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Beef cattle production in northern Australia

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1.1 Introduction

The beef herd of Australia is estimated to be approximately 26 million head (ABS, 2012) and with a current population of around 22 million people the export of cattle products play an important role in the country's economy. Australia is one of the world's largest exporters of red meat, exporting to more than 100 countries, which represents over 60% of the industry's production (MLA, 2012). The cattle production areas in Australia extend over much of the country. These production areas are generally located inland. The majority of the beef herd is located in northern Australia with 65% of total herd located above about the 30^0 latitude. The grazed area in this region is over 145 million hectares and there are very few feedlots; only 36% of pastures are intensified and the remaining pastures are native grasslands. The climate in this region is predominantly tropical, arid and the rainfall occurs mainly over summer. The pastures have low crude protein (CP) and low digestibility for long periods of the year, often limiting in quantity as well. In this context, animals have low annual liveweight gain and lose body condition in the dry season. During the wet season high liveweight gains can be reached, but only for a short period, which results in a great proportion of animals in northern Australia only reaching appropriate market weight at an older age compared to southern regions of Australia. This also affects meat quality. Reproduction can be an issue without appropriate management and the first calf heifer is particularly vulnerable. The challenges faced by northern Australia's beef cattle producers are to a certain extent very similar to the ones faced by Brazil's beef cattle industry. We intend in this review to talk about the management strategies used in Australia to manage cows and growing livestock within a dry and variable environment.

1.2 The cattle in northern Australia

From European settlement, in 1788, cattle were brought into Australia primarily to provide meat and milk for locals, but it soon expanded into a major industry for the national economy. The first successful exportation of Australian beef occurred in 1879-80, but it was only 70 years later that significant developments in the industry were made, in particular influenced by the trade of meat for hamburger into USA in the 1950s (Henzell, 2007). Nowadays, this scenario has changed drastically. Australia became one of the world's largest exporters of red meat, exporting more than 60% of the total production to more than 100 countries (MLA, 2012) with a range of market specifications. Australian beef cattle are noted internationally for their high eating quality and high health standards. Australia is also closely located to some of the world’s fastest growing economies and most populous nations (Bortolussi *et al*., 2005b). Cattle in Australia are targeted for a range of market specifications, from simple weight requirements and higher percentage of *Bos indicus* cattle for live export to Indonesia, Malaysia and the Philippines (Ffoulkes, 2012) up to high standards of meat quality with more specific requirements, such as a very high marbling score for the Japanese market.

A number of cattle breeds have been introduced to Australia, *Bos taurus* breeds from the United Kingdom and also Zebu cattle from India. At present around 64 breeds from all parts of the world have been introduced to the country, eg Brahman cattle brought from the USA in 1933 (Tonts *et al*., 2012). The selection of breed types with adaptation to tropical environments has enabled the northern beef herd to expand to its dominant position. At present, as shown in Figure 1, Queensland retains almost 50% of the beef cattle herd in Australia (ABS, 2012). It was here that the Droughtmaster was developed in 1930 from a blend of Shorthorn and Zebu brought from India and Brahman bloodlines (Tonts *et al*., 2012).

