn-off data can be expressed as a percentage of total cattle on the property or as a percentage of total calves weaned[38]. Interpreting the result requires an understanding of the general production goals and ages of typical turn-off. Over time this simple index can provide a performance measure that can be used for benchmarking.

All of these indicators rely on similar underlying assumptions that have been outlined in earlier sections in relation to percent female sales, and may be used as general indicators to identify potential problems rather than as methods for estimating actual breeder mortality rates.

2.4 Herd modelling

Breedcow is a widely used herd modelling package that allows users to model various scenarios to understand relationships between different drivers of beef production and also to model impacts of various decisions concerning beef management. It has been widely used in Australian beef research and in applied consultancy to provide advice to producers on options for managing beef herds[48]. There are examples of other software programs being used for modelling beef performance[9].

A number of studies have used herd modelling to estimate a range of performance including breeder mortalities on individual or representative properties or at the regional level[26,27,39,48,49]. Software such as Breedcow and Dynama require estimation of a reasonable number of input parameters and it may be difficult to define these values accurately using available property records.

Instead estimated starting figures are entered into the model and then interim model outputs on a range of performance measures (number of calves born / weaned / branded, number of animals turned-off, and estimated age structure of the breeding herd) can be compared to producer records and expectations. Input parameters such as herd structure, conception and weaning rates, and mortalities can then be adjusted and the model re-run and outputs again compared to producer records and expectations. This process continues until the model outputs are considered to be both plausible and consistent with producer expectations for their property or with some other source of records such as regional records on turn-off[39,49]. The process itself is often a valuable learning tool and results in many producers realising that their assumptions about important measures such as weaning rate and mortality rates may not be correct[39]. Reports describing the use of this approach consistently indicate that estimates derived from producers are likely to under-estimate their mortality rates and over-estimate weaning rates[39,49]. Once this validation process had been completed the model outputs can then be used to estimate other parameters of interest including breeder death rates and female turnoff percentage.

There are some problematic issues associated the use of herd modelling programs such as Breedcow to produce estimates of specific outcome measures such as breeder mortality. Effective application of this approach seems to require relatively intensive effort either one-on-one with producers or in small groups to go through the iterative process of revising input parameter estimates until the outputs are considered plausible and consistent with producer expectations.

Breedcow can appear relatively complex with several sets of input parameters to be entered before the model can run and it requires individuals to have familiarity with computers and spreadsheet or database systems as well as knowledge of beef cattle management. The simpler version of Breedcow is designed to model a static herd and may be more problematic to apply in a situation where an individual property may be moving cattle onto (purchases, transfers in and newly branded animals) and off (sales and transfers) the property. The more complex version (Dynama) is capable of handling year to year variation in cattle numbers but requires more input data. The parameterisation process is likely to be most effective when it involves a consultant or advisor running the modelling program in close discussion with the producer. Iteratively changing input parameters is a relatively subjective process that may be based more on consideration of the subsequent output values than on a detailed understanding of the likely values of the input parameters, their relationship to each other and the details of the mathematical algorithms operating within the model. Breeder mortality rates are one of the input parameters that must be set in this process which may be less than ideal when breeder mortality is an output of primary interest. Finally, input parameters such as breeding herd structure, weaning rate and mortality rate are related so that different combinations of values for these parameters can potentially produce similar model outputs.

The major strengths of herd modelling programs such as Breedcow lie in their ability to be used to model 'what-if' scenarios and the impact of different decisions or interventions on animal production measures or economic measures[27-29]. The use of herd modelling systems to measure or estimate actual performance for individual properties relies on detailed and accurate records so that input parameters and model outputs can be validated against property data. Where input parameter values are poorly defined and have to be entered using a combination of opinion, experience and back-checking based on model outputs, the use of the modelling process to generate specific measures of key performance outcomes should be viewed with some caution.

3 Estimates of breeder mortality

There have been relatively few research projects/observational studies that have attempted to accurately and specifically measure breeder mortality in extensive beef properties. Variation in definition and/or methods of estimation, and availability and quality of data, are expected to influence results.

It is also noted that annual death rates for cattle (including cows) in northern beef production areas are likely to be quite variable and depend on a range of local and regional factors including climate, soil and management strategies such as animal selection, stocking rate, weaning and supplementation and other forms of nutritional management[18].

Finally, there are important longer-term trends in breeder mortality that may be attributed to changes in market forces and improvements in infrastructure (roads and trucks), management and animal genetics[37]. Caution should therefore be applied in interpreting the findings of historical studies when considering the current northern beef industry situation.

Early reports describing mortalities in northern beef herds reported that very few female cattle were generally sold from many properties, meaning that females were expected to die on the property[1]. Jubb *et al* (1996)[37] have estimated that annual breeder mortality in the Kimberley region during the 1960's may have ranged between 24-33% and climbed as high as 47% in severe dry seasons[1]. Management practices at this time were limited to annual harvesting of saleable cattle with virtually no control over stocking rates or breeding[37]. By the early 1990s, annual breeder mortality in the Kimberley region had been estimated to range from 11-18%, using aggregated data from across the region to estimate sex turn-off differences[37].

