

The challenges in managing cattle herds for growth and reproductive efficiency on pastures in north-coastal New South Wales

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Abstract: *There are a number of challenges facing beef producers attempting to produce meat efficiently from beef cattle on the North Coast of New South Wales. Whilst there is a need to reduce green house gas (GHG) emissions by managing efficient cattle types there are the continuing 'challenges' imposed on their growth and reproduction by the low quality of pastures for much of the year in a subtropical environment. In this paper, pasture growth curves for native/naturalised grasses for improved native grass pastures and for kikuyu grass pastures are described for each month, as is their quality.*

The monthly metabolisable energy (ME) for cows grazing these pastures has been partitioned into that required for maintenance (ME_m), pregnancy (ME_p) and lactation (ME_l) for British breed cows typical of the current production systems. This partitioning, compared to the pasture curves, indicates that the demand for ME is highest during those months (Aug-Nov) when availability of energy and nutrients are least. Various strategies for addressing this imbalance are discussed.

Significant improvement in reproductive efficiency and growth of suckled calves, or post-weaned steers, can be obtained from protein meal supplementation during the critical months for stock grazing native grass pastures. On the more fertile soils, incorporating a winter forage into existing summer-growth pastures allowed for excellent growth of weaned cattle when irrigated and fertilised during the dry winter period. Since there is a move by consumers to a choice of lean meat from young animals, producers of beef meat on the NSW north coast should adopt some of the nutritional strategies outlined to improve the growth and reproductive efficiency of their herds in pastoral areas that should be favourably treated by climatic changes.

Introduction

The combination of predominance of summer-growing grasses using the C4 photosynthetic pathway for carbon metabolism and the effect of cool dry winters on such grasses on the north coast of NSW leads to a significant feed gap that reduces cattle growth and reproductive efficiency. Studies, commencing in the 1970s, looked at mineral supplementation, plus rumen-available nitrogen and readily fermentable feed components, as the causal factors restricting growth of cattle grazing matured forages during winter and before summer plant growth resumed.

Later, management and strategic supplementation of breeding herds of varying genetic background

were studied to understand the nature of the nutritional restrictions. The strategies are based on studies that were undertaken using the existing cattle types and predate the challenges imposed by climate change and carbon emissions by ruminant animals.

The beef cattle areas of north coastal New South Wales

The coastal area extends from the border (at lat 28° 10' S) with Queensland to the catchment of the Hastings River (~31° 20' S) in the south and west to the escarpment (up to 200 m above sea level)

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of the Great Dividing Range. The topography includes the relatively flat flood plains along the mature parts of the rivers (13% of the total area), through undulating slopes (20%) and to the timbered and rugged areas (47%), abutting the tablelands. These rugged areas include most of the National Parks, State Forests and areas of private land approved for timber harvesting.

The climate ranges from subtropical in the north to warm temperate in the south. Rainfall varies from 800 mm in the western valleys to 1200 mm in the coastal mouths and up to 1800 mm along the sub-coastal ranges. The distribution also changes from 67% from November to April in the north to 61% in the south. Rainfall is lowest from June to October, with variation highest in October; October being the most likely month for plant moisture stress. Temperatures, away from the moderating influence of the coast, fall below zero from June to September resulting in substantial impairment to growth of summer-growing species. Conversely, temperatures exceed 35°C on many days from November to April, impacting unfavourably on the growth of temperate grasses or those with the C₃ photosynthetic pathway.

Most soils in the northern coastal areas have developed from rocks of sedimentary origin, with smaller areas toward the escarpment developing from those that underwent metamorphic changes. Basaltic intrusions occur in the central and northern parts, particularly in the Richmond-Tweed districts. Those soils that develop from a parent material of sedimentary origin invariably have a low mineral content and little organic matter. These soils form duplex types with impervious clay layers close to the surface which impede drainage. Concomitant with low organic matter the soils have low available nitrogen. Minerals that are especially low in availability include phosphorus (P), potassium (K), sulfur (S), calcium (Ca) and many of the 'trace' elements such as zinc (Zn), selenium (Se) and copper (Cu). Conversely, alluvial soils along the flood plains and those derived from basaltic parent material have higher organic matter allowing for high plant growth when moisture is non-limiting.

Description of the pasture growth patterns and quality

The summer predominance of rainfall is illustrated with temperatures in Fig 1 from the Agricultural Research & Advisory Station at Grafton (lat 29° 37'S), a site located centrally to the area.

