Effect of wet season rotational grazing on pasture and animal production in buffel (*Cenchrus ciliaris*) – siratro (*Macroptilum atropurpureum*) pastures in south-east Queensland

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Abstract

This paper reports changes in animal and pasture production in response to wet season rotational grazing of buffel grass (*Cenchrus ciliaris* cv. Biloela) – siratro (*Macroptilium atropurpureum* cv. Siratro) pastures. The system comprised early and late wet season, 2- and 3-month spelling/double stocking regimes, compared with set stocking. The spelling periods were chosen to represent those most beneficial in the control of cattle tick, but animals were kept tick-free during the trial.

During the study period, summer rainfall was mostly below the long-term median but similar to the median for the 30-year period 1969 – 1998. Average pasture presentation yields in March – April, plus estimated animal intake, were about 4000 kg/ha over the 5-year treatment period, with little difference between set-stocked and rotationally grazed treatments. The yield of siratro increased under rotations with late wet season spelling in the earlier years but then declined in all treatments in the later dry years. The frequency and percent composition of buffel grass differed little between treatments, but yields declined to very low levels (1600 – 2800 kg/ha) in the later years.

Overall, animal liveweight gain was 21% higher (P<0.05) in set-stocked pastures than in rotationally grazed pastures, with little difference between early and late spell rotations. Two-month rotations produced better liveweight gains (18%) than 3-month rotations, with differences being significant (P<0.05) in the last 3 of the 5 years when rotations were imposed. Estimated utilisation rates were in the range 39 – 51% for the different treatments during the 5-year treatment period. With the substantial decline in pasture yield in the later post-treatment years, there was an associated increase in pasture utilisation (to more than 60%) and a decrease in animal production. The implications of wet season rotational grazing on buffel-siratro pastures for animal and pasture management are discussed.

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Introduction

The black speargrass (*Heteropogon contortus*) region covers a total area of approximately 25 M ha in northern Australia (Weston *et al*. 1981). Historically, this country had low quality pasture in the dry season, with protein levels as low as 1% (Christian and Shaw 1951; Shaw and Bisset 1955) and was used mostly for cattle breeding, rarely for fattening. Methods developed to overcome this shortcoming, to improve conception rates and/or allow the possibility of fattening cattle, included introducing legumes such as *Stylosanthes* species (Shaw and Mannetje 1970; Bowen and Rickert 1979) or siratro (*Macroptilium atropurpureum* cv. Siratro) (Lowe 1974; Nicol *et al*. 1982), or replacing native pastures with an introduced grass such as buffel grass (*Cenchrus ciliaris*) and a legume (Mannetje and Jones 1990; Tothill *et al*. 2008a, 2008b).

Dipping to control cattle tick (*Boophilus microplus*) on British breed (*Bos taurus*) cattle was a significant cost in much of the southern speargrass region. While the use of *Bos indicus* breeds and crossbreds has reduced the need for tick control in the region, cattle ticks still have a negative impact on animal weight gains, mortality rates and calving percentages (Holroyd and Dunster 1978; Milles *et al*. 1982; Mellor *et al*. 1983). Sutherst *et al*. (1979) indicated 2 possible spelling systems for reducing tick populations:

rotational spelling with 6 spells; or a single strategic spell for 2–3 months. They concluded that, on a cost-benefit basis, the single spell might be the more acceptable, if it were combined with dipping at each transfer.

While this strategy was considered beneficial for tick control, little was known of the impact of a single 2–3 month spell on pasture composition or animal production. Further, in commercial practice, if part of a property is to be spelled, the stock have to be retained elsewhere on the property, either by increasing the stocking rate on a number of paddocks, or by using some form of rotational grazing. Many studies on rotational grazing using short-duration fixed time periods (*e.g*. Mannetje and Jones 1990) have shown little or no benefit to pasture composition or animal liveweight gain. However, systems of wet season spelling are inexpensive to adopt, require little management and have been shown to provide some benefits (Ash *et al*. 2001).