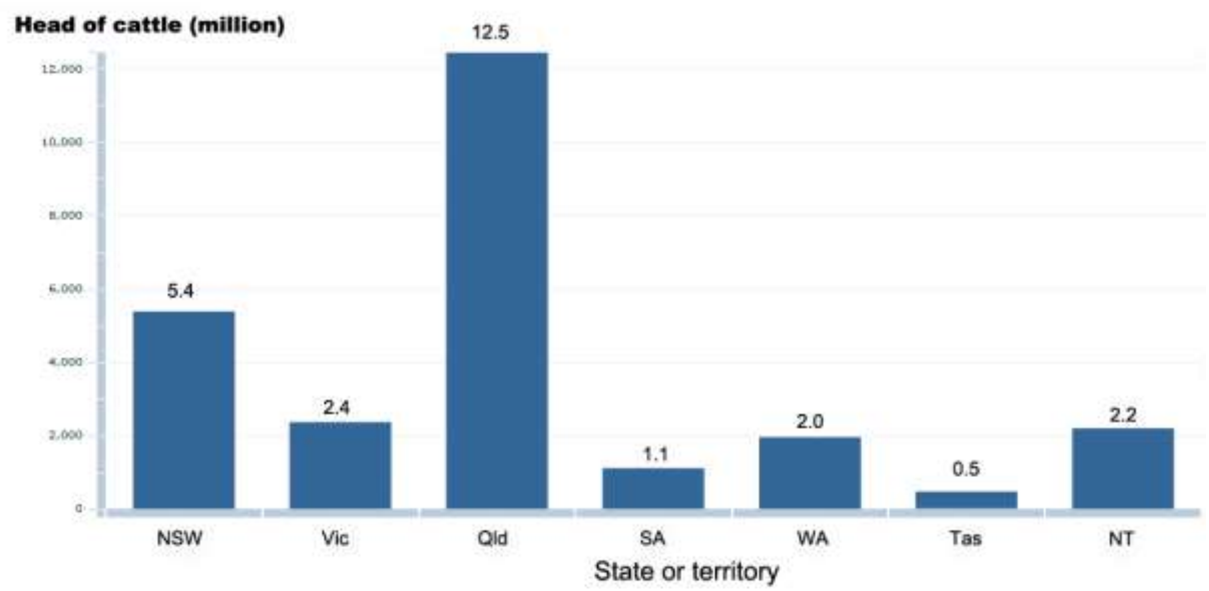

Figure 1. Estimated number of head of beef cattle in Australia (Adapted from ABS, 2012)

Bos indicus cattle were the most adapted to the northern regions of Australia (Tonts *et al*., 2012) and are preferred by the live export industry (Ffoulkes, 2012). They continue to be the major breed type in the northern Australia cattle industry. Brazil has a herd of more than 200 million head (MAPA, 2012) and the great majority are located in the tropical areas of the country; it is estimated that more than 80% of these cattle are *Bos indicus* breed types (ABIEC, 2012). In Brazil and Australia *Bos indicus* genotypes are chosen because of their adaptation to the tropical environment with its heat and parasites.

1.3 Pastures of northern Australia

Eighty percent of Australia is covered by rangelands and around 58% of that area is occupied by pastoral enterprises (Rangelands Australia, 2012). The cattle enterprises of northern Australia are generally of substantial size with some localised areas supporting a limited range of grain crops, one of the reasons why there is a lack of feedlots in this region. A great part of northern Australia is located in the tropics and sub-tropics (Figure 2), where the majority (i.e. 90%) of beef produced is derived from low CP tropical native pastures (Winter *et al*., 1991, MLA, 2012).

