Nutritional management of heifers in northern Australia

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Summary

With over 14 million head of cattle, the north Australian beef industry (north of 26ºS) comprises 57% of the Australian cattle population (MLA 2003). The majority (85%) of properties in this region are breeding enterprises in which breeder fertility is critical for profitability. The turn–off age of cattle has decreased from 4–5 years of age to 1–1.5 years of age, potentiating the impact of breeder fertility on profitability. Although significant improvements in reproductive efficiency have occurred in northern Australia over the last twenty years, reduction in age of puberty and improvement in the rate of reconception of heifers is possible. Most heifers in northern Australia are first mated at two years of age. Breeder lifetime productivity could be improved by mating heifers at one year of age. Reconception rates for yearling and 2–year–old heifers can be as low as 25%. Recent work in northern Australia suggests that these inefficiencies can be overcome with the right combination of nutrition, genetics and management.

Keywords: heifers, northern Australia, nutrition, yearling mating, reconception rates, genetics, reproductive efficiency

Introduction

Beef production in northern Australia is characterized by extensive, low–input systems based on native pastures that are seasonally deficient in nutrients for the purposes of beef cattle breeding (McCosker and Winks 1994). Monsoonal rainfall patterns of hot, wet summers and cool, dry winters are typical of the region, but the amount and frequency of rainfall varies. The dominant breeds of cattle are Brahman and Brahman–crosses with *Bos taurus* (European and British) infusion. Some operations in tick–free (cattle tick, *Boophilus microplus*) regions run cattle with little (<50%) or no *Bos indicus* infusion; occasionally, tropically–adapted *Bos taurus* breeds (Sanga) are used (Bortolussi *et al*. 1999).

Commercial cattle properties in northern Australia are relatively large, typically ranging in size from 1000 ha to two million ha. A continuous (non–rotational) grazing system using large paddocks (1000–200 000 ha) is standard management practice. Stocking rates vary according to land type and seasonal conditions. Livestock drink from steel or concrete drinking troughs, for which water is sourced from artesian and sub–artesian bores, or from rivers, creeks (often non–permanent) and the occasional dam.

Cattle are mustered for processing using various combinations of helicopters, small airplanes, motorbikes and horses. Processing of cattle involves activities such as weaning, vaccination, culling of sub–fertile, non–lactating cows, culling of injured bulls and in some circumstances, branding, de–horning and castration of progeny (Peatling, S.R.; personal communication, 2003). Bulls are normally joined at the rate of 2–5% (2–5 bulls for every 100 breeders) all year round (Bortolussi *et al*. 1999), but some herds practice controlled mating (3–4 month joining period) or strategic removal of bulls (3 month removal). Where control mating is practiced, calves are weaned once–yearly. For continuously mated herds, twice–yearly weaning is the most common practice, but practices such as once– or thrice–yearly weaning, and no weaning are also encountered. As native pastures of northern Australia are seasonally deficient for beef breeders in energy, protein and phosphorus, nutrient supplementation is a common practice (McCosker and Winks 1994). Supplements are fed to breeding stock primarily in the late dry–season (August to December) but some properties also feed during the growing period (January to April) (Savage 1997). A range of supplement delivery systems are used to deliver non–protein nitrogen and phosphorus. For properties located near sugar–cane farms, molasses may also be used as an energy supplement (Boorman 1996). The approach to supplementation differs between properties in the form of delivery system, timing of delivery, type of nutrients provided and classes of stock targeted

(Savage 1997). The inconsistency in approaches to nutrient supplementation is primarily due to varying opinions on the most cost–effective approach (Savage 1997; Goodacre and Adams 1999).