A survey of cattle producers in north-west Queensland which collected information from the 1950s and early 1960s, reported breeder mortality rates of around 11% or more against an overall mortality rate from all cattle on beef properties that ranged from 2.5% to 15.2%[35].

An observational study conducted in the Pilbara region of Western Australia in the mid-1970s reported cow mortalities ranging from 8 to 23% with the higher mortalities being associated with higher stocking rates, increasing cow age and lower annual rainfall[22].

These results were similar to findings from reports in the 1980s of an average breeder mortality of 11% in the east Kimberley,[59] and a study in the Adelaide River area of the Northern Territory that reported 15% and 21% annual mortality rates in Brahman-Shorthorn cross mature cows and first lactation cows, respectively[44]. These findings were in cows that received no nutritional supplement. When animals were supplemented during the dry season alone (urea), mortality rates fell to 7.5% (mature breeders) and 11.6% (first lactation cows), and when animals were supplemented during the dry and wet seasons, mortalities fell further to 3.7% (mature cows) and 3.1% (first lactation cows)[44].

O'Rourke *et al* (1995) analysed long-term records for two different birth cohorts of cows (animals born between 1970-72 and those born between 1973-87) at the Swan's Lagoon research station in north Queensland and found that in the two different cohorts, the mean cow mortality rate was 1.7% (0 – 5.3%) and 1.2% (0 – 11.6%)[52]. The authors acknowledged that a number of factors were likely to have contributed to a lower annual mortality rate at Swan's Lagoon compared with many other commercial properties. Swan's Lagoon was described as a relatively favourable environment for cattle production with subdivision providing opportunities for effective close supervision of the herd, calving dates were able to be closely matched to seasonal conditions through the use of controlled mating, cows were culled at a maximum age of 10 years, lactating animals were weaned each year and strategic supplementation was provided to cows when required[51,52]. The conditions on a research station were not considered likely to directly reflect conditions on commercial beef properties under normal management[51].

A study of mixed cows (Brahman and Shorthorn) in north Queensland reported 21% cow mortality in a drought year (1982-1983), despite supplementary feeding being initiated in November 1982[18]. Cows more advanced in pregnancy and those in poorer condition in the early stages of the drought had lower survival probabilities (Table 3). Cows aged over 7 years also generally had a reduced probability of survival[18].

The experience of this initial result was used to develop a strategic approach to survival feeding of at-risk cows during a subsequent drought in 1987-88, resulting in <1% losses from 293 cows[18].

Table 3: Effects of body condition score and stage of pregnancy on the probability of survival of 3-7 year-old cows in 1982-1983[18].

Stage of pregnancy	Condition score				
	≤ Poor (≤ 3)	B'ward store (4)	Store (5)	F'ward store (6)	Prime (7)
Non-pregnant	0.87	0.95	0.97	0.98	1.00
1st trimester (1-3 mths)	0.58	0.79	0.87	0.92	0.98
2nd trimester (4-6 mths)	0.43	0.67	0.78	0.86	0.97
3rd trimester (7-9 mths)	0.33	0.58	0.7	0.80	0.96

Body condition score was assessed on a 9-point scale from 1 (moribund) to 9 (overfat).

Mortality rates in breeding females at Kidman Springs research station in the Victoria River District of the Northern Territory were described over a 9-year period (1981-1990)[51,54]. Annual mortality rates were similar from ages 2 to 9 years (9.4 to 12.4%), but increased markedly as cows aged, to 15.5% for 10-year olds, 18% for 11-year olds and >20% for older cows[54]. The authors noted that while Kidman Springs was also being managed as a research station, it was considered to be in a harsher environment than Swan's Lagoon and under less intensive management and these factors were likely to have contributed to the higher mortality rates when compared to those reported for Swan's Lagoon.

Cobiac (2006) reported the results of a trial at the Kidman Springs Research Station during 1995 to 2001 to evaluate the breeding efficiency of several *Bos indicus* and *Bos indicus*-cross beef cattle herds when run under a customised management system developed at the station (The Best Bet Management System, or BBMS)[12]. Seasons and pasture production during the trial period were favourable. Mortality averaged 2.1% per annum across all herds, indicating that the BBMS for the region successfully minimised the stresses associated with the environment. Annual mortality rates reported in this study were low relative to other reports from northern Australia and appear to reflect the benefits of specific management systems such as the BBMS.

There have also been a limited number of producer surveys that have collected self-reported estimates of various production measures including breeder mortality.