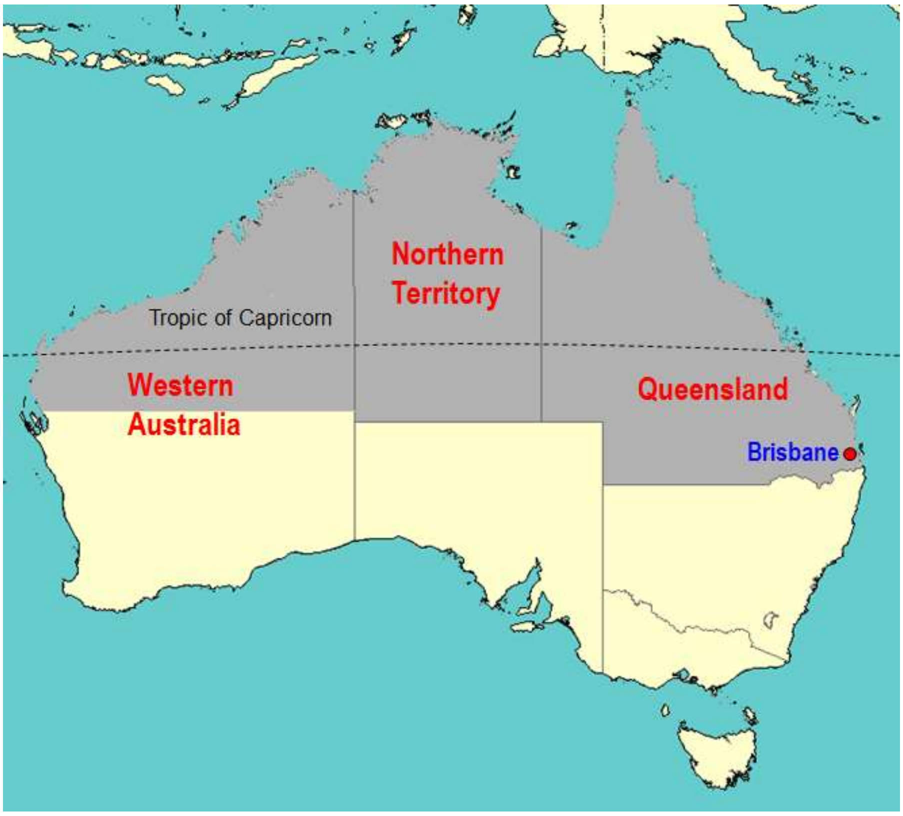

Figure 2. Map of northern Australia (McLennan, 2012)

The pastures in northern Australia are usually vast areas characterised by very low stocking rates, no easy access to water points and long distances to markets. Degradation of the grazing lands has occurred mainly through over-grazing but weeds are also an issue (MLA, 2012). In Brazil weeds are also one of the main problems for degradation of pastures (Lorenzi, 1991). Additional issues in Australia are the increase in grazing pressure by kangaroos and rabbits in some areas. Other pests, like the fox in southern Australia brought from Europe, can also be a problem (MLA, 2012), in particular for sheep farmers. The native wild dog, dingo, is a problem in some areas of northern Australia during calving. Foreign markets are the main market and beef cattle typically graze native pastures (MLA, 2012). These pastures are very low in digestibility and CP content for a great part of the year (Hennessy, 1980) and depending on grazing pressure may be limited in quantity as well. These pasture systems are recommended to be grazed with a utilisation rate of 20-25% and such systems can be sustained with good ground cover and the maintenance of perennial pasture species within the landscape (Landsberg *et al*., 1998; O'Reagain *et al*., 2011). They are also more profitable (O'Reagain *et al*., 2011). The use of models in these scenarios is a problem as there is no information on diet selection or on intake (Poppi and McLennan, 2010). The issues facing the beef industry were reviewed by Poppi and McLennan (2010) who emphasized the need to apply current information within a logical framework and that models were a good way in which to do that. Long held basic principles still hold and should not be discarded. New technology, such as electronic tags, can provide much more data so as to make better decisions based on existing principles. A good example of the application of existing knowledge combined with new technology is the use of faecal near-infrared reflectance spectroscopy (FNIRS) to derive knowledge of diet selection and use of such data in current nutritional models.

1.4 The production systems in northern Australia

The majority of the cattle production systems in northern Australia are based on a cow-calf system, with some controlled mating and others with the bull having free access to cows all year round. In the past these calves would take up to 4-5 years to reach marketable weight and the only markets available for this were the low price processed meat trade eg hamburger trade with USA (Farmer, 2011). Other options to sell these animals were to transport or drive cattle down to southern regions for fattening. There were disease restrictions on the movement of cattle but with the Brucellosis and TB eradication campaigns these restrictions have disappeared. Australia is free from Foot and Mouth Disease, Brucellosis, TB and also has a very reliable traceability system (MLA, 2012). These are still issues with African and Latin American nations, eg Brazil (Scoones *et al*., 2010). Ticks still pose a problem for the movement of cattle north to south and strict protocols need to be observed in cattle movement. More recently the industry has developed other supply chains to get cattle into better quality higher priced markets. In order to access these better markets (i.e. cattle finished at an early age 2-3.5 years), improvements in the production systems were required. Poppi and McLennan, (1995) listed a range of options that could assist producers reach these higher market targets, such as the use of supplements high in protein and energy sources and use of legumes. Bortolussi *et al*., (2005b,c) reported that marked improvements have been made to northern Australia cattle production systems. Other examples of approaches adopted by producers in northern Australia are:

- Weaners moved to better class grazing land (more rainfall, longer growing season, improved pastures) located in Central and Southern Queensland and in the crop livestock systems of NSW, Victoria, South Australia and Western Australia although

Queensland is the main destination for these cattle.