Mature breeder performance in northern Australia has improved substantially in the last decade, increasing from an average of 50% to more than 80% (McCosker *et al*. 1991; Bortolussi *et al*. 1999; Savage 2004). Improved nutritional management, breeding practices and infrastructure developments have driven these improvements. Heifer reproductive performance remains an area where improvements are needed. When yearling mating has been practiced, heifer reconception rates greater than 50% are rare (Hasker 2000). However, studies have shown that high reconception rates (89%) are possible (Savage *et al*. 2004).

The importance of nutrition for reproductive performance

North Australian extensive beef production areas commonly experience seasonal deficiencies in the nutritive value of native pastures (Robinson and Sageman 1967; Romero and Siebert 1980; Hall 1981; McIvor 1981; Foran *et al*. 1985; Wadsworth *et al*. 1990; Ford 1992). Management of nutritional regimens is therefore one of the most critical aspects determining breeder herd productivity and profitability (Topps 1977; Entwistle 1984). Improved breeder herd nutrition can be achieved via appropriate stocking rates, regular weaning (twice yearly) and appropriate supplementation (Van Niekerk 1982; Van Niekerk and Jacobs 1985; Fordyce and Entwistle 1992; Sullivan and O'Rourke 1997). In recent years, research in this field has focussed on quantifying the extent of nutrient deficiencies in grazing cattle in northern Australia because published nutrient requirements are not appropriate for animals in this region (Coates 1994; Bolanos *et al*. 1996; Bortolussi *et al*. 1996; Coates *et al*. 1996; Fordyce *et al*. 1996; Miller *et al*. 1996; Ternouth *et al*. 1996; Ternouth and Coates 1997; Dixon *et al*. 1997a).

Reproductive performance of a herd is measured as the weight of calf weaned per breeder per year (Baker and Carter 1976). Therefore, pregnancy rate and duration of anoestrus are key components of reproductive indices. Undernutrition reduces pregnancy rates and increases the duration of anoestrus in extensively grazing beef herds in northern Australia (Lamond 1970; Chenoweth 1984; Randel 1990; Dixon *et al*. 1996a; Herd 1997). The impact of undernutrition is expressed through breeder body condition and weight (O'Rourke *et al*. 1991a).

The importance of weight and body condition for reproductive performance

Body weight and body condition score are indicators of energy status and reconception after calving (Randel 1990; Wiltbank 1991; Herd and Sprott 1996). The effect of undernutrition on the duration of post–partum anoestrus and calf growth has been reviewed (Wiltbank *et al*. 1961; Lamond 1970; Topps 1977; Entwistle 1983; Chenoweth 1984; Entwistle 1984; Randel 1990; Herd and Sprott 1996). On a nine–point scale, cows with body condition scores less than or equal to four had lower pregnancy rates than those with body condition scores of five or greater (Rae *et al*. 1993). In thin, first–calf heifers, body condition score at calving (score = 4 on a nine–point scale) accounted for a greater proportion of the variation associated with postpartum interval than the change in body condition score or weight from calving to 90 days postpartum (Figure 1; Derouen *et al*. 1994; Lalman *et al*. 1997; Savage 2004).

Postpartum nutrition has a limited effect on postpartum anoestrus if cows calve in good body condition (≥ 5; nine point scale) (Jolly *et al*. 1996; Savage 2004). Stimulation of ovarian activity in response to weaning is dependent on body condition of breeders at weaning: duration of acyclicity increases 1.2–fold for

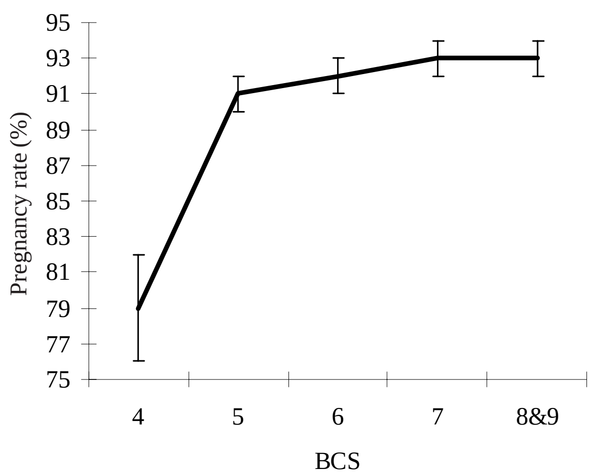

Figure 1 Relationship between body condition score (BCS) and pregnancy rate (%), (Savage 2004). Pregnancy diagnosis was established by rectal palpation.

every 0.5 unit decrease in body condition (Houghton *et al.* 1990; Jolly *et al.* 1996).