This paper presents results of an experiment examining the impacts of wet season rotational grazing on animal and pasture production and pasture composition, when used as a management strategy on buffel-siratro pastures in south-east Queensland. While spelling periods were chosen to suit tick control, the experiment was conducted in the absence of ticks so that the results reflected only the rotational grazing effect on pasture and animal production. Although the experiment was conducted some time ago, the results are still highly relevant. While most producers in northern Australia now run tick-resistant breeds of cattle so pasture spelling to control cattle ticks is of reduced importance, most see a role for tropical pasture plants (McDonald and Clements 1999), and some 30 – 50% of producers are still using a combination of native and introduced pastures (Bortolussi *et al*. 2005) for beef production.

Materials and methods

Site

The experiment was located on the former CSIRO Narayen Research Station (25° 41´S, 150° 52´E) in south-east Queensland. The original vegetation was eucalypt woodland dominated by silver-leaf ironbark (*Eucalyptus melanophloia*) (Coaldrake *et al*. 1972). The soil is a yellow-red podzolic (paleustalf or albic luvisol) or yellow chromosol (Isbell 1993), derived from granite.

The climate is subhumid subtropical with a mean annual rainfall of approximately 700 mm, which is summer-dominant (December – March). Low rainfall and low minimum temperatures (including frosts) severely reduce plant growth in winter. Detailed meteorological information is available in Cook and Russell (1983).

Treatments

The buffel-siratro pastures were established during 1971-72 and during 1972-77 were grazed at 4 stocking rates as part of an earlier experiment (Tothill *et al*. 2008a). Single superphosphate (9% P) at 200 kg/ha plus molybdenum at 300 g/ha was applied with the initial pasture sowing operations in 1972. Subsequently, biennial applications of 100 kg/ha of triple superphosphate (18% P) were applied aerially and from1979 to 1986, 100 kg/ha of triple superphosphate was applied at 3-yearly intervals. There was no significant difference in yield or composition between stocking rates in the previous experiment (Tothill *et al*. 2008a), and pastures were spelled for 12 months before new treatments were applied in 1978. Hence, residual effects of the previous experiment at the commencement of the new study were not significant.

In this study, treatments on the buffel-siratro pastures compared set stocking (continuous grazing) with 4 rotational grazing systems, comprising early and late growing season spelling, coupled with double stocking in late and early growing season, respectively, and short (2-month) and long (3-month) duration rotations. Early spelling (early November to early January and early October to early January) coincided with the period of build-up of tick populations, while late spelling (early January to early March and early January to early April) coincided with the population peak. The spelling durations fell within the range (minimum 8 weeks, maximum 12 weeks) needed to break the tick life cycle (Sutherst *et al*. 1979). Each treatment/paddock was spelled/double stocked over the same period each summer. Under commercial conditions, graziers would normally not spell or double stock a particular paddock at the same time each year.

However, we wished to study the impact of the combinations of spelling and double stocking on the pastures, so did not want further confounding. The different rotations were implemented for 5 years (1978/79 – 1982/83), while any residual or reversal effects were monitored during the remaining 3 years.