- Weaners moved to backgrounding pasture based systems and then into a feedlot usually in southern Queensland or northern NSW
- Weaners exported live from Australia to a variety of countries in Asia, Middle East and Turkey although Indonesia accounts for most of the live export of cattle

The development of live export has dramatically changed the cattle industry of the north providing an alternative market for local cattle with higher prices and providing competition to the multinational processing companies in the south eg Brazilian companies. The live export trade has restrictions on size of animal, but the animal does not need to be finished and hence it fits better into the current production systems eg cattle destined for Indonesia to be fattened in feedlots need to be less than 350kg (Ffoulkes, 2012). This means that after weaning, animals are held with minimal supplement for a dry season, gain weight over a wet season and then are in the market weight range to be sold at the start of the following dry season at 15-18 months of age. *Bos indicus* genotypes are preferred. Wet season liveweight gains or annual liveweight gains are low in these situations (Bortolussi *et al*., 2005a,b,c). Annual liveweight gains across the northern regions ranged from 87-180kg, but tended to be < 150kg (Bortolussi*et al*., 2005c) .In their survey, other variables were shown to have drastically changed over the years; for example the weaning % moved from 50-60% in the 1960s to around 60-70%. Today individual properties achieve around 80% weaning but others can still be as low as 50% largely as a consequence of not getting management right and not aligning periods of high nutrient demand (lactation) with high feed supply. Another very interesting fact of their work was that for all regions surveyed there was a single calving peak, demonstrating a seasonal pattern even for the more extensive regions with longer and sometimes uncontrolled mating seasons. Regardless of the control, the calving period lasted between 5 to 7 months, which demonstrates a strong climate influence where the most important determinant of conception date was the start of pasture growth.

Good reproductive performance and/or high gains will only be achieved through the combination of nutrition and genetics. However, the high costs of supplements, in particular protein sources, can make supplementation uneconomic. Therefore researchers and producers have invested a great deal in the search for alternative sources of supplements.

1.5 Supplementation in northern Australia

The pattern of change of diet quality has been known for a long time with digestibility, CP and mineral content showing marked seasonal variation. These changes in nutritive value are shown in Figure 3. Faecal NIRS has enabled these values to be more accurately determined and with some confidence. A decision on limiting nutrients and target weight gains can then be made.