Dray *et al* (2011)[16] reported on a survey of the Pilbara and Kimberley that asked pastoralists to estimate their 2009 and 2010 mortality and weaning rates. The results showed that estimated breeder and old cow (>9 years) mortality rates over the two years ranged around 4% to 8% per annum. Interestingly, the weaning rate for the breeders and old cows ranged from 66% to 71%. It is useful to note that discussion of these results with one of the authors indicated that these results should be interpreted with some caution – particularly the mortality and weaning estimates – since many pastoralists did not have accurate cattle inventory records[a].

Producer surveys in the Northern Territory have reported producer estimates of breeder cow mortality ranging from 2.7% (Top End region), 3.0% (Katherine and Alice Springs regions), to 3.5% (Barkly Tableland)[24,55] (Table 4). These surveys summarise self-reported performance measures and therefore validity of performance measures is likely to be variable. The fact that the breeder mortality measures are generally lower than measures derived from observational and experimental studies suggests that these measures may be under-estimating actual mortality rates.

Table 4: Summary statistics for key production measures for beef producers in the Northern Territory[55].

	Weaning %	Breeder mortality %	Heifers retained as replacement breeders %
Alice Springs	76	3.0	62
Top End	70	2.7	63
Katherine	71	3.0	57
Barkly Tableland	70	3.5	61

The Smart Manager project involved producer groups in north Queensland creating herd and regional benchmarks on selected performance measures for assessment of performance[39]. Smart Manager combined producer estimates of branding and mortality rates with use of Breedcow modelling in an iterative manner with producers to derive realistic input parameters based on comparison of output measures from the model with producer expectations for their own properties. The experience supported suggestions that initial producer estimates of branding and mortality rates were likely to be optimistic (reported branding rates were higher and mortality rates lower than the likely true values), and required adjustment in an iterative fashion during the development of

[a] P. Smith personal communication, 2011

Breedcow models. The final annual breeder mortality rate estimates ranged from 2 – 9%[39].

Modelling approaches to estimate breeder mortality in northern Australia have been used in a small number of additional studies.

Niethe and Quirk (2008)[49] assessed annual stock returns to the Western Australia Pastoral Lands Board over the period from 1985 to 2007. Estimates provided by pastoralists of breeder mortality produced an overall average of 3.6% deaths per year.

Modelling in Breedcow involved entering the ‘typical’ figures for weaning percentage, mortality rates and turn-off parameters and then fine-tuning the herd in the model until the total number of stock sold matched the figures for the Kimberley (158,282 head) and the Pilbara (82,024 head)[49]. When the percentage of females sold also corresponded with the Kimberley and Pilbara figures (38.2% and 39.2% respectively), it was assumed that the models were providing realistic outcomes. Some spaying was also incorporated in the modelling for both the Pilbara and the Kimberley.

The resultant models were used to estimate a variety of outcomes including breeder mortality[49]. Modelling suggested that the key performance measures for a ‘typical’ Kimberley or Pilbara breeding herd included 60% weaning rate, 10% breeder mortality rate and 61% heifer retention rate. The authors noted that the modelling also provided strong evidence that the likely estimate of the total cattle population in both regions was significantly larger than that estimated from Western Australia Pastoral Land Board annual returns[49]. In the Pilbara the estimated female percentage of total sales was more difficult to interpret because properties in that area appeared to be retaining heifers to build up their breeding herd as the region moved from sheep to beef cattle, resulting in fewer females being presented for sale than expected.

The proportion of females in the annual sales figures was around 39% while more favoured regions of northern Australia were achieving >47%[49]. Herd modelling using Breedcow also showed that realistic improvements in regional herd performance of increasing weaning rates to 68% and reducing mortality rates to 3.5% would boost turn-off by 25% in both regions. The authors warned that profitability and affordability of achieving such improvements could only be accurately assessed on an individual station basis[49].

Similar modelling completed in the Pilbara region reported an estimated annual breeder mortality rate of 12%[26]. The authors reported that sale records were the most reliable record available from the co-operating stations, and these formed a key part of the modelling process. Female sales as a percentage of total sales were calculated over a five year period, allowing for fluctuating breeder numbers over the years, to provide an indication of female death rate. Weaning numbers and breeder numbers were discovered to be less accurate than sales information (particularly with once a year mustering) as these can vary dramatically between years, and as such provide only a guide as to how well the herd is performing.

4 Importance of breeder mortality

It has long been recognised that breeder mortalities have an impact on profitability and even viability of beef breeding enterprises in northern Australia[31,50,51,54]. Different benchmarking exercises conducted in northern Australia have reported that breeder mortality is either one of the key benchmarks used for assessing performance[26,39,49], or the single most important driver of gross revenue per livestock unit in central Australia[45].