Stocking rate/rotations. The overall stocking rate of 1.11 hd/ha was based on the trial experiences of Mannetje (Mannetje and Butler 1991) and Tothill (Tothill *et al.* 2008a; 2008b) at Narayen. All treatments were stocked with mostly Belmont Red steers. Animals were introduced as weaners at 6 – 8 months of age (170 – 220 kg) in May and remained on the trial for 2 years. Paddock sizes were set to accommodate 4 or 5 animals on each treatment, with the 2 or 3 older animals in each paddock removed each year. In practice, if half of a property is to be spelled for a period and the animals retained on the property, the remaining half must be double stocked during that period. The reverse occurs when the second half has its spell period. Therefore, the early/late spelled rotations in our study were managed as a pair. Animals were moved from one of the pair into the other for spelling, *i.e.*, during the period of early spelling (early October to early January for the 3-month rotation, early November to early January for the 2-month rotation), animals from the early spell rotation were moved in with the existing animals in the paired late spell rotation. During the late spell period (early January to early April for the 3-month rotation, early January to early March for the 2-month rotation), all animals were moved from the late spell rotation into the paired early spell rotation. At the end of the late spell period, animals were returned to their respective treatments. Therefore, for the duration of the spelling period, the stocked treatment of the pair was grazed at twice its normal stocking rate. This maintained the same annual stocking rate and number of animal grazing days per year over all treatments. However, because animals moved between the treatment pairs, no valid comparison can be made between early and late spell rotations with respect to animal liveweight gain over the period of rotational grazing.

Measurements

Animals were weighed at 5 strategic times during the year. The times selected were those that, based on the previous 5 years of information, coincided with times of significant change, *i.e.*, late dry season-early wet season and late wet season-early dry season. Animal intake was derived from animal live weights and rates of gain using the formula of Minson and McDonald (1987). Intake was apportioned into green and dry components based on preliminary diet selection studies by R. McLean (personal communication).

Pasture composition, pasture yield and pasture species frequency were estimated using the BOTANAL procedure of Tothill *et al.* (1992). Details of the sampling procedures used are given in Tothill *et al.* (2008a). Sampling was carried out once a year at the growth peak of the year in March – April.

Percent ground cover was estimated simultaneously with pasture estimates. This was on the basis of projected foliar and/or litter cover within each quadrat, as this was considered an indicator of degradation or sustainability, and an important parameter in rainfall runoff considerations.

Temperature data were recorded daily at the official weather station for Narayen, located 3 – 4 km north-west of the experimental site. Rainfall was recorded daily at the experimental site.

Statistical analyses

The data analysed for pasture production were total (green + dry) and green dry matter yields of speargrass, siratro, other grasses and forbs and total green herbage dry matter. For pasture composition, except for total values, the same parameters were analysed as for pasture production. Animal liveweight gains were analysed using analysis of variance on an annual and seasonal basis.

The analyses were carried out using a completely randomised design with 2 replications, using GENSTAT © 1980 Lawes Agricultural Trust (Rothamstead Experimental Station).

Results

Climate

Rainfall over the experimental period was below average (Table 1), and considerably less than that

Table 1. Annual and spring-summer (October – March) rainfall over the experimental period (1978-86) and the long-term (1885-1998, LTM) and recent 30-year (30YM) medians.

	Annual		Spring-summer
		(mm)	
1978	805		
1979	475	1978-79	391
1980	581	1979-80	402
1981	913	1980-81	601
1982	548	1981-82	647
1983	1125	1982-83	306
1984	915	1983-84	634
1985	588	1984-85	351
1986	635	1985-86	396
LTM (1885-1998)	691		488
30YM (1969-98)	633		414

during the preceding experiment (Tothill *et al.* 2008a). Only 3 of the 8 years had above median annual (691 mm) or spring–summer (488 mm) rainfall, and in 5 of the 8 years spring–summer rainfall was at or below decile 3 (401 mm), based on long-term (1885 – 1998) records.

Mean monthly maximum temperatures ranged from 19.6°C to 32.2°C, while mean monthly minimum temperatures ranged from 6.6°C in July to 19.3°C in January, and grass minimum temperatures from 2.7°C to 17.3°C. There were 27 frosts per year on average, with the highest number of heavy frosts (grass minimum < -2.2°C) occurring in the winter of the very dry year 1982, while there was none in the following wet winter of 1983.