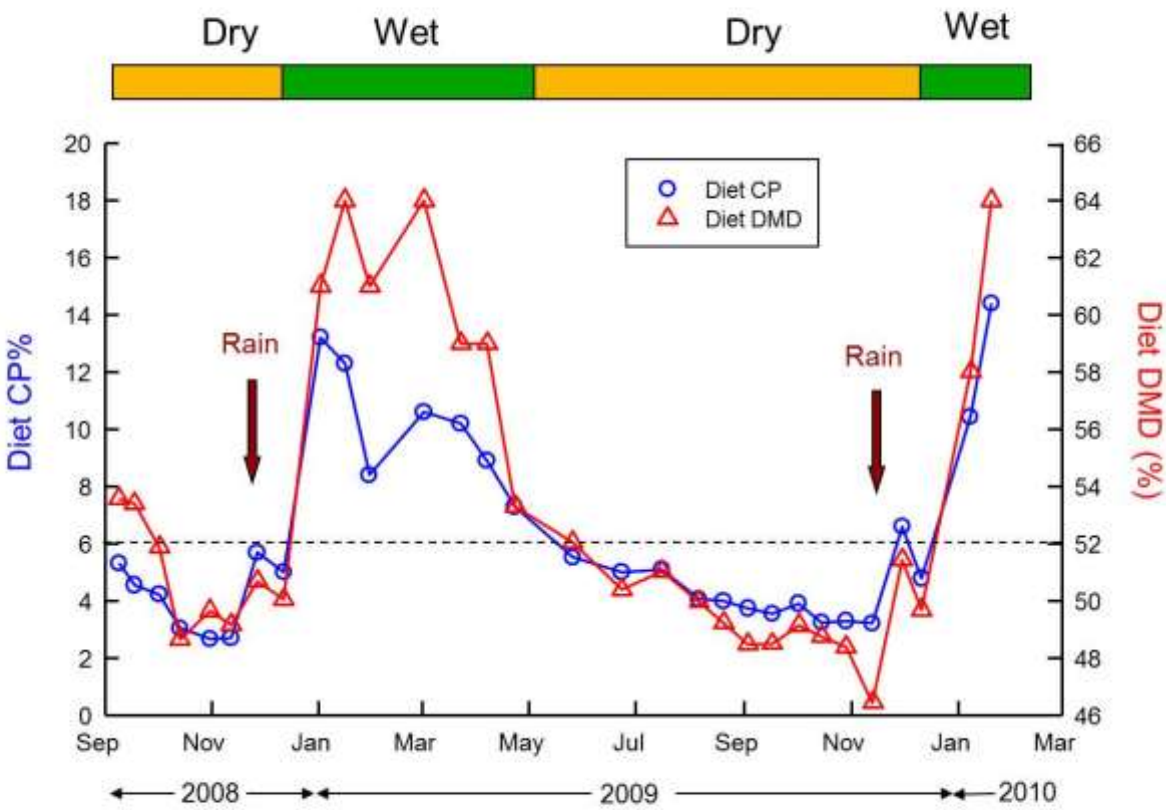

Figure 3. Changes in nutritive value of tropical pastures with season (McLennan, 2012)

There are a range of feeding standard systems which can assist this decision. McLennan and Poppi, (2012) used both CSIRO, from Australia, and CNCPS, from USA, finding little discrepancies between the two systems and reasonably accurate predictions of growth rate across a wide range of supplements. However, the authors emphasized that the estimates of the various components of energy use were substantially different between the two systems and care is needed in their application. The grazed diet is continually changing due to influences of climate and forage ecology (McLennan and Poppi, 2012). Therefore, it is important to constantly monitor the diet. The decision to supplement has to be specific to each scenario (i.e. category and weight of animals, type and amount of vegetation available, season of the year, use of fertilizer, market, etc). Currently in northern Australia, animals are fed supplements mainly during the dry season, with very limited options because of distance from grain production areas and costs of transport. Bortolussi*et al*. (2005c) found that steers were the least supplemented category and weaners were the most common. Supplementation tended to be longest in more northern regions. The authors also mentioned that in their survey, N was the main component in more than 90% of the supplements utilised. Urea is probably still the main source of N offered during the dry season, with Phosphorus fed in the wet season. Unavailability (and cost) of other protein and energy sources is an issue. The supplementation strategies focus on supplying limiting nutrients for the rumen first and then consider the animal as a whole. Meeting the rumen bacterial requirements meets most of the needs of an animal eg the protein requirements of an animal >250kg live weight can be met entirely from rumen microbes providing there is adequate N for the microbes. The level of liveweight gain will be dependent on ME intake for this class of animal and, on dry season pasture, digestibility is such that only low levels of liveweight gain around 200g/d can be achieved by this strategy of supplying urea to meet N requirement. Some parts of the basal diet need to be replaced with feed of higher ME content (either grains or protein meals) if higher live weight gains are targeted (Poppi and McLennan, 1995). The establishment and analysis of response curves of live weight gain to protein meals or grain provide the information required. McLennan (1997) developed response curves which show that there are different responses to grain and protein meal and that the response is greater in the dry and transition wet/dry periods than during the wet season (Figure 4).

