Utilising temperate and tropical pastures and compensatory growth during winter to maximise growth in cattle

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Abstract

The effect of combinations of temperate and tropical pastures, and of interactions with compensatory growth, on liveweight gain in steers was investigated over the winter–spring period in the subtropics. Sixteen Brahman crossbred steers (294 ± 4.4 kg; ± s.e.) were either not supplemented (low growth rate; L) or supplemented with silage and with a mixed sorghum-barley grain-based ration (2 kg/hd/d) (high growth rate; H) in autumn. Growth rates over *ca.* 100 d (hereafter autumn) for L and H groups were –0.21 and 0.71 kg/d, and liveweights at the end of autumn were 270 ± 5.4 and 365 ± 8.2 kg, respectively. Steers were re-allocated within original groups so that half grazed ryegrass (*Lolium multiflorum*) cv. Aristocrat alone (LR, HR) and half grazed ryegrass (3 d/week) and carryover pangola grass (*Digitaria eriantha*) (4 d/week) (LRP, HRP). Liveweight gains over the next 88 d (winter–spring) were 1.17 ± 0.056, 1.05 ± 0.055, 0.86 ± 0.057 and 0.67 ± 0.037 kg/d, and final liveweights were 373, 362, 441 and 423 kg for LR, LRP, HR and HRP, respectively. Growth rates over winter–spring were higher ($P<0.05$) for steers grazing ryegrass alone than for the combined grazing treatment, and were higher ($P<0.05$) for unsupplemented steers than for those supplemented in autumn, but there was no interaction between winter–spring and autumn treatments. Over the winter–spring grazing period, herbage mass on offer averaged 2725 and 4280 kg/ha dry matter (DM) for the ryegrass and pangola grass pastures, respectively. Average green leaf percentages were 43 and 22%, and within this component crude protein (CP) concentration was 24–29% and 11–14% and *in vitro* DM digestibility (IVDMD) was 75–78% and 56–62%, respectively. The concentrations of ammonia-nitrogen in rumen fluid from steers grazing ryegrass or pangola ranged from 93–126 mg/L, with no treatment effects.

The results indicate that carryover tropical pasture can be used in practical feed plans to augment the limited supply of temperate pasture, thereby reducing costs with only small reductions in animal performance. They also indicate that severe restrictions in growth rate during the autumn period will result in compensatory growth later on, but may jeopardise attainment of market specifications for heavy carcases at a young age.

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Introduction

Achieving target weights at specified ages in beef cattle in order to satisfy carcase specifications for premium markets requires high liveweight gains. This involves knowing the growth rates achievable from pasture types and developing decision rules on pasture allocation. Strategies to overcome short-term periods of low liveweight gain, or loss, need to be devised. In subtropical and tropical regions, tropical pastures are used commonly in the summer–autumn period and temperate pastures in the winter–spring for both dairy and beef production (Winter *et al.* 1991; Kaiser *et al.* 1993).

This system can support high annual liveweight gains but suffers from 2 deficiencies. Firstly, there is usually an autumn feed gap associated with the declining growth rate of tropical pastures and the need to increase stocking rates on these pastures as land is set aside for the development of temperate pastures. Secondly, the area of land available to grow temperate pasture is limited on most properties by soil type and irrigation capacity. This autumn feed gap can be addressed by: feeding supplements to enhance growth rates in autumn; or, accepting reduced weight gain or weight loss in autumn and then exploiting compensatory growth in the following period when animals graze high quality temperate pasture (Nicol and Nicoll 1987). The issue of limited temperate pasture availability in winter–spring might be addressed by providing animals with limited access to temperate pasture and augmenting it with access to low quality carryover tropical forage. Such a system has been described recently for dairy cows (Walker *et al.* 1996).

We addressed these issues in an experiment in which steers were grown at high or low rates in autumn and then grazed on either ryegrass (*Lolium multiflorum*) cv. Aristocrat alone or ryegrass and carryover tropical pasture during the winter–spring. The influence of these strategies on liveweight gain was examined and comparisons of measured gains and those predicted by the computer model GRAZFEED (1996) were made.

Materials and methods

Experimental site

The experiment was carried out at the Mt Cotton Research Farm, The University of Queensland (27°37' S, 153°14' E) where mean annual rainfall is 1490 mm which occurs predominantly (*ca.* 70%) in summer.