Concerns have been expressed that there may be variable appreciation of the importance of breeder mortality as a key factor limiting performance and profitability on many northern properties, in part because of poor quality data leading to under-estimation of typical breeder mortality rates[49]. An example of this is reported by Niethe and Quirk (2008)[49] where estimates of breeder mortality in northern Western Australia derived from annual stock returns to the Pastoral Lands Board averaged around 3.6% per annum, while separate estimates derived from a modelling exercise for the same region suggested that a more realistic breeder mortality rate for the region was around 10% per annum[49]. Similar issues relating to under estimation of breeder mortality rates derived from producer estimates have been raised elsewhere[39,45].

A number of publications have described results from modelling impacts of different management strategies on production or economic measures of performance.

Stefani (1992)[62] modelled a representative herd in the Barkly district of the Northern Territory to compare impacts of interventions designed to improve either branding rates or mortality rates. The starting herd had branding rates ranging from 55 to 70% and breeder mortality rates of 3%, 6% or 10%. When initial breeder mortality rates were around 10%, it was more beneficial to invest in reduction of mortality instead of improving branding rates. As breeder mortality fell it was more beneficial to invest in improving branding rates. The recommended priority of investment therefore depended on knowing initial branding and mortality rates.

Niethe and Holmes (2008)[48] used Breedcow to examine the impact of improving the average value of cows sold, the risk of decreasing the number weaned, and total sales on the profitability of northern Australian cattle breeding properties. Production parameters, prices, costs and herd structure were entered into BCOWPLUS for six northern Australian breeding properties and an iterative process conducted in discussion with property owners/managers to fine tune the models so they reflected the actual herd performance. The models were then used to compare the impact of separately decreasing breeder cow mortality rates by 1%, increasing weaning rates by 1%, or improving live weight gain by 1% (in relation to the original starting values for each property).

In all regions a 1% decrease in breeder mortality resulted in the greatest percentage improvement to the gross margin per animal equivalent though the difference between the impact of the three management changes was small enough to be of little consequence in choosing one of the three options[48]. Similar impacts have been reported in sensitivity analyses conducted on representative herd templates produced for multiple regions across northern Australia[28,29].

5 Factors influencing breeder mortality

The precise timing of cow mortalities and the cause is often not known because of limited opportunities to observe animals around the time of death. It may be difficult to specify factors that influence breeder mortality as distinguished from factors that may be part of general recommendations to optimise beef cattle management with one of the benefits of best practice being a reduction in mortality risk.

O'Rourke (1994)[51] provides one of few relatively detailed studies of breeder mortality over time under northern conditions. Major identified causes of death were: unknown (36%), poverty or poor body condition (28%), calving related deaths (10%), infection or poisoning including sporadic botulism outbreaks (18%) and accidents (8%)[51].

The major combination of factors producing elevated mortality risk is cows in late pregnancy to early lactation, in poor body condition and during the late dry to early wet seasons.

Most cow deaths occur in the late dry and through the early wet seasons (October to April)[12,51]. This period coincides with late pregnancy, calving and early lactation for many breeding cows, representing periods of peak nutritional demand from the cow. The late dry and early wet periods also represent the period when pasture supply across the northern beef regions of Australia is likely to be most severely restricted both in terms of quantity and quality. The period when the first heavy rains fall in the transition from late dry to early wet represents a short period of increased risk for cows already weakened from the combination of pregnancy / lactation status and the dry season. The wet, cooler and boggy conditions coupled with poor feed and physical weakness may result in increased mortalities during this transition period.

Of those deaths that occurred outside the period from the late dry to the early wet, more occurred in the dry season than in the wet season[51].

Holroyd and Fordyce (2001)[32] produced a summary table (Table 5) of management factors affecting production parameters including animal survival and have categorised these into four levels:

- Basic management which should be applied by all property owners/managers;
- First-level management options which are considered to be most important;
- Second-level options which should only be considered once all the first-level options have been considered; and,
- Third-level options which should be the last group of options to be considered.

Table 5: Management factors with potential to influence breeder mortality. Adapted from Holroyd and Fordyce (2001)[32].

		Survival	
		Weaner	Cow/Heifer
Basic Management	Sustaining pasture resources	++	++
	Cattle control	++	++
First-level management	Appropriate genotype	++	++
	Supplementation	++	++
	Weaning and weaner management	++	++
	Botulism control	+	++
Second-level management	Control of reproductive disease	+	+
	Heifer management	++	+
	Efficient culling		++
	Selecting breeding cattle	+	+
Third-level management	Controlled mating	+	+
	Dry season segregation of cows		+
	Spike feeding		+
KEY	++ : significant benefit in most years		
	+ : significant benefit in some years; small benefit in most years		

5.1 Basic management practices

The foundation of efficient cattle production lies in having sufficient infrastructure and resources to be able to effectively control and segregate cattle so that they can be managed in groups and mustered when required for management procedures[10,32].