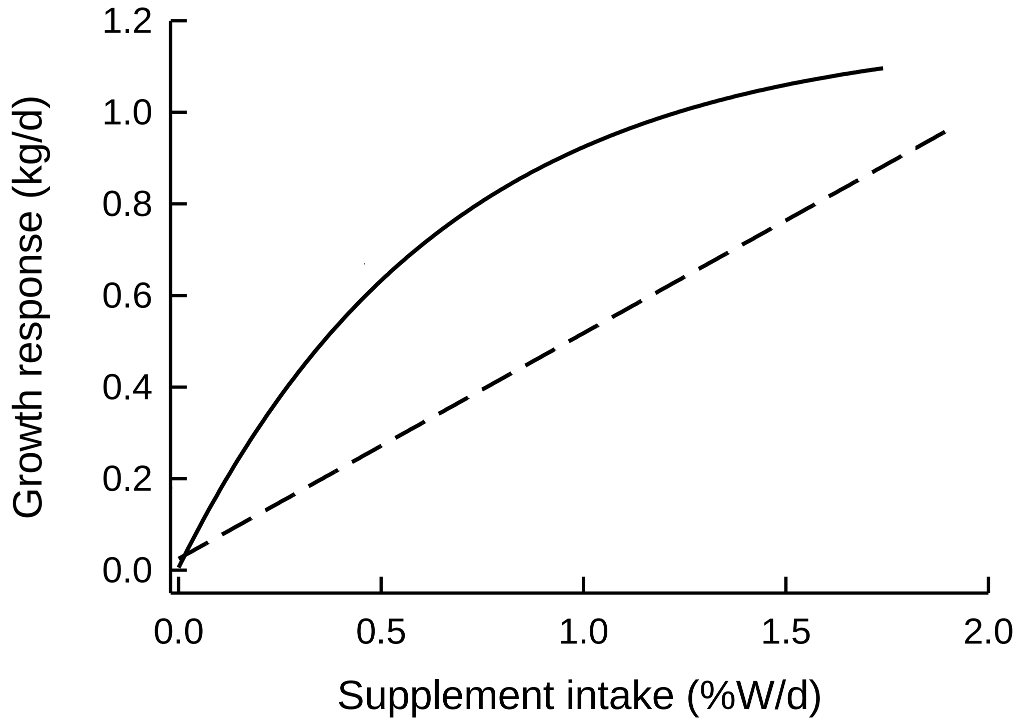

Figure 4. Relationships between the growth response (gain in excess of unsupplemented control) and supplement intake for protein meals (solid line) and "energy sources" (dashed) based on the results of several experiments (McLennan, 1997)

Poppi and McLennan, (2007) emphasized how the response curve approach can be a very powerful tool. Very simple spreadsheeds can be designed and recommendations can be made based on cost and a particular level of response to a specific supplement.

Irrespective of this, the cost of supplements especially protein meals is high and usually uneconomic to use. Also over the time taken for an animal to reach market weight usually two wet and dry seasons are experienced and so further questions relate to when should a supplement be used eg in the dry season after weaning or in the following dry season as animals approach slaughter weight. McLennan and Poppi (2011) examined this and developed growth curves with different levels of supplement in either the first or second dry season. The major finding was that compensatory growth can erode any liveweight advantage established by year 1 dry season supplements and hence it is better to target year 2 dry season for supplements as, depending on season and compensatory growth, animals might need little or a lot of supplement to reach a weight for age target. Similarly if early weaning is used then an animal of 100kg weaning weight will need a lot more supplement to reach a target live export weight or a slaughter weight as it is always 80-

100kg behind its cohort. There is a need to find and develop cheaper supplement sources especially proteins. Basically any protein that is developed is priced commercially to similar protein meals already in the market. Producers will never be able to supplement at these price levels. Hence there is a need to develop on-farm productions systems of protein and algae offer promise in this regard. Other options that have been successfully used in Australia are to use tree legumes such as leucaena but this requires higher soil P than is present over the more extensive rangelands.

1.6 The use of algae as supplement for cattle

Algae have been used in biotechnology of fuel production (Rojo, 2008) and for carbon fixation to ameliorate C emission from various factories (Minowa *et al*., 1995; Freund, 1998). In aquaculture or pond production systems algae is used as a source of food (Palmegiano *et al*., 2008) or as biofilters to maintain water quality (Chuntapa *et al*., 2003; Msuya and Neori, 2008). There are many species of algae and the chemical composition can vary from strain to strain and from batch to batch (Becker, 2004). However, different species vary markedly especially in protein and fat content and in the composition of their fatty acids (FA). These all have variable effects within the rumen and provide a range of nutrients which may have an additive effect over a simple NPN supplement. The primary interest for cattle in this situation is the protein within algae, but the FA composition of algae and its supply might also affect the response of the animal. A source of algal by-product is becoming available from many different industries and will be soon available for use as a feed for animals. Algae are also grown commercially in aquaculture ponds, and similar systems could be devised to grow algae locally on the rangelands.

Potential algae species have been screened based initially on chemical composition (Costa *et al*., 2010) and then for effects on rumen function, weight gain and feed intake (Panjaitan *et al*., 2010; Costa *et al*., 2011; Costa *et al*., 2012). The mode of action of algae appeared similar to that of any protein meal. The cost of algae will determine how competitive it will be as a supplement and if produced locally it has the potential to change production systems in northern Australia.

1.7 Managing the nutrient requirements of the cow

Little attention has been paid to genetic selection for reproduction within the predominantly *Bos indicus* genotypes in the north (Schatz *et al*., 2010). The reproductive performance (i.e. days to puberty and post-partum ovulation) influenced by nutrition has been reviewed (Scaramuzzi *et al*., 2011). The same principles would apply to any animal (in the tropics or temperate areas) and it was demonstrated that weight and body condition had direct effects on fertility in *Bos indicus* heifers in northern Australia (Schatz *et al*., 2011). That is even more important for heifers with the first calf because of the high nutritional demands for lactation and growth at the same time.