Experimental animals and treatments

Sixteen Brahman crossbred steers originating from north Queensland (Ayr) and which had grazed pangola grass (*Digitaria eriantha*) pasture during the 1995–96 summer (average growth rate *ca.* 0.8 kg/d) were used. The steers were allocated randomly to 2 treatment groups, on the basis of unfasted liveweight on April 16, 1996, and grazed pangola and setaria (*Setaria sphacelata*) pasture at low herbage mass with either no supplement (low growth rate; L) or silage plus a supplement of sorghum and barley grain (2 kg/d) aimed at achieving high growth rates (H), between March and July (98 d; hereafter autumn). The liveweight at allocation was 294 ± 4.4 (± s.e.) kg and was 365 ± 8.2 and 270 ± 5.4 kg for the H and L groups, respectively, at the end of the supplementation period. Following this autumn grazing period, the steers were re-randomised on the basis of unfasted liveweight, within original groups, and allocated equally (n = 4 from H and L) to winter–spring grazing treatments of either ryegrass alone (R) or a combination of ryegrass (3 d per week) and carryover tropical (pangola grass) pasture (4 d per week; RP). These treatments continued for 88 d between July 22 and October 22 (hereafter winter–spring). This represented a 2 × 2 factorial arrangement of autumn (H and L) and winter–spring (R and RP) treatments, *i.e.*, HR, HRP, LR and LRP.

Pastures and animal management

One 1.6 ha paddock of tropical pasture, predominantly pangola grass, was used. Ryegrass was sown into 3 adjacent paddocks, 2 × 1 ha and 1 × 0.5 ha in late March at the rate of 16–20 kg/ha of seed and fertilised with 200 kg/ha superphosphate, 100 kg/ha muriate of potash and 60–75 kg/ha nitrogen (as urea) at sowing. Urea was applied at the same rate 8–10 weeks after sowing, and at 6-weekly intervals thereafter. The pasture was irrigated throughout, at approximately 60% of open pan evaporation. This level was chosen because the soil was susceptible to waterlogging.

Group R grazed ryegrass 7 days a week and RP steers grazed ryegrass from Tuesday to Thursday and pangola from Friday to Monday. Both groups grazed the same pasture from Tuesday to Thursday. Whenever RP steers were shifted to or from the ryegrass, the ryegrass paddock used by the R group was also changed so that steers always had access to high quality pasture with pasture height always maintained above 6 cm.

The steers were treated with Ivermectin (Ivomec® – Merck and Co.) at the beginning of autumn grazing in March and again in August.

Animal and pasture measurements

The steers were weighed unfasted on Tuesday and Friday mornings, just prior to changing paddocks. Paddocks were assessed visually each week to ensure herbage mass was not limiting animal growth (>2000 kg/ha DM). On 3 occasions coinciding with the changeover of paddocks, *i.e.*, July 30, August 29 and September 16, 1996, total herbage mass was determined for the ryegrass and pangola grass pastures in paddocks being entered and exited. Pasture quadrats were cut to ground level and samples dried to constant weight at 60°C for dry matter (DM) determinations. Four quadrat samples, 2 at the mean and 2 at 1 standard deviation either side of the mean DM herbage mass, were separated into green leaf, green stem and dead material components. These components were then bulked across quadrats for chemical analysis and determination of *in vitro* DM digestibility (IVDMD).

The crude protein (CP) concentrations in the plant fractions were determined by the Leco combustion method. The IVDMD of these plant fractions was determined using the *in vitro* pepsin-cellulase method as described by McLeod and Minson (1978), incorporating *in vivo* standards of tropical forages. IVDMD determinations on ryegrass were not corrected in this way as there were no *in vivo* standards available.

Samples of rumen fluid were taken, using a stomach tube, from 2 steers selected at random from each of the 4 treatment groups, at 1330 h on September 10, 1996. On this day, the RP steers had been grazing the pangola grass pastures for 4 d. The rumen fluid was strained, acidified to pH <4, and frozen. Ammonia-nitrogen (ammonia-N) concentration in the rumen fluid was later determined by volatilisation with sodium tetraborate as base and with titration using a Tecator system.

Statistical analysis

Liveweight gain of individual steers was estimated by linear regression of liveweight against time. The results were analysed by analysis of variance for a 2 × 2 factorial design.

Computer simulation

The computer simulation model GRAZFEED (1996) was used to predict liveweight gain of the steers using information on pasture herbage mass and composition of pasture components. These predictions were compared with measured liveweight gains.

Results

Supplemented steers (H) gained weight at 0.71 kg/d and unsupplemented steers (L) lost weight at 0.21 kg/d during the autumn grazing phase. Liveweights for the 2 groups were 365 ± 8.2 and 270 ± 5.4 kg, respectively, at the end of this period.

There were significant effects of main treatments, *i.e.*, of growth rate in the autumn grazing period (H *vs* L) and of grazing regime in the winter–spring period (R *vs* RP), on liveweight performance in this latter period. Steers grown at low rates in autumn (L; hereafter compensating steers) had higher growth rates in winter–spring than their counterparts (H) grown at high rates in autumn (1.11 *vs* 0.76 kg/d; $P<0.05$). Steers with access to ryegrass alone in the latter period (R) grew faster than those on the combined (RP) pasture regime (1.02 *vs* 0.86 kg/d; $P<0.05$). There was no interaction of previous growth rate and pasture regime in winter–spring. Growth rates for treatment combinations are shown in Table 1. The liveweight gains predicted using GRAZFEED are also compared with measured gains in Table 1. There was close agreement between predicted and measured gains for LR steers only. The concentrations of ammonia-N in rumen fluid were similar for steers grazing ryegrass and pangola grass at the time of sampling (118 *vs* 106 mg/L; $P>0.05$; Table 1).