Jayawardhana and McCool (1992)[34] described a linear relationship between stocking rates and breeder mortality using data from six herds on four commercial properties in the Victoria River District of the Northern Territory. The authors suggested that stocking rates on some properties may have exceeded sustainable levels based on pasture availability and that more effective management of stocking rates through sale of surplus stock including females, would reduce mortality and improve long term sustainability and profitability.

The impacts of increased stocking pressure on general ecosystem health as well as longer term animal health and production measures have been noted in other reports[9,46,60,63]. This is supported by papers reporting benefits associated with either reducing grazing pressures or applying flexible stocking rates that are adjusted depending on the season in extensive environments, with the benefits increasing dramatically under dry and drought conditions[9,56].

5.2 Genotype

The infusion of *Bos indicus* genetics into the northern beef herd has been responsible for significant improvements in profitability and efficiency of the industry and the proportion of *B. indicus* and *B. indicus* cross cattle has risen from 5% in 1970 to 85% currently[8,70]. An important part of this is the ability of *B. indicus* cattle to survive under harsh environmental conditions with little management input and inherent resistance to ticks and tick-borne diseases[2]. Over the past several years there has been increasing interest in both developing production characteristics of *B. indicus* breed through selection pressure and in development of cross-breeding programs that offer tropical adaption as well as efficient production[10,23,36,42].

5.3 Supplementation

Animal nutritional status has important effects on fertility through influencing ovarian cyclicity, conception and pregnancy maintenance as well as lactation. At its simplest, cows in better body condition are likely to have higher pregnancy and weaning rates than cows in poorer condition. If body condition is depressed sufficiently, animals will have an elevation in mortality risk.

Cows in poorer body condition have a higher risk of mortality and cows that are heavily pregnant have higher mortality risk[18,51,54,67]. The highest mortality risk was reported in cows that were in poor body condition and that were in the last trimester of pregnancy[18].

The strategic management of supplemental feeding incorporates issues such as maximising benefit from available pasture, segregating cows based on nutritional need so that supplementation can be provided to only those cows that need it most, and using controlled mating and weaning to manage key events such as early lactation so that they coincide with optimal pasture quality[32].

The aim of nutrient supplementation is to augment the pasture supply of baseline dry matter with key nutrients to optimize the ability of livestock to utilize pasture. For much of the northern region of Australia this means supplementing with phosphorus in the wet season and in some cases salt and sulphur. In the dry season supplementation of nitrogen is more important and in some cases salt and sulphur[69].

Phosphorus is one of the most important nutritional deficiencies within the limitations of potential metabolisable energy intakes of grazing cattle in the seasonally dry tropics, and is a major constraint to beef cattle productivity in northern Australia[15]. Meat & Livestock Australia has recently released an updated manual outlining strategies and practices for feeding phosphorus to beef cattle in northern Australia[33].

Nitrogen intake is essential for rumen function and protein deposition in animals and is a major limiting nutrient in northern pastoral areas. Mature cattle require about 6-8% crude protein in the diet to maintain liveweight[58] and young growing cattle (weaners) and lactating cows require higher levels of protein (9-11%)[17]. Nitrogen supplementation (often through urea mixes or blocks) can minimise or prevent liveweight loss during the dry season and can reduce breeder mortalities[32].

The term crisis supplementation is used to describe short-term feeding of higher levels of nutrition (nitrogen and possibly energy) to prevent mortalities when there is a severe shortage of quality feed such as when the onset of the wet season is delayed or under drought conditions[32]. Crisis supplementation is generally part of a range of management interventions that might include radical weaning, sale of surplus stock, movement of stock to where more feed is available, and segregation of remaining stock into groups based on nutritional needs so that feeding can be managed as efficiently as possible[10].

Supplementary feeding can be used to avoid excessive weight loss that might ultimately expose a cow to elevated mortality risk. Drafting breeders on the basis of stage of pregnancy, body condition and age may allow producers to strategically initiate survival feeding to the highest risk groups first and minimise costs by avoiding survival feeding in other groups for as long as possible[18].

Supplementation in the dry season alone[30] and both the dry and wet seasons has been shown to reduce cow mortality rates[41,44].

5.4 Weaning

Weaning strategies in northern beef herds are based mainly on the potential benefit to the dam as a result of removing lactational demands on the dam at a time when pasture availability is generally limiting. Even in the wet season when native pastures may be considered to be at their best, there may be circumstances when some native pasture will be insufficient to meet nutritional requirements for lactating cows to be able to maintain their body weight while supporting a growing calf[17]. During the dry season when pasture energy and protein levels will be expected to be low, most lactating cows will lose weight and in very poor years weight loss may be severe enough to result in a high risk of mortality.

Weaning is therefore considered to be the single most effective tool available to benefit the body condition of the breeding cow and will increase the likelihood of cows avoiding high mortality risk and being able to regain condition and get pregnant again[68].

The general recommendation is to wean calves weighing about 100 kg or more at each mustering round on those places that muster twice per year and that continuously mate.