In managing cow-calf systems, livestock producers cannot afford high supplement inputs and rely on managing the nutrient requirement of the cow to align with nutrient demand by timing when cows calve. Even with unrestricted bull access this can be achieved by early weaning down to 70kg even though most animals will be weaned at around 150-180kg. Most of the cows thus align naturally with a wet season calving pattern. In other cases bulls are put out for defined periods so that a mating pattern is achieved. Cows would only get a urea based supplement (loose licks, blocks or water medication) in the dry season and a P supplement in the wet season in P deficient regions (Bortolussi *et al*., 2005a,b,c). The only animals to get a significant supplement are likely to be weaners. Meat and Livestock Australia published a weaner booklet which details how weaners are to be managed and what types of supplement can be used (Tyler *et al*., 2012). Weaners in the 70-100kg range require a high energy supplement and most likely a calf pellet formulation. From 100-150kg a protein or grain supplement, from >150kg maybe a low level of protein supplement but at least a urea based supplement. The type and level of supplement depends on the target liveweight gain.

Early weaning is a management strategy and has been adopted in northern Australia (McLennan, 2012). Higher conception rates were observed in breeders that had calves weaned at younger ages with better results than supplementation of breeders (Fordyce *et al*., 1997). Calves can be weaned on the first round at approximately 160-180kg, which means that they would most likely have to be supplemented at least with a urea based supplement. In spite of that, this approach can preserve the cow from losing more body condition in such harsh times of the year. A second weaning can be done with calves weighing down to 80-100kg. That is an extreme approach, but necessary. The last option a livestock producer would aim for is the supplementation of breeders. However, in this situation, it is important to feed aiming for maintenance, making sure that the feeding costs are low and hence urea is the most likely supplement.

Since the use of urea is wide spread in northern Australia, ways of administering this source have been studied. Urea is mostly supplied in the form of loose lick or blocks but water medication is another way. It has the advantage that all animals will get an appropriate level but the disadvantage is that equipment malfunction can result in death of animals.

1.8 Faecal near-infrared reflectance spectroscopy (FNIRS)

A relatively new tool used by producers in southern parts of USA and in Australia is the use of FNIRS. McLennan and Poppi (2012) suggested that one of the main challenges for livestock producers and researchers is to describe adequately the diet consumed by grazing animals. The difficulties of sampling the forage is the main challenge for accurately measuring intake and the nutritive value of the diet selected. Plucking the forage by hand has been a common way of trying to simulate selection by the animal which is very subjective. The use of oesophageal fistulated animals is a standard scientific approach, but caution is required. Coates *et al*. (1987) suggested that there were differences between these animals and the main group of grazing animals. An approach that has also been adopted is to collect the whole plant or in some cases the grazed horizon, according to pasture management adopted (Costa, 2007). However, with this approach the researcher or producer has to be aware that there may be big differences between what is collected and what is harvested by the animal. In northern Australia the adoption of any of the above methods would be very hard due to size and heterogeneity of the grazed areas. FNIRS has become the preferred technique to predict these variables (McLennan and Poppi, 2011). Basically, a faecal sample is analysed by NIRS and dry matter digestibility (DMD), CP and proportion of C3 to C4 plants are measured (Coates, 2004). This bulked faecal sample could easily be taken from water points, feed bunks or shade areas where animals usually gather. The method has particular application to scenarios like northern Australia, where it is very hard to sample the forage. Further equations have been developed to measure the DMD and CP content of diets containing supplements (Gibbs, 2007). The advantage of the method is that it is quick and inexpensive (Coates, 2004). Faecal NIRS has been used commercially in Australia to measure diet quality and make recommendations on which supplements to use and the method could be adopted in Brazil without major difficulties.