Liveweight can be used as an indicator of breeder fertility (Lamond 1970), but body weight loss (Somerville *et al.* 1979) or gain (Dixon 1998) are better indices of fertility than liveweight. Cows that lose more than 20% of their weight will enter anoestrus and will not re–establish normal sexual activity until they have reached a weight significantly heavier than that at which it ceased (Hale 1975). Under north Australian conditions, every 10 kg increase in bodyweight of breeders weighing less than 340 kg at the beginning of mating increases pregnancy rate by 5% (Dixon 1998). Breeder weight change may (Pleasants and Barton 1992) or may not affect the duration of anoestrus (Whitman *et al.* 1975; Morrison *et al.* 1999). Body condition moderates the effect of liveweight change on the duration of post–partum anoestrus (Cavalieri and Fitzpatrick 1995). McSweeney *et al.* (1990) also reported that the reconception response to weaning is slower for cows in poor body condition than for those in good body condition. This emphasises the importance of maintaining cows in good body condition rather than allowing them to lose weight and attempting to remedy the situation immediately prior to the mating season or during post–partum period. Moreover, nutritional setbacks after weaning increase the target weight for puberty in heifers (Sparke and Lamond 1968).

Breeders that maintain calving body condition during the early postpartum period have shorter intervals to first postpartum oestrus than cows that loose body weight (Osoro and Wright 1992; Bolanos *et al.* 1996). Body weight is also of importance for cyclicity, but it is difficult to differentiate between the effect of weight *per se* and that of weight change (Topps 1977; Cavalieri and Fitzpatrick 1995; Bolanos *et al.* 1996).

The relationship between liveweight and pregnancy is shown in Figure 2. The concept of a target weight has been applied to heifers and second–calf heifers in northern Australia (Entwistle 1984; Doogan *et al.* 1991). Undernutrition will delay the onset of puberty in heifers (Joubert 1963; Lamond 1970; Topps 1977). *Bos indicus* (Brahman) cross–bred heifers should reach a target weight of 270 kg to achieve 80% conception under controlled mating situations (Doogan *et al.* 1991). Growth rate, rather than weight, determines the age at which heifers reach puberty (McDonald *et al.* 1995). Heifers less than 401 days of age at joining, or less than 210 kg and gaining less than 0.8 kg/d, will have reduced fertility (Cunningham *et al.* 1981). Heifers that conceive at a low liveweight are vulnerable to subsequent nutritional stress and liveweight loss; this increases the risk of elevated mortality rates (MacDonald 1994). As long as heifers are growing and meet a minimum liveweight before mating, patterns of growth may be altered in the post–weaning period without decreasing conception or calf growth potential (Freetly *et al.* 2001).

Although undernutrition may have a negative impact on ovarian follicle development, there is no direct evidence that undernutrition affects ovarian function in cattle (Jolly *et al.* 1995). Hormonal responses to the presence of bulls may also increase cyclic activity in anoestrous cows (Burns and Spitzer 1992; Hornbuckle *et al.* 1995; Bolanos *et al.* 1998). Further studies are needed to determine whether nutritional or metabolic state influences ovarian function directly in a manner that affects the duration of postpartum anoestrus and fertility in postpartum cows (Jolly *et al.* 1995; Stevenson *et al.* 1997; Ciccioli *et al.* 2003).