Once-yearly weaning (removal of calves weighing 100 kg or more in June) was reported to reduce cow mortality rates at Kidman Springs from 8.5 to 15.6% (across unweaned groups), to 4.5 to 8% (across weaned groups)[64]. Similar beneficial effects of weaning have been reported elsewhere including in the east Kimberley region of Western Australia where twice-yearly weaning (removal of calves weighing 140 kg or more) was associated with a drop in breeder mortality in Shorthorn cows from 18% to 9%[59]. A subsequent study comparing once yearly weaning (removal of calves weighing 100+ kg in June) with twice yearly weaning (removal of calves weighing 100+ kg in June and October), also performed at Kidman Springs, reported no difference in cow mortality[65] though the authors suggested that twice yearly weaning might be beneficial if the first weaning round was conducted a little earlier to allow more time between the two rounds.

A combination of management factors including an earlier first weaning round (April instead of June) and year-round supplementation with urea-based licks in the dry and phosphorous licks in the wet was credited as contributing to a reduction in breeder mortality on Kidman Springs from around 10% per annum to around 5% per annum[41].

Petty (1994)[57] compared the impact of once a year weaning of calves to 60 kg (radical weaning) with twice a year weaning at 150 kg (removal of calves weighing 150 kg or more). The work was carried out in the east Kimberley region and the results suggested that there was little difference in breeder mortality rates for the two weaning strategies. The breeder mortality rates recorded, 2 – 3%, were low by industry standards[57].

5.5 Botulism

Botulism is a bacterial disease caused by *Clostridium botulinum* and is a significant cause of mortality in northern beef herds that do not vaccinate[10]. Precipitating factors include drought and phosphorous deficiency. Prevention is based on phosphorous supplementation and annual vaccination of susceptible cattle against botulism[10,32].

5.6 Ticks and tick-borne diseases

The cattle tick (*Rhipecephalus microplus*) is an important external parasite of cattle and is endemic in northern parts of Western Australia, Northern Territory and Queensland. Cattle tick is a notifiable disease when occurring outside the endemic areas[b]. Heavy infestations of ticks can cause loss of condition and death in severe cases and ticks also can carry and transmit tick fever organisms which may separately result in clinical disease and death in affected cattle[3]. *Bos indicus* (Brahman) type cattle have been shown to be resistant to ticks and producers are also encouraged to use selection for increased tick resistance within breeds as a preventive strategy[2]. Brahman type cattle are also reported to be more resistant than British breeds to tick fever organisms[3,4,11]. Best practice methods for prevention and control of ticks and tick fever are well described and include use of Brahman genetics, selection for resistance, pasture spelling, application of chemicals to reduce tick burdens and vaccination of animals against tick fever[10].

5.7 Major reproductive diseases

A number of infectious diseases have the potential to result in failure of fertilisation, abortion and pregnancy loss, and peri- or post-natal losses including bovine pestivirus (BVD), bovine ephemeral fever (3-day sickness), akabane virus infection, vibriosis due to *Campylobacter* infection, trichomoniasis, leptospirosis and infection with *Neospora* organisms[8,32]. While many of these conditions have less impact on the dam, they may result in loss of the pregnancy or neonate, and any condition that compromises the health and welfare of the dam has the potential to increase risk of breeder mortality.

5.8 Heifer management

Selection and management of heifers has the potential to influence not only their performance as first calvers in the breeding herd but also their subsequent lifetime productivity. Major benefits of improved heifer management include increased weaning rates and lower mortality rates with associated benefits through increased surplus stock for sale[32]. A recent MLA publication provides key information and recommendations concerning heifer management[61].

[b] http://www.daff.qld.gov.au/4790_12815.htm

5.9 Culling and selection strategies

Discretionary culling of breeding cows is generally based on their reproductive history and cull cows are replaced with heifers in the breeding herd[10,53]. Cows are also culled for non-discretionary reasons such as physical abnormality (emaciation, lameness, udder abnormalities, cancer eye, lumpy jaw, vaginal prolapse), temperament, age and infertility[6,51]. In more extensive areas cows may be culled based on fatness with an expectation that these animals are likely to have failed to rear a calf[6].

The combination of cull cows and breeder mortalities provides an indication of the number of replacement heifers needed to maintain a stable breeding herd[51]. This can be considered as a minimum replacement level which is made up of non-discretionary culls plus breeder mortalities. Under a stable breeding herd scenario the level of discretionary culling that is possible may be limited by the number of suitable replacement heifers that are available. The percentage of heifers retained as breeders varies from 50-80%[6,51].

There is an association between cow age and mortality rate though there may be relatively little effect of age between about 2 and 9 years on well managed properties. Once cows reach 10 years or older there appears to be a consistent and relatively rapid rise in mortality rate with increasing age[35,51]. An age-associated increase in cow mortality risk during drought that appears in animals older than 7-years has been attributed to deteriorating dentition[18,67].