Pasture growth curves have been determined from three associations in the area. Carpet grass (*Axonopus affinus* Chase) is an introduced species from Central America that has become endemic to the wetter slopes and valleys of the area. Growth rates from unfertilised swards of carpet grass are presented in Fig 2 and are low except for the moister, summer months. Growth rates of carpet grass can be increased provided good soil moisture persists through warmer months by increasing P availability, as shown by high initial (500 kg/ha) and annual (250 kg/ha) applications of superphosphate (Mears *et al.* 1993b). Growth rates for an association between carpet grass and adapted ecotypes of white clover (*Trifolium repens*) have been determined on a sandstone soil in the Grafton district (also Fig 2). A simulated growth rate for kikuyu grass (*Pennisetum clandestinum* Hochst, ex Chiov), another introduced species but one confined to alluvial soils or fertile sections of other soil types), is presented (Fig 2) and is based on data from three sites: Wauchope (lat 31° 20'S), Grafton and Wollongbar (28° 50'). Since the area of each species is additive on the growth axis of Fig 2, therefore the species growth rates are the difference between the outline of each area.

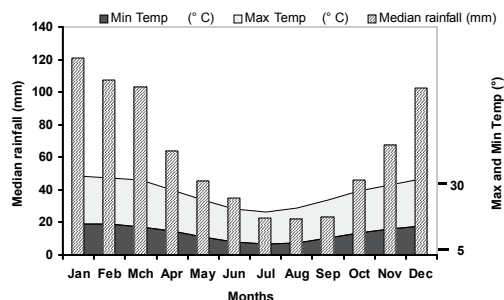
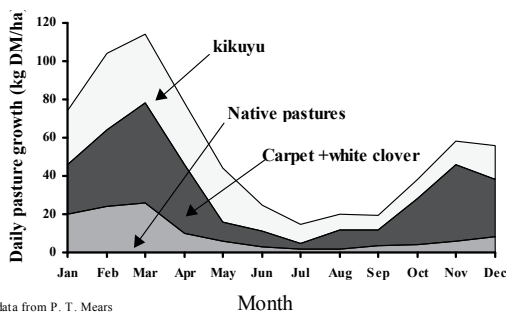


Fig 1. 83-year median rainfall and mean max and min temperatures at the Agricultural Research & Advisory Station, Grafton New South Wales.



data from P. T. Mears

Fig 2. Annual growth rate of pastures in the northern coastal area of New South Wales

Native grasses, including carpet grass, have low growth throughout much of the year, summing to an annual growth of 2500 kg dry matter (DM) per year. Favouring legume growth by providing superphosphate on sandstone soils increases the growth of carpet grass-dominant pastures during wet summers and favourable moist winters. However, low soil temperatures continue to restrict growth during winter in the presence of sufficient moisture.

Kikuyu grass is a competitive grass on the higher fertility soils such as the river alluviums and those of volcanic origin. When N-fertilised, kikuyu plants show strong growth during warmer moister months (see Fig 2) and in frost-free locations maintain a 'winter-green' appearance as a consequence of continuing growth, especially during mild winters. Even in this context, kikuyu grass, in concert with other summer-growing grasses, has only a small growth rate during winter, resulting in pastures having low forage availability for cattle from July to September.

Organic matter digestibility (OMD %) and crude protein content (CP%) are the two criteria of plants that are useful for predicting the growth of ruminant animals grazing pastures. This is because of the relationship between (a) digestibility, and the rate and potential

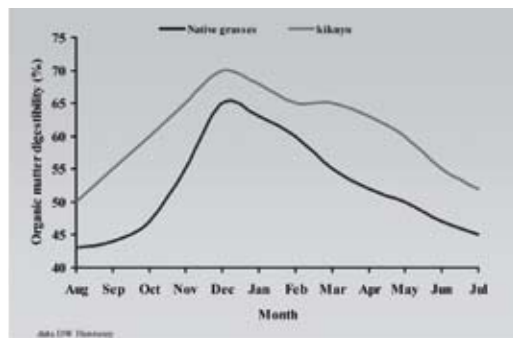


Fig 3. Organic matter digestibility typical of kikuyugrass pastures on alluvial soils of the North Coast and of native grass pastures on sandstone soils.

degradability of the carbohydrate component of plant-parts in the rumen, and (b) crude protein, which indicates a potential level of useable N for growth and maintenance of rumen microflora and fauna. These organisms break down the structural carbohydrates in the rumen, releasing 'energy' (*viz.* volatile fatty acids and ATP bonds) for the host ruminant. In temperate species there is a close 'link' between OMD and CP but this relationship is less close in summer-growing species and in subtropical NSW may be decoupled further with the onset of cold nights, and frosting. The annual pattern of OMD content of selected plant material in two pasture associations is presented in Fig 3, and their crude protein contents in Fig 4.