Pasture production and composition

Pasture production was calculated as the sum of the presentation yields in March – April and estimated animal intake from liveweight data. Double stocking early followed by late spelling (DSE-LS) was consistently the most productive treatment combination, yielding significantly (P<0.01) more than the early spelling followed by double stocking (ES-DSL) in 4 of the 5 years when rotational grazing was imposed, and for the mean over the 5 years (Figure 1). Over the 5 years, DSE-LS combinations gave higher pasture production than continuous grazing, though the difference was not significant. The 2-month rotation generally produced higher yields than the 3-month rotation and the continuously grazed treatment, although the effect was not obvious until the third year.

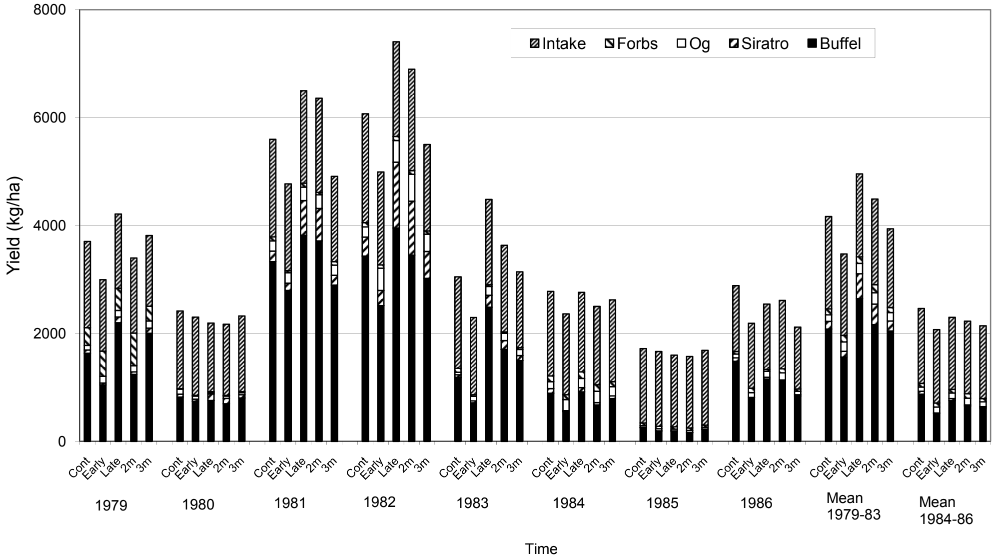

Figure 1. Annual pasture yields and composition for the period 1979-86 and the 5-year (during rotational grazing) and 3-year (post rotational grazing) means for the continuously stocked (Cont), early spell followed by double stocking rotation (Early), double stocking followed by late spell rotation (Late), 2-month rotation (2m) and 3-month rotation (3m) treatments for buffel grass, siratro, other grasses and forbs, plus an estimate of animal intake.

The 2-month DSE-LS combination yielded significantly (P<0.05) more than most other treatments in 3 of the 5 years. The 3-month DSE-LS combination was generally the second most productive, followed by continuous grazing. The ES-DSL combinations were the least productive treatments, regardless of duration, consistently yielding less than the continuously grazed treatment, although not significantly so. In the 3 years after rotations ceased, yields were not affected by previous treatment (P>0.05) (Figure 1).

Green yields of the individual pasture components (buffel grass and siratro) differed significantly (P<0.05) between early and late spell rotations for 4 and 3 of the 5 years, respectively, as well as for the 5-year average. Yields of both components were generally higher for the 2-month than the 3-month rotations. Siratro yielded substantially more under rotational grazing than under continuous grazing, whereas buffel grass was relatively unaffected. In the dry years of 1984–86 after rotations ceased, siratro declined to almost negligible proportions. Other grasses and forbs were very minor components of the pasture and were only marginally affected by the treatments, though favoured slightly by the 2-month DSE-LS combination (Figure 1).