1.9 Fatty acid isomers and lipid synthesis

The diet of ruminantsis normally low in lipids because of the small amount present in most plant food sources (Jenkins, 1993). A commonly accepted recommendation is that the lipid content in the diet of cattle should not exceed 6 to 7% of total DMI (NRC, 2001). The diet of lactating dairy cows typically contains 4 to 5% lipids (Bauman *et al*., 2008); however, for grazing animals in northern Australia these levels of lipids in the forage would rarely be reached (O'Kelly and Reich, 1976). Chilliard *et al*. (2001) suggested that most of the influence in FA profile of animal product resulted from supplementation with sources of lipids and therefore, the forage FA content seems to be disregarded. Costa *et al*. (unpublished) studied the FA profile of the rumen fluid of steers grazing a temperate grass (i.e. ryegrass) and a range of tropical forages and little difference was found between forage types grazed during the same season. Tropical forages could be different to temperate forages because the retention time could influence the extent of hydrogenation in the rumen due to a longer exposure to microbes in the rumen. However, despite the differences in CP content and DMD (estimated by faecal NIRS) between the temperate grass and the tropical forages, there was little difference in RT and the biohydrogenation process appeared to be extensive for all pasture types, resulting in similar FA profiles in the rumen of steers grazing those forages. There were much greater differences in rumen FA profile of steers grazing forages in different seasons of the year than between types of pastures.

Most supplements used in northern Australia usually contain N as the main ingredient and have low lipid content. In certain areas whole cottonseed is used as a supplement and its high lipid content is an advantage when trying to increase energy intake. In Costa *et al*. (unpublished), the inclusion of low quantities of lipids (i.e. 3% of total DMI) in the diets of ruminants grazing low quality pastures had little, if any, effect on rumen function. The large differences in the FA profile of the oils did not translate into major differences in the FA profile in the rumen of steers that were supplied with the oils when fed a low quality tropical forage. It is known that some CLA isomers can inhibit fat synthesis, especially the isomer CLA *t*10 *c*12, in the mammary gland and subcutaneous and intramuscular tissues

(Bauman *et al*., 2011). It was hypothesized that this isomer could arise from supplements and/or forages used in northern Australia. However, the levels of this isomer were too low to expect inhibition, even when steers were supplemented with oils (Costa *et al*., unpublished).

The conclusion was that it would be highly unlikely that the small quantities of lipids, which would be present in protein supplements fed to cattle grazing low quality tropical pastures in the dry season in northern Australia, or just the lipids within the grazed forages, wouldn't have any effects on fat metabolism, other than the associated increase in N or energy supply from the supplement. Even though some plant products, such as whole cottonseed, are high in lipid, and the quantity of lipid would increase it is unlikely that the FA profile in the rumen fluid would give rise to isomers which might affect fat metabolism.

1.10 Conclusions

There are many similarities in the production systems of northern Australia and Brazil. The supplementation and other management strategies discussed could be adopted in Brazil by adapting to each scenario according to market requirements. With low quality tropical pastures, which are also found in Brazil, in particular during the winter period, supplementation with protein meals gave a greater response than with grains especially at low levels of supplement intake. The higher the quality of the pasture, the lower was the difference between protein meals and grains in terms of the response to the supplement. There was little difference between supplement types as intake of supplement increased above 1%W. The decision on type and level of supplement to be made will be made based on weight target for a specific market. The live exports in northern Australia were responsible for drastic changes in these weight requirements and fit well with the northern Australian production systems. The management of the cow's nutrient requirements is a very important tool and it can be done either by early weaning or simply aligning the requirements with nutrient demand by timing when cows calve. The use of FNIRS has been adopted by producers in Australia as a tool to predict diet quality and assist in the decision on which type and when to supplement. This approach could be used in Brazil as well. New sources of protein supplements have been studied in Australia and the researchers in Brazil should also search for new and alternative sources of supplement due to current prohibitive supplement prices found in particular for protein meals.

Nutrition is a mature science and the challenge is to apply the basic principles within existing and new scenarios of animal production. When Brazilians look at the Australian production systems they should not only look for new technology, but instead they should look at similarities and the application of basic principles in devising management strategies. Australia has recognised that nutrients may be limiting and have used the management of nutrient demand to limit the effect of a nutrient limitation. In addition they have recognised that it is not essential to always achieve maximum liveweight gain and so the type and level of supplement may be lower than nutrient requirement tables recommend. Thus low input systems are the norm although high input may be required for short periods for certain classes of cattle eg early weaners of low live weight. The desire to reach higher quality markets means animals need to be marketed at a younger weight for age. Feedlots are one way to achieve that but the majority of cattle will be finished at pasture in the better endowed areas (longer growing season, improved pastures) or with higher more targeted supplement levels.

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