OMD also has a direct relationship to the *energy density* of a feedstuff that describes the fraction of *gross energy* that can be used metabolically by cattle after ingestion of forage. *Energy density* is therefore expressed as metabolisable energy (ME) (MJ/kg DM) and can be estimated from OMD as follows:

$$M/D = 0.151 \cdot (\text{OMD}\% - 1.8) \quad (\text{Standing Committee on Agriculture 1990})^2$$

The native pasture curve is characterised by low crude protein contents from May until November each year and whilst this represents a number of species (*Axonopus*, *Bothrichloa*, *Cymbopogon*, *Andropogon*, *Digitaria* and *Imperata* spp) there is little variation in the May to October 'trough' for individual species.

² This equation reliably predicts the energy density of forage from organic matter digestibility for those forage materials with ash contents between 2– 12%. The M/D should be increased by 1.08 where the OMD is determined in vivo.

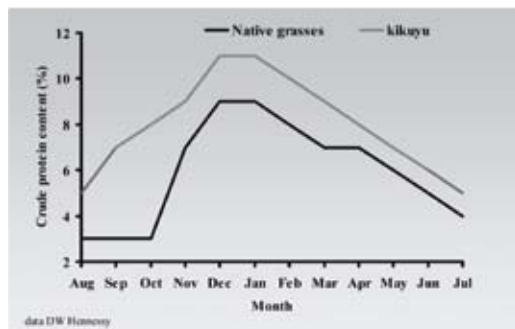


Fig 4. Crude protein contents of kikuyugrass and native pastures according to month of sampling in Fig 3.

Annual pattern of requirements for energy and nutrients by cattle in north coastal NSW

Breeding herds are the major enterprise on native and naturalised pastures that predominate on the sandstone and lower fertility soils of north coastal NSW. The total ME required by a breeding cow for each month of the year is partitioned into ME_m (maintenance), ME_p (pregnancy), and ME_l (lactation) based on calving at the end of August (Fig 5). The standard cow used is a *Bos taurus* genotype (e.g. Hereford) whose mature weight changes from 350 kg at mating in November to 420 kg before calving. ME_l is calculated (GrazFeed 1998) on the expectation of the milk required by the calf to reach 180 kg at 210 days-of-age in April, and ME_m on a declining liveweight expected for cows grazing lower quality pastures.

Using the standard 420 kg pregnant *Bos taurus* cow calving in August, the TME (total ME required) increases by 8.8% to 87 MJ/day in the first month of lactation, compared to the last

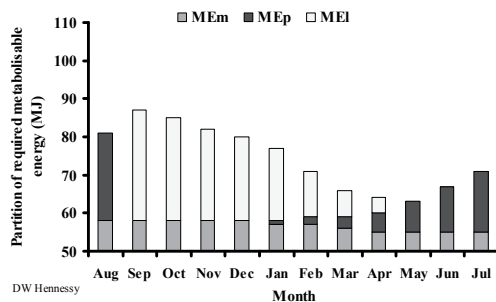


Fig 5. Monthly partition of total Metabolisable Energy required for production of an annual calf of 180 kg at weaning by a *Bos taurus* cow grazing native/naturalised grass pastures

month of pregnancy. Lactation then represents 53% of the TME at a period of the year in subtropical areas where the yield and pasture quality are low. The progressive reduction in TME during October to December reflects more the inability of a cow to ingest sufficient feedstuff, of declining quality, to maintain its potential milk yield, and body mass, than any innate decline in milk yield or feed intake. Milk production, as measured by a weigh-suckle-weigh technique (Williams *et al.* 1979), declined monthly on these pastures, and by April was as low as 1.8 kg/day (Hennessy *et al.* 2001). By May, 16% of the TME is estimated to be partitioned into the foetus and the products of the conceptus and any continuation of lactation by delaying weaning beyond 7 months might reduce the amount or proportion to foetal growth, deleteriously affecting growth and development. This can result in low birth weight calves with affected postnatal growth. By November, when re-mating is due, cow liveweight drops to 350 kg. Frosting often occurs in late May, the effects of which are reflected in a further decline in OMD of native pastures (Fig 3) with the reduced pasture quality at this time limiting the ability of cattle to ingest more forage owing to slow degradation of plant material in the rumen.