Based on the estimated animal intakes, utilisation rates mirrored the different pasture yields. Averaged over the 5 years when rotational grazing was applied, utilisation under continuous grazing was higher (45%) than under DSE-LS rotations (39%). However, owing to the lower yields in ES-DSL rotations, the rate on these treatments was 51%. Overall, there was little difference between the 2-month and 3-month rotation treatments (43 *vs* 45%). In the dry years after rotational grazing ceased, utilisation averaged more than 60% on all treatments.

The frequency of occurrence of buffel grass remained very high throughout the study with the only significant difference between treat-

Table 2. Frequency of siratro and buffel grass and cover in March – April each year for the continuously stocked (Cont), early spell rotation (Early), late spell rotation (Late), 2-month rotation (2mth) and 3-month rotation (3mth) treatments. Values are the means of 2 replications.

Year	Cont	Early	Late	2mth	3mth
Siratro frequency			(%)		
1976-77[1]	94	98	98	98	99
1978-79	52b[3]	48b	73a	62ab	59ab
1979-80	23b	22b	53a	49a	25b
1980-81	40b	33b	76a	68a	41b
1981-82	55b	61b	95a	88a	68b
1982-83	25b	34b	59a	53a	40ab
1983-84[2]	45ab	27b	65a	49ab	43ab
1984-85[2]	21	10	17	14	14
1985-86[2]	19	3	15	8	11
Buffel frequency			(%)		
1976-77[1]	93	98	98	97	98
1978-79	96	96	98	95	98
1979-80	96	97	99	98	98
1980-81	98	99	97	99	97
1981-82	96	92	98	93	98
1982-83	95	97	97	99	95
1983-84[2]	94	85	89	86	88
1984-85[2]	96a	79b	87ab	82b	84ab
1985-86[2]	96	93	91	88	86
Cover			(%)		
1976-77[1]	98	99	99	100	99
1978-79	89	91	93	93	92
1979-80	79	80	83	80	83
1980-81	80	87	90	92	86
1981-82	92b	91b	98a	97a	92b
1982-83	80bc	82bc	94a	90ab	86bc
1983-84[2]	80ab	78b	90a	85ab	82ab
1984-85[2]	52ab	50b	61a	53ab	57ab
1985-86[2]	76ab	73b	79a	77ab	75ab

[1] Values prior to imposition of treatments.

[2] Post-treatment years.

[3] Values within the same year followed by different letters are significantly different (P<0.05).

ments occurring in 1984–85 (Table 2), after rotational grazing ceased. In contrast, frequency of siratro was high initially and declined to negligible levels by the end of the study. It was significantly (P<0.05) higher in the DSE-LS rotations than in the ES-DSL rotations and continuous grazing treatment in every year while rotational grazing was imposed (Table 2). Siratro frequency was significantly higher (P<0.05) in the 2-month than in the 3-month rotation in 3 of the 5 years of rotational grazing.

Cover was initially very high at around 90% and remained at or above 80% in all treatments until the last 3 years, when it fell as low as 50% in the ES-DSL rotations in 1 year (Table 2). There was no significant difference between treatments until 1981–82. Cover was significantly (P<0.05) greater in the DSE-LS than the ES-DSL rotations in the last 2 years of rotational grazing and the difference remained significant for the 3 years after rotational grazing ceased. The largest difference occurred in the very dry summer of 1982–83.

Animal production

Liveweight gain per head (LWG) in the continuously grazed treatment was always better than in the rotationally grazed treatments (mean of 23%), significantly so (P<0.05) in 4 of the 5 years of rotational grazing (Table 3). The advantages were related to seasons, with summer LWG significantly (P<0.05) better under continuous grazing in 3 years as well as overall (Table 3), while liveweight changes in autumn and winter were unaffected by grazing system (P>0.05). Differences in LWG were not significant in the 3 years after rotational grazing ceased.

Statistical comparisons of annual LWG between ES-DSL and DSE-LS rotations are not appropriate as the animals grazed together over the rotational period. However, the DSE-LS rotation consistently supported better LWG than the ES-DSL rotation (9% advantage over 5 years), and this resulted from reduced weight loss in winter, when animals were grazing their respective treatments (Table 3).