Choice of culling strategy has the potential to reduce breeder mortality, improve herd reproductive performance and increase sales[53]. Culling or selection based on a single reproductive failure has the effect of reducing lifetime productivity by an average of 0.9 calves reared over a cow’s lifetime when compared to discretionary culling that is triggered only when a cow has failed to rear a calf on two consecutive years[53]. The rising mortality risk observed in older cows also means that many producers will impose an upper age limit when most or all remaining cows will be culled. O’Rourke et al (1995)[53] suggest that the age at which cows should be culled for age in northern Australia be set between 8-10 years while also acknowledging that the most effective strategy for an individual property may depend on more detailed assessment of lifetime productivity and profitability for cows under different management options. Survey data suggest that culling at 10 years of age is the most common age-based culling strategy in northern beef properties with 6-20% of responding properties indicating that they retain cows beyond 10 years of age and almost no properties indicating that they do not cull for age[6].

Spaying is a commonly applied management procedure that may be employed in conjunction with culling. The value of spaying cull females is to eliminate the risk of inadvertent pregnancies occurring in cull females and allow cull animals to direct any available feed into weight gain instead of pregnancy development[32].

5.10 Selection of breeding cattle

Selection of bulls has a long term impact on genetic improvement in the herd and should be based on criteria developed in alignment with production objectives and market requirements[10]. Assessment of breeding soundness of bulls is an important way to ensure that bulls used in the mating program are likely to get cows pregnant.

Selection of heifers from the available replacement pool on criteria related to genotype, temperament, post-weaning growth and early pregnancy, also has the potential to improve herd performance[10].

Genetic selection is included in this section because selection has the potential to reduce mortality risk through long term improvements in cattle suitability for particular environments and through reduced susceptibility to specific problems such as ticks and tick borne diseases that may in turn elevate mortality risk.

5.11 Controlled mating

Controlled mating refers to the practice of only allowing bulls to be with the breeding herd for selected weeks or months of the year in order to control when cows get pregnant and therefore when they calve. The main objective is to time calving to coincide with peak pasture availability and quality to ensure maximal survival of cow and calf, optimal growth of the calf and a high likelihood of the lactating female to get back in calf in a timely manner. In the northern beef regions of Australia an important reason for controlled breeding is to avoid lactation during the nutritionally challenging dry season[32]

Most northern beef properties still use continuous mating of breeding cows in conjunction with controlled mating in heifers[10,55]. Continuous mating is likely to result in more calves born through the year but the spread of calving is much wider. Under optimal conditions controlled mating appears likely to result in long term improvements in herd performance but under the variable and often harsh conditions of northern Australia there is a risk of worse performance from controlled mating than continuous mating.

5.12 Dry season segregation of cows

Table 3 provides a clear indication of the variation in survival probability for cows in differing combination of pregnancy status/duration and body condition score[18].

Under drought conditions pregnant and lactating cattle can lose weight because what little nutritional intake they are achieving is being directed towards the uterus or milk production. Segregation of breeding females at pregnancy diagnosis based on stage of gestation and body condition during the dry is based on creating groups of similar status and then directing intervention (supplementary feed or moving animals on to better feed) to those groups with the highest risk of mortality. This ensures that expenditure is directed to where it is most needed and if this practice is implemented in the early dry when there is still standing feed and before cows have lost too much condition it can avoid a high proportion of the mortalities that might otherwise occur if no supplementation were provided.

5.13 Spike feeding

Spike feeding is the practice of feeding a higher quality supplement to late pregnant heifers or cows for a short period in the late dry season with benefits including a shortened interval post-calving to resumption of cycling, improved milk yields and weaner weights, and potentially reduced mortalities in extended dry seasons[19]. Spike feeding should begin about 6 weeks before the main calving season starts and continue for about 50 days[19]. The main target group for spike feeding is heifers late in their first pregnancy with insufficient benefit to cost to warrant extending the practice across the entire breeding herd.

6 Best practice management strategies

Cattle production in northern Australia is characterised by large herds, low stocking rates, low level of management and low cost and lower production (in terms of liveweight gain and reproductive rates) compared to southern beef production systems[21].

A range of publications describe management options that may be used to improve performance on beef herds with breeder mortality being one measure amongst many that may benefit from these practices[8,10,12,21,32,38,51,61,68]. Many of these publications provide recommendations that are very closely aligned to the major factors influencing breeder mortality that are summarised in the previous section of this report.

The majority of northern beef herds continuously (year-round) mate, and manage two mustering rounds (with weaning) each year[6,32,55]. Most producers across all northern regions reported supplementary feeding at some stage throughout the year, with most supplying dry season supplement (commonly maintenance feeding with nitrogen, phosphorus and sulphur) to all classes of stock, with many also feeding supplement over the wet-season (phosphorus). The predominant genotype is *Bos indicus* or *B. indicus* crosses, as tropical adaptation including tick and heat resistance becomes increasingly important in northern regions.