The higher quality and yield of kikuyu grass pastures support a British Breed cow of 500 kg, up to calving, compared with the 420 kg cow on native or unimproved grass pastures (Fig. 6). This cow partitions 34% of TME into the foetus and products of conceptus in the final weeks of gestation and additionally, during the first month

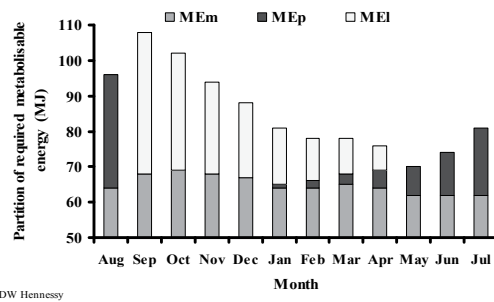


Fig 6. Monthly partition of total Metabolisable Energy required for production of an annual calf of 210 kg at weaning by a *Bos taurus* cow on kikuyugrass pasture

of lactation, up to 37% of TME is accounted for by lactation demands. At re-mating (November) cow liveweight drops to 435 kg and ME_m for cow maintenance decreases slightly. In the final weeks of lactation (April), as little as 10% of TME is accounted for by lactation. Quality and yield of kikuyu grass declines from late May and accelerates from late June with increasing frost damage.

The usefulness of protein meal supplements to breeding cows whilst grazing native pastures on the North Coast

It has been established from the positive results of a number of studies in tropical and subtropical grasslands that supplements containing slowly rumen-degradable proteins enhance rumen function and intake of low protein pastures. In separate studies at Grafton, forage intake of steers was increased by 19% (Hennessy and Murison 1982), by 70% in lactating cows (Lee *et al.* 1985) and by 85% with steers (Lee *et al.* 1987) that were offered different supplements containing slowly rumen-degradable proteins. In one study the increase was as little as 10% when steers were offered daily a kilogram per day of cottonseed meal (Hennessy *et al.* 1989), but this small increase in intake has been attributed to a lower protein requirement of the mature-aged steers used in the study. The effect of protein meal supplements on intake has been used to

assist in partitioning TME in breeding cows on low quality pastures (Fig 5), and to a lesser effect for cows on higher quality pastures (Fig 6) during a 12 month grazing period. The monthly distribution and energy density of the low quality pasture, modelled in Fig 5, are listed in Table 1.

Yields in Table 1 were recorded during the drought of 2002-03 for a native/naturalised grass pasture stocked at one cow equivalent per 2 ha and are lower than would be the case for many extensively stocked properties in favourable rainfall seasons. Significantly, the green DM as a proportion of the total yield was low in August and September, which is the case for all years and that this 'green' DM had a low energy density (M/D), relative to temperate or C_3 grasses, in all months.

Supplementation in August and November provided directly 15 MJ to TME of each cow that was predicted to increase further due to a 17% increase in forage intake by cows. Despite these increases there is insufficient TME for a cow to maintain lactation at the early prenatal level so tissue mobilisation occurs in providing for 'top up' energy/nutrients for essential metabolic processes and for a progressively reducing level of lactation (Fig 6).

Tissue mobilisation continues between August and November as the cow remains in a negative daily energy balance, but from November to

Table 1. Yield and quality of a native grass-dominant pasture on a duplex soil derived from sandstone in the Clarence Valley of NSW.