The 2-month rotation consistently supported better LWG than the 3-month rotation with significant differences (P<0.05) in 3 years and a 12% advantage overall (Table 3). Most of this effect resulted from consistently better summer and autumn production, with differences being significant (P<0.01) in 1 year out of 5 in summer and 4 years out of 5 in autumn.

Discussion

This study has shown the beneficial effects of wet season rotational grazing on pasture performance, especially siratro survival and growth. However, this was at the cost of reduced animal performance. As little as a 2-month rotation with double stocking early in the pasture growing season followed by spelling late in the pasture growing season (January – February) achieved the pasture benefits.

The pasture presentation yields coupled with estimated animal intakes suggested that double stocking early in the pasture growing season followed by spelling late in the season led to higher overall yields than for other treatments studied. However, this could be largely a reflection of the timing of pasture sampling, which occurred shortly after spelling finished in this treatment combination. With over 90% frequency of buffel, there was little effect of treatment, while siratro frequency increased with double stocking early, followed by spelling.

Since spring–summer rainfall during the study was below the long-term (1885–1998) average for the area, it might be expected that performance would be better under 'normal' conditions. However, rainfall figures were similar to the average for the more recent 30-year period (1969–98), with 4 out of 8 years below median annual (633 mm) and 5 years below median spring–summer (414 mm) rainfall (Table 1). Therefore, performance recorded in this study is probably representative of what could be expected in the future.

Pasture production

Owing to the low rainfall, overall pasture presentation yields were low. By making adjustments for estimated intake, yields of 3000 kg/ha or less were recorded in 5 of the 8 years, while the average in the earlier trial from 1972–77 was 6 – 7000 kg/ha (Tothill *et al.* 2008a). Nevertheless, the results showed significant benefits in pasture production and composition, particularly in enhanced siratro production, from 2-month (Jan–Feb) and 3-month (Jan – Mar) spells following

Table 3. Effects of continuous (Cont) *vs* rotational (Rot) grazing, early *vs* late spell rotational grazing and 2 *vs* 3-month rotational grazing of buffel-siratro pastures on annual liveweight gains of steers. Statistical comparisons between early and late spelling are not appropriate except for the winter period when animals grazed their respective treatments.

	Cont	Rot	Early	Late	2-month	3-month
No of animals	8	36	16	18	16	20
Annual liveweight gain			(kg/hd)			
1978–79	148.3x[2]	107.5y	100.9	114.1	114.9	101.6
1979–80	135.1x	108.8y	101.5	117.8	116.1	102.9
1980–81	169.5	156.7	152.2	159.6	165.6x	145.2y
1981–82	162.5x	137.3y	136.8	136.7	151.4x	126.1y
1982–83	136.8x	111.3y	104.3	123.6	128.2x	96.7y
1983–84[1]	122.1	115.1	106.5	123.6	107.0	121.6
1984–85[1]	103.4	97.7	108.5	86.8	97.4	98.0
1985–86[1]	76.8	71.3	69.3	76.4	73.0	72.7
Seasonal averages 1978–83						
Winter	-9.7	-11.1	-16.4	-5.6	-10.6	-11.5
Spring-summer	131.5x	113.6y	114.9	112.1	117.4	109.8
Autumn	28.7	22.3	20.6	23.9	28.4	16.2
Annual	150.4x	124.8y	119.1	130.4	135.2	114.5

[1]Post-treatment years.
[2]Values within the same year or season for matching pairs followed by different letters are significantly different ($P<0.05$).