Nutrient supplementation in northern Australia

Supplementation of breeders on seasonally deficient native pastures during dry and wet seasons can shorten the time from calving to reconception. Prolonged postpartum anoestrus interval or anovulation is a significant contributor to the low fertility of beef herds in northern Australia (Entwistle 1983, 1984; Schlink *et al.* 1992; Dixon *et al.* 1996a). As a consequence of tropical adaptation (and therefore adaptation to periods of nutritional stress), *Bos indicus* cattle appear to be more susceptible to postpartum (and lactational)

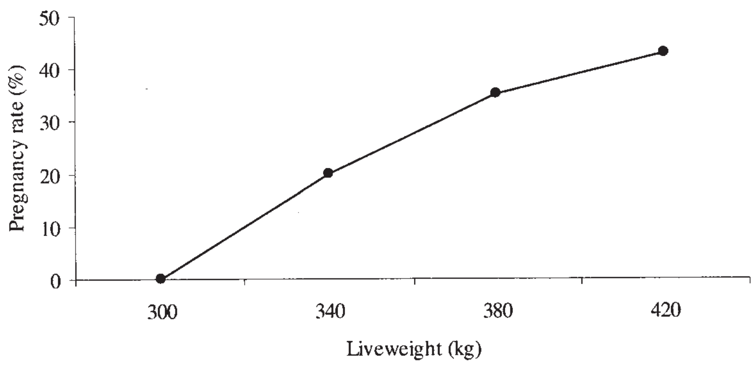

Figure 2 Relationship between heifer liveweight at the start of mating and pregnancy rate (Goddard *et al.* 1980).

anoestrus than *Bos taurus* breeds (Chenoweth 1984, 1994). During periods of energy deficiency, *Bos taurus* and *Bos indicus* cows that experience positive changes in energy balance respond by resuming ovarian cycles (Stevenson *et al*. 1997; Sullivan and O'Rourke 1997).

Supplementation of breeders grazing native pastures that are seasonally deficient in protein and phosphorus can improve reproductive performance (Schlink *et al*. 1992; McCosker and Winks 1994; Hennessy *et al*. 2001b). Protein and energy limit production from low–quality forages in the winter (dry) months (Van Niekerk 1982). During the summer (wet) months, phosphorus is the major limiting nutrient (Miller *et al*. 1997). Supplementation improves cow weight, body condition, fertility, and calf growth rate to weaning. For mature cows, the major factors influencing conception rate are: month of calving (Savage *et al*. 2003), time since previous lactation, adjusted mid dry season weight and body condition score (O'Rourke *et al*. 1991a). It is not clear which of these variables is most sensitive to changes in nutrition. Supplement regimens produce varying results according to the type, amount and timing of supplement delivery.

Matching the nutrients provided in supplements with seasonal conditions, and thus to the stage of plant growth, is of paramount importance (Sparke and Lamond 1968). Varied levels of success with supplementation during the dry season, wet season or both have been reported. For example, providing lactating breeders with wet season protein and phosphorus may (Dixon *et al*. 1996b) or may not (Dixon *et al*. 1996a) reduce postpartum anoestrus. A combination of dry– and wet season protein supplementation appears to be most successful for improving weight gain and body condition of cows (Schlink *et al*. 1994a) and calves (Schlink *et al*. 1994b), and for increasing fertility of breeders (McCosker *et al*. 1991; Dixon *et al*. 1996b).

Supplementation of native pasture in vegetative growth with protein, energy and phosphorus for postpartum heifers had a greater effect on liveweight gain of heifers and their calves, and subsequent weaning weights than postpartum anoestrus (Dixon *et al*. 1996b). However, it is worth noting that all heifers, including those that did not receive supplement, displayed relatively high reproduction rates (72% weaning).