Month	Yield (kg/ha)	Green DM (%)	M/D green	M/D dead
Aug	1400	15	8.5	3.9
Sep	1300	17	8.6	3.9
Oct	1400	33	8.8	3.6
Nov	1500	50	8.8	4.5
Dec	1700	75	8.5	4.8
Jan	2500	92	8.3	4.5
Feb	2700	93	7.9	4.2
Mar	2900	88	7.7	4.2
Apr	2500	67	7.9	4.2
May	2200	54	7.9	4.2
Jun	1800	38	7.9	4.2
Jul	1400	23	8.0	4.1

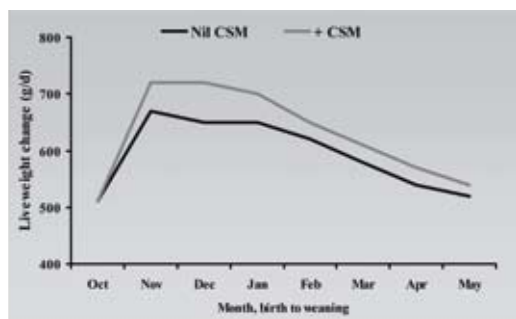


Fig 7. Liveweight change of calves suckled by cows non-supplemented or offered CSM when grazing native pastures

April the cow's TME exceeds requirements for maintenance and a declining lactation, at the end of which the calf is weaned.

Pasture yield declines in May, as does energy density, so that in May and June the cow again is in a negative daily energy balance. However, the rate of decline into a severe energy deficit is 'buffered' in July when cows are offered 0.5 kg cottonseed meal/day, increasing to 1.5 kg/day from August until November. In addition, protein meal supplements can reduce the rate of decline in milk yield of cows grazing low quality pastures. (Lee *et al.* 1985) found that cows offered *c* 1.5 kg/day of cottonseed meal, milk consumption by their calves declined from 7 kg/day at day 37 of lactation to 3.0 kg at day 85 of lactation compared with a decline to 1.2 kg/day by calves on unsupplemented cows. This is reflected in the liveweight change of calves from supplemented and non-supplemented mothers (Fig 7).

The advantage of supplementing cows on native pasture with protein meal can be seen (Fig 7) to maintain growth rates of their suckled calf above 700 g/day during the summer pasture growth and mostly above 600 g/day towards the end of lactation before weaning.

Changing the pasture base, or incorporating temperate species into summer pastures and establishing robust legumes

Grazing management and weather conditions both affect pasture species composition as well as affecting plant growth and subsequent pasture yield. The effect is often greater when, under lax grazing management, grazing pressure increases

inadvertently during drought or a period of poor plant growth.

When overgrazing occurs, the populations of desirable plants are reduced substantially, plant density decreases and undesirable species are able to germinate and establish in exposed patches. Observations on plant species during the drought period 1991–1994, a low quality pastures grazed by breeding cows study revealed a progressive decline of carpet grass (*Axonopus affinis*) from 80% of the DM (Oct 1991) to 30% (April 1994 (Hennessy *et al.* 1998)). Carpet grass is a summer growing plant that has a degree of frost tolerance but it favours moist aspects since its root distribution is either surface or shallow (96% of roots in top 5 cm). Hence, carpet grass succumbs to the effects of persistent grazing during dry periods, losing its vigour.

Also recorded during the study was an increase of Giant Parramatta grass (GPG) (*Sporobolus fertilis*) from 2 to 8% of total DM, and, an increase in blady grass (BG) (*Imperata cylindrica*) from 4 to 14%. Both of these species are aggressive invaders (by seeding, GPG, and by rhizomes, BG) and their spread is favoured by cattle avoiding grazing them unless at the expense of others. Grazing management should be directed to avoid frequent defoliation of desired species, and to increase pressure on unwanted species when they are vulnerable.

Legumes sown into stabilised pastures on the lower fertility soils of the north coast have only increased animal production when sufficient P has been applied. White clover in native pastures that were fertilised annually with 250 kg/ha of superphosphate allowed a 60% increase in stocking rate and increased mean annual daily gains from 0.21 to 0.38 kg/steer (Mears *et al.* 1993a). However, for these pastures soil P levels dropped markedly within 12 months (from 32 to 12 mg P/kg) in the absence of an annual dressing of superphosphate, and pasture yield and quality declined within 18 months of the last dressing.

Mears *et al.* (1993a) concluded that when stocking rates are less than 2 steers/ha on fertilised native pastures with white clover, sufficient clover seed is generated (*c* 4000 seeds/m² of soil) for clover to

survive dry seasons and restore pasture stability through plant re-establishment when favourable conditions return. When stocking rates are maintained above 2 steers/ha, the soil seed bank of white clover is reduced to < 2500 seeds/m², ensuring a decline in white clover presence. The contribution of other robust legumes *viz* Wynn cassia (*Cassia rotundifolia*) and *Arachis* spp still requires evaluation with animal production data on pastures growing on low to medium fertility soils on the North Coast.