double stocking early in the pasture growing season, compared with spelling early followed by double stocking or continuous grazing. The increase in siratro growth was somewhat less than the 3-fold increase reported by Jones and Jones (2003); however, conditions were less favourable in this experiment. Tothill *et al.* (2010) reported greater increases in siratro yield in response to spelling on adjoining native grass-siratro pastures but, in that case, the spelling was from March to May, which would have been more beneficial to siratro seeding, and was not preceded by a period of double stocking, as in this study. Until 1982, siratro frequency (plant numbers) remained quite high, even though yields were quite low, indicating a reasonable residual siratro plant population. With better climatic conditions, and a later spelling period when siratro was seeding, greater benefits from rotational grazing might have been possible. The frequency of siratro was considerably lower than at the conclusion of the previous experiment (Table 2). These results indicate that, in this environment, siratro persistence is threatened during a series of dry years, especially under continuous stocking. Jones *et al.* (2000) reported similar poor persistence of siratro in the dry years of the 1990s, owing to poor seed set, leading to low soil seed banks and little recruitment.

Unlike the increase in green panic (*Panicum maximum* var. *trichoglume*) with spelling reported by Tothill *et al.* (2010), wet season rotational grazing provided little benefit to the buffel component of the pasture. However, buffel was already the dominant pasture component at the start of this trial, so there was little capacity to increase its composition or frequency.

Animal production

Mean animal liveweight gains of 150 and 125 kg/hd/yr for the continuously grazed and rotationally grazed treatments, respectively, were similar to the 141 and 114 kg/hd/yr reported by Mannetje and Jones (1990) for continuously stocked and rotationally grazed pastures, and similar to those from set-stocked buffel-cassia (*Chamaecrista rotundifolia* cv. Wynn) and buffel-stylo (*Stylosanthes scabra* cv. Seca) pastures reported by Jones *et al.* (2000). The lesser decrease in LWG from 2-month (10%) than from 3-month rotational grazing (24%) suggests that longer rotations might have adverse effects on overall pasture quality, as there was little difference in pasture yield (Figure 1), and utilisation rates were lower.

It is significant that these differences in LWG between treatments did not accrue uniformly across seasons but developed in the spring-summer periods. The superior gains on the continuously grazed treatment at this time were no doubt a function of the added pressure on the rotational grazing treatments during their periods of double stocking. At double the stocking rate, animals have reduced opportunity for selection, which limits performance. When they gain access to the spelled area at the end of the double stocking period, there would be adequate pasture available to allow good selection, but the spelled pasture could be at a mature stage of growth, so overall pasture quality limits performance. The absence of significant differences in liveweight gain between treatment paddocks in the post-treatment period indicates that the differences measured during the treatment period were a reflection of the management strategies imposed at the time and not a result of permanent changes in the paddocks as a result of the specific treatment.

Conclusion

The results of this study suggest there are advantages to be gained in pasture production and composition from strategic rotational grazing of pasture. While rotational grazing had no impact on the dominant buffel grass, rotations with late spelling following a period of double stocking enhanced siratro composition. With the availability of tick-resistant *Bos indicus* cross cattle, the issue of tick control is less important than when this study was conceived. However, spelling of pastures to maintain biodiversity and retain desirable species remains an important issue. Appropriate strategies to achieve these aims without causing serious detriment to animal performance need to be developed. While our results suggest that rotational grazing for as little as 2 months in the growing season can achieve desirable pasture outcomes, the lower liveweight gains from these regimes indicate that there is a price to pay for this benefit. In this experiment, we spelled half of the property on each occasion and the spelling-double stocking combinations occurred at the same time in each paddock each year. This is unlikely to happen on a commercial grazing property. Graziers are more likely to spell a smaller percentage, *e.g.* 33%, of their property each year during the growing season and thus the increase in stocking rate on the remainder would be less. Under this management system, spelled areas would not be subjected to double stocking in the same growing season, so effects on both animal and pasture performance could be different from what we recorded. While we measured short-term disadvantages to LWG from the combinations of double stocking and spelling we employed, there might be long-term benefits to LWG from the ensuing better pastures, but this requires validation from further study.

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