Improved nutritional management of a Droughtmaster herd in northern Australia increased weaning by 25% (55–80%), weaning weight by 40 kg (150–190 kg) and breeding herd efficiency from 23.4–37.5 kg calf weaned per 100 kg cow mated per year (Sullivan and O'Rourke 1997). Other studies have reported a 17% increase in pregnancy rates for wet–season protein supplementation (McCosker *et al*. 1991).

The importance of weaning for reproduction

Weaning is considered by many pastoralists in northern Australia to be the best means of managing undernutrition in breeding stock (Arthur and Mayer 1974). This concept is supported by the work of Hunter and D'Occhio (1995), who found that cows that had calves that were weaned at birth had a 16–day postpartum anoestrus interval, compared with a 6–month interval for cows subjected to restricted udder capacity through the occlusion of two teats. Partial re–direction of nutrients to maternal tissue growth rather than milk secretion did not result in a more rapid return to cyclic ovarian activity, whereas weaning did. The mere presence of a calf will delay the onset of postpartum ovulation (Stevenson *et al*. 1997; Lamb *et al*. 1999).

A reduction in cow mortality from 14% to 5% and an improvement in conception rate of 25% due to once–yearly weaning was reported by Sullivan *et al*. (1992). Weaning calves early in the dry season (May/June) increases cow weight (Holroyd *et al*. 1988a), body condition and fertility (Arthur and Mayer 1974) relative to weaning from September to November. Dixon (1998) reported that weaning before April improved breeder liveweight by 10–15 kg, which is twice that of urea–based supplementation. Early weaning at 50 kg liveweight will reduce post–partum anoestrus in *Bos indicus* cattle (Schlink *et al*. 1988). Adoption of early weaning by north Australian beef breeders has been slow, possibly because of the potential for a reduction in calf growth and increased feeding costs. Optimising calf performance without sacrificing breeder reproductive performance appears to be difficult. For example, Holroyd *et al*. (1988a) reported that although time of weaning had no effect on pregnancy rate, late weaned calves (July) grew significantly faster (+ 0.52 kg/d) than early weaned (April) calves. Other work has found that calf performance (kg/d) may or may not be retarded in early–weaned calves (Schlink *et al*. 1988).

The influence of breed on reproduction

Breed influences age at puberty and postpartum anoestrus (Table 1). This is of particular relevance for heifer management in northern Australia because of the need for breeds that are tropically adapted. Unfortunately, tropical adaptation and production traits such as growth can be negatively correlated (Frisch and Vercoe 1984). Consequently, many beef producers have implemented cross–breeding or composite breeding programs. To balance production potential and

Table 1 Least square means (± s.e.) for postpartum interval of heifers (days) (Freetly and Cundiff 1998).

Breed	Postpartum interval
Hereford	68 ± 4^{abc}
Angus	59 ± 5^{b}
Belgian Blue	68 ± 2^{bd}
Brahman	71 ± 3^{cde}
Boran	78 ± 2^{e}
Tuli	76 ± 2^{ae}

^{abcde}Means without a common superscript differ (P<0.05) environmental adaptation, levels of *Bos indicus* infusion of 75% and above for tick–infested regions and 37–50% for tick–free regions are recommended (Holroyd and Fordyce 2001).

Heifer reproduction in northern Australia

Most beef herds in northern Australia manage breeders of all age groups (heifers, second–calf heifers and cows) collectively. Differences in reproductive performance between age groups have been recorded (MacDonald 1994). In particular, pregnancy rates of second–calf heifers as low as 25% have been recorded for some herds in northern Australia (Hasker 2001). As a result of this, Entwistle (1984) and Fordyce and Entwistle (1992) recommended that different age groups should be segregated.

Various heifer management strategies are practiced in northern Australia. Heifers are normally mated at two years of age, but yearling mating (12–18 months of age) is occasionally practiced (Bortolussi *et al*. 1999). Heifers are initially exposed to bulls in December/January or March/April. Replacement heifers may be managed as contemporaries separate from the mature breeding herd or introduced to the mature breeder herd at initial joining. On some properties, heifers are managed as a separate herd until they are pregnant with their second calf.