Winter forages sown into summer grass pastures on higher fertility soils of the north coast may be necessary to promote animal growth during winter (especially July, August, September) when the enterprise aims at meat production. Where irrigation is not available, oats are preferred because of their tolerance to drier conditions. Oat varieties, sown from April to June, provide reliable 2–3 grazings till mid-September. Where irrigation is available, using a mixture of short term (Tetila) and long term (Flanker, Concord) Italian ryegrasses (*Lolium multiflorum*), can increase production markedly (Hennessy and Morris 2003).

High growth rates (i.e. ≥ 650 g/day) in weaners can be obtained by this combination of grasses, direct drilled into a ‘retarded’ summer-grass pasture in April and irrigated with the equivalent of 25 mm of rain each month with desirably nitrogen fertiliser (45 kg N/ha) applied monthly between June and October. Production from this pasture system does depend on careful grazing management to ensure stability during winter and avoiding metabolic diseases in cattle (e.g. nitrate toxicity or grass tetany).

The appropriate strategy for ryegrass pastures grazed by beef cattle is to allow a majority of plants to be at a 3-leaf stage before grazing. By then energy density of plants is maximal and Ca and Mg contents are elevated relative to K and nitrates (Fulkerson and Donaghy 2001), which should reduce the likelihood of metabolic disease in cattle. Grazing should be confined to small areas with a restriction on ‘back’ grazing (i.e. allowing refoliation of recently grazed plants). On the Far North Coast, grazing intervals required for 3-leaf recovery are *c.* 40 days in July

reducing to 15 days in September-October when plant growth rates are higher.

The future direction of the industry on the north coast

The future for beef consumed domestically is for smaller individual cuts and using small portions that add flavour to pasta and rice-based meals. This presages a decline in consumption from 34 kg/head annually (2005) to a level more in line with southern European intakes.

The increasing use of beef as a flavour-enhancer dictates meat from younger animals that is tender, has minimal fat, and is capable of retaining flavour from stir-fry cooking. Producers on the north coast will have to increasingly meet these changes to maximise their gross income from the sale of stock.

There has been a decline in the number of weaners presented for sale at the major centres of the north coast over 20 years. This decline has mirrored the decline in the terms-of-trade for store weaners and the shift to vealers that are desired by the markets. The decline in prices received adjusted to 1987 values are seen in the following figure (Fig 8).

There has been a decrease in the price paid for store weaners from 1987 in terms of the parity purchasing power of the Australian dollar in the domestic and international markets. Approximately 20-30% of NSW-produced beef has been sold internationally and the challenge for producers is to ensure that a high quality product, free of chemical or biological contaminants, is available for sale to our principal

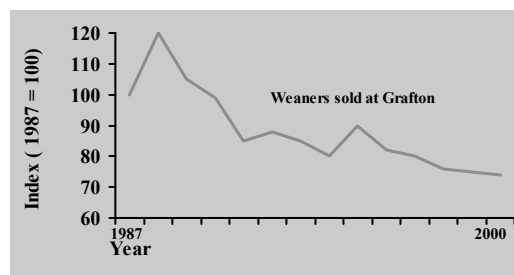


Fig 8. Prices received for weaners sold at Grafton Regional Selling Centre adjusted to 1987 parity, 1987 – 2001.

markets of Japan, Korea, the United States and the European markets.

It is clear that these primary markets have become sensitised to diseases with high morbidity or social consequences such as Foot and Mouth Disease and Bovine Spongiform Encephalopathy. Consequently, Australia has to maintain an individual identification scheme with a national perspective that will direct our international customers to the specific source of any complaint. Continuous care will be necessary to avoid accidental contamination of animals by pesticides or agricultural chemicals and to reduce our reliance on chemicals for internal and external control of parasites on cattle.

As we enter the 21st century, Australian livestock producers have to acknowledge the effect of their animals on green house gas emission (GHG). Of the 580 million tonnes of CO₂ emitted in Australia, 16% has been attributed to Agriculture. Producing 1 kg of beef releases 36 kg of CO₂ equivalents (Australian Financial Review 2007). This is mainly due to the eructation of methane which is estimated to be 60 times more potent than CO₂ on its effects on the environment, leading to suggestions that Australia should reduce its reliance on sheep and cattle for meat and harvest kangaroos instead (Garnaut 2008)!