An example of many of the components of best practice management on northern breeding properties is seen in the systems applied at Swan's Lagoon in northern Queensland which includes continuous mating, conservative stocking rates, two annual musters, weaning all calves at each muster that weigh 100 kg or more, crisis supplementation when required, vaccination for botulism and leptospirosis, initial mating of females at 2 years of age, culling of females at 9 years of age and performance-based selection of replacement bulls and heifers[20].

Cobiac (2006)[12] described the Best Bet Management System (BBMS) which had been developed over time from breeder research conducted mainly at Kidman Springs research station. The BBMS was designed to have beneficial impacts on animal survival, production and profitability. The BBMS incorporates the following practices:

- annual vaccination against botulism for all cattle, and bulls vaccinated annually against *Campylobacter fetus*;
- breeding herds supplied with 100g/head/day mineral supplement year-round (non-protein nitrogen, phosphorus and sulphur);
- calves weaned at 100 kg or heavier at both musters, then grazed on saved native pasture;
- cows culled for age (from 10 years old);
- cows culled on poor reproductive performance (empty and dry at the May muster, or very long inter-calving intervals);
- replacement heifers:
    - selected at two years of age on body weight (>280kg) and desirable body type;
    - bred under a controlled mating system; and
    - run separately until they wean their first calf (allows separate management and additional feeding if required)

- moderate stocking rate of 6 – 7 breeders per square kilometre (in the Victoria River district),
- two musters per year in May and October; and
- fire use in management of native pasture.

Jubb et al (1997)[38] provided a range of recommendations for consideration to improve management of extensive beef herds. These included:

- aiming to achieve high mustering efficiency through good stock control;
- having a culling policy which improves herd quality and controls stocking rate by removing surplus females;
- adopting conservative stocking rates around good quality, well-spaced waters so that cattle are well fed, land degradation is avoided and the need for supplements is minimised;
- having an effective weaning program and good weaner management to ensure breeders are able to more effectively maintain body weight coming into the next breeding season, and also ensuring good growth in young cattle;
- using tropically-adapted breeds to reduce parasite problems and heat stress;
- controlling predation (dingos) to minimise calf losses;
- managing fires to preserve or improve pastures;
- vaccinating against botulism;
- dehorning to minimise bruising and meet export market requirements;
- using good restraint and surgical technique when castrating;
- looking after employees; and
- maintaining infrastructure.

There are many additional sources that provide advice and suggestions for improving management of breeding herds. Recommendations are typically aimed at achieving a wide range of improved outcomes and not necessarily focused on single measures such as breeder mortality.

7 Conclusions

This review highlights the difficulties in sourcing accurate data to describe mortality in breeding cows on northern beef properties and the use of a variety of alternative and indirect measures used to estimate breeder mortality.

The review describes approaches used to estimate breeder mortality and provides estimates from properties and regions across much of northern Australia. Major factors influencing breeder mortality are identified along with management strategies for minimising their potential to adversely impact breeder deaths.

There are a small number of more detailed studies that have collected data on breeder mortality from observations conducted on northern beef properties. A number of studies have collected retrospective property records or used survey approaches to collect producer estimates of breeder mortality rates. A number of reports have used indirect methods based on sales data in combination with estimates of breeding populations to estimate mortality rates in breeders. Other studies have used herd modelling software generally in combination with records either from producers or from other sources (sales, abattoir or animal movement records) to generate estimates of mortalities in breeders.

There is considerable variability in estimated breeder mortality rates between properties and regions within northern Australia. There are undoubtedly individual properties where the combination of environmental, animal and management factors are able to produce relatively low breeder mortality rates (under 3%). Across much of northern Australia, the literature reviewed in this report from the last two decades suggest that typical annual breeder mortality rates are likely to be between 2 and 12% per annum with higher mortality rates expected in cows aged 10 years or older (15 to 20% or higher) and in severe drought conditions (>20%).

There is relatively little available information to characterise the causes of breeder mortality in detail. The combination of conditions likely to increase mortality risk are poorer condition cows that are heavily pregnant or in early lactation and during the late dry to early wet seasons. There is an age associated increase in mortality risk that is likely to occur in cows older than 8-10 years, though this is expected to vary between animals and properties and individual cows that are able to maintain good dentition and body condition may be able to remain productive past 10 years of age.

Where breeder mortality is higher there is strong evidence to suggest that strategic investment should be directed at reducing breeder mortality before attempting to increase weaning rates for example. Where breeder mortality is relatively low it may not be useful to direct further investment into reduction of mortality.

It is recognised that breeder mortality is only one of many performance measures that can be used to assess enterprise performance and guide strategic decisions. Further effort is recommended to better characterise breeder mortality and to incorporate consideration of breeder mortality into benchmarking and strategic management options for producers in the future.

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