Due to a lack of bull control in most areas of northern Australia, yearling mating may be practiced unintentionally. Consequently, some researchers have suggested that heifers should be mated as yearlings to reduce the risk of out–of–season calves and that of heifer mortality (Braithwaite and de Witte 1999). Yearling mating of heifers is common in southern regions of Australia where higher pre– and post–weaning growth is achieved. Higher planes of nutrition (and associated growth) reduce the age and weight of heifers at puberty (McDonald *et al*. 1995).

Reproductive performance of heifers in northern Australia is variable (Table 2). A review of yearling heifer mating practices by Holroyd and Fordyce (2001) indicated that yearling heifer pregnancy rates in northern Australia range from 25–63%. From this, they estimated that yearling heifer mating would increase a breeder's lifetime output by 02.–0.4 calves. Although great variation in performance exists, two consistent problems are low pregnancy rates when yearling mating is practiced (<80%) and low reconception rates for heifers mated as yearlings or two–year–olds (<50%) (Hasker 2001).

Current industry benchmarks suggest that improvements in breeder lifetime productivity of up to 0.4 calves can be expected through yearling mating of heifers (Holroyd and Fordyce 2001). However, improvement in lifetime calf output in excess of the industry average can be achieved (Savage 2004). For breeding operations wishing to achieve high pregnancy and re–breeding performance from heifers mated to calve at two years of age, age at puberty will be a major determinant of success (Ciccioli *et al*. 2003). For over 20 years, researchers have acknowledged that there is a need to develop a greater understanding of the mechanisms by which nutrition influences puberty and rebreeding success (Entwistle 1980; Schillo *et al*. 1992; Ciccioli *et al*. 2003). Currently, body condition seems the best indicator for managing reproductive efficiency.

When suitable nutrition is provided, yearling mating of heifers can be practiced and pregnancy rates exceeding 90% can be achieved under north Australian semi–arid grazing conditions with as little as 37.5% *Bos indicus* infusion (Savage *et al*. 2004). Maintaining breeders at a body condition score of five or above at both weaning periods was a significant factor in achieving this performance (Figure 1).Yearling mating of heifers has been regarded as a strategy for managing a lack of bull control. Yearling mating can also mediate significant improvements in reproductive efficiency (Patterson *et al*. 1992; Holroyd and Fordyce 2001). There is now evidence that through management of breeder body condition and pre–joining growth, heifers in northern Australia can achieve high (>80%) breeding and rebreeding performance.

Management of replacement heifers has the greatest potential to improve reproductive efficiency in northern Australia. Calving at two years of age is necessary to attain maximum lifetime productivity. For

Table 2 Pregnancy rates (%) of heifers in various regions of northern Australia.

Location	Pregnancy rate	Age at joining	Breed	Source
Barkly Tableland, NT	90	12–15 months	Composite	(Savage *et al*. 2004)
Barkly Tableland, NT	61	12–18 months	Santa	(Stefani 1994)
Richmond, Qld	65	12–18 months	Santa	(Hill 1996)
Hughenden, Qld	91	12–18 months	Droughtmaster	(Holroyd 1988)
Gayndah, Qld	58	12–18 months	Brahman cross	(Gulbransen 1994)
Ayr, Qld	76	2 years	Brahman cross	(Holroyd 1990)
Cloncurry, Qld	85	2 years	Brahman	(Sullivan 1996)
Blackall, Qld	99	2 years	Hereford	(Edmonston 1998)
Mingela, Qld	31–46	12–18 months	Brahman cross	(Taylor *et al*. 1982)

commercial beef breeding, management of heifers to breed as yearlings involves careful economic planning. Research focused on defining practices required to achieve puberty at an optimal age for various levels of *Bos indicus* infusion will enhance the efficiency of north Australian beef production.

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