Studies continue in Australia and New Zealand for vaccines or selective rumen defaunating agents to reduce methane eructation from cattle, and more efficient genotypes (i.e. lower C losses from fermentation) may be available from the CRC-sponsored 'Gene Star' program to counter these criticisms.

Cattle production is also attributed with a heavy reliance on water. Under US conditions, beef production is estimated at requiring 44 kL of water/kg beef but in Australia the estimate is from 27-540 L/kg (Meat and Livestock Australia 2008) with the latter estimate including abattoir washing and discounting much of the rainfall on the land. But as the global climate change increases the variability of rainfall and raises temperatures, especially in beef production areas of southern Australia, the north coast of NSW is likely to become the more reliable beef


production area where the effects on rainfall are expected to be less severe.

Acknowledgments

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References

- Australian Financial Review 2007, *Thirsty Beef*, page 14, 20 July 2007
- Fulkerson, WJ, Donaghy, D 2001, Plant-soluble carbohydrate reserves and senescence - key criteria for developing an effective grazing management system for ryegrass-based pastures: a review, *Australian Journal of Experimental Agriculture* **41**, 261-275.
- Garnaut, R 2008, The Garnaut Climate Change Review, ISBN-13 978052174447 Cambridge University Press Australia.
- GrazFeed 1998, A Nutritional Management System for grazing Animals, **ver 4.0**.
- Hennessy, DW, Kempton, TJ, Williamson, PJ 1989, Copra meal as a supplement to cattle offered a low quality native pasture hay, *Asian-Australasian Journal of Animal Science* **2**, 77-84.
- Hennessy, DW, McLennan, DJ, Williamson, PJ, Morris, SG 1998, Changes in characteristics of pasture in the coastal subtropics when grazed by cattle during years of low rainfall, *Australian Journal of Experimental Agriculture* **38**, 813-820.
- Hennessy, DW, Morris, SG 2003, Effect of preweaning growth restriction on the subsequent growth and meat quality of yearling steers and heifers, *Australian Journal of Experimental Agriculture* **43**, 335-341.
- Hennessy, DW, Morris, SG, Allingham, PG 2001, Improving the pre-weaning nutrition of calves by supplementation of the cow and/of the calf while grazing low quality pastures 2. Calf growth, carcass yield and eating quality, *Australian Journal of Experimental Agriculture* **41**, 715-724.
- Hennessy, DW, Murison, RD 1982, Cottonseed meal and molasses as sources of protein and energy for cattle offered a low quality hay from pastures of the north coast of New South Wales, *Australian Journal of Experimental Agriculture and Animal Husbandry* **18**, 140-146.
- Lee, GJ, Hennessy, DW, Williamson, PJ, Nolan, JV, Kempton, TJ, Leng, RA 1985, Responses to protein meal supplements by lactating beef cattle, *Australian Journal of Agricultural Research* **36**, 729-741.



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Mears, PT, Garden, DL, Dicker, RW 1993a, Evaluation of pasture for sustained beef production in subtropical New South Wales, *Proceedings of the 17th International Grassland Congress* 17, 1898-1900.

Mears, PT, Havilah, EJ, Price, GH, Darnell, RE, McLennan, DJ, Wilson, C 1993b, Superphosphate maintains soil fertility and beef production on grazed white clover pastures in the subtropics. 1. Residual soil phosphorus, sulfur and nitrogen, and pasture growth responses, *Australian Journal of Experimental Agriculture*. 33, 425-434.

Standing Committee on Agriculture 1990, Feeding Standards for Australian Livestock. Ruminants (ed. Corbett, JL), CSIRO Publications East Melbourne, Vic.

Stricker, JA, Matches, AG, Thompson, GB, Jacobs, VE, Martz, FA, Wheaton, HN, Currence, HD, Krause, GF 1979, Cow-calf production on tall fescue-ladino clover pastures with and without nitrogen fertilization or creep feeding: spring calves, *Journal of Animal Science* 48, 13-24.

Williams, JHA, Erson, DC, Kress, DD 1979, Milk production in Hereford cattle. 1. Effects of separation interval on weigh-suckle-weigh-weigh milk production estimates, *Journal of Animal Science* 49, 1438-42.