The herbage mass and proportions of green leaf, green stem and dead material are shown in Table 2. Herbage mass on the pangola carryover pasture was high initially and declined during the experiment, while ryegrass herbage mass varied less and exceeded 2000 kg/ha DM throughout. The proportions of green leaf for ryegrass and pangola grass were relatively constant for both pastures although much higher for ryegrass than for pangola (43 *vs* 22% average). Crude protein concentration in green leaf was also much higher for ryegrass than for pangola grass (26 *vs* 12% average), as was IVDMD (77 *vs* 60%).

Residual herbage for ryegrass when steers were shifted from the paddocks was 2562, 2696, 2194 and 2224 kg/ha DM on August 8, August 12, August 29 and September 16, 1996, respectively.

Discussion

Many grazing production systems have an autumn feed gap, when animal productivity is

Table 1. Liveweight gain during the winter–spring period, and concentration of ammonia-nitrogen (N) in rumen fluid, for steers grazing either ryegrass alone (R) or a combination of ryegrass and pangola pasture (RP) after a period of high (H) or low (L) liveweight gain in autumn (details of treatments in text), the liveweight gains predicted using GRAZFEED (1996) and the final liveweights in October after 88 d on treatment.

	HR	HRP	LR	LRP
Liveweight gain (kg/d)				
Measured	0.86 ± 0.057a[1]	0.67 ± 0.037b	1.17 ± 0.056c	1.05 ± 0.055ac
Predicted	1.12	0.36	1.24	0.46
Final liveweight (kg)	441 ± 13.0	423 ± 12.4	373 ± 5.1	362 ± 5.0
Ammonia-N (mg/L)				
Average	126	118	110	93
Range	81–171	102–134	81–138	84–102

[1] Mean values within a row followed by different letters are significantly different ($P < 0.05$).

Table 2. Herbage mass (dry matter; DM) of total pasture and the herbage mass and peicentage (in brackets), crude protein (CP) concentration and *in vitro* dry matter digestibility (IVDMD) of the green leaf, green stem and dead material fractions separated from pasture quadrats.

	Ryegrass			Pangola grass		
	Herbage mass	CP	IVDMD	Herbage mass	CP	IVDMD
	(kg/ha DM)	(%)	(%)	(kg/ha DM)	(%)	(%)
30.7.96						
Total	3231			6795		
Green leaf	1745 (54)	25	77	1495 (22)	11	56
Green stem	1034 (32)	15	76	3330 (49)	5	45
Dead	452 (14)	14	61	1970 (29)	7	—
29.8.96						
Total	2249			3361		
Green leaf	877 (39)	29	78	605 (18)	14	62
Green stem	832 (37)	19	71	1311 (39)	7	55
Dead	540 (24)	19	64	1445 (43)	7	40
16.9.96						
Total	2695			2695		
Green leaf	997 (37)	24	75	674 (25)	11	61
Green stem	1132 (42)	16	67	782 (29)	8	50
Dead	566 (21)	14	49	1239 (46)	8	39

low because summer pastures are mature, and of poor quality, and winter forages are not yet available. Managers can supplement their animals during this period to achieve a reasonable growth rate, or accept the low production and rely on compensatory growth in the winter grazing period to offset this growth restriction. Where these alternatives were investigated in our study, steers unsupplemented in autumn grew considerably faster in the winter–spring period than their supplemented counterparts (1.11 *vs* 0.76 kg/d) but were still lighter than the previously supplemented steers at the end of this period (368 *vs* 432 kg). This finding is consistent with that of Gibb and Baker (1991) where unsupplemented animals gained more than supplemented animals (0.75 *vs* 0.62 kg/d) when subsequently grazed on ryegrass, although the compensatory effect was greater in our experiment. Nicol and Kitessa (1995) have suggested that the short, sharp restriction in growth rate, as observed in autumn in our experiment, would promote high recovery liveweight gains, especially when the quality of the pasture was high such as with the ryegrass used in winter–spring.

The failure of compensating steers to attain the final liveweight of the previously-supplemented steers during the 88 d winter–spring grazing period, on either pasture type, suggests that the duration of the recovery period was too short. Total compensation might have occurred if the recovery period was longer, as has sometimes been demonstrated following dry season supplementary feeding in the tropics (Winks 1984). Ryan *et al.* (1993) found that total compensation in liveweight following growth restriction in their study took 11 months. However, this possibility of complete compensation in liveweight is of little practical significance in intensive systems where the time required is beyond that available to meet market specifications for carcases of specific age and weight. In our study, the unsupplemented LR and LRP steers would have required an additional 23 and 36 d respectively, at existing growth rates, to attain a liveweight of 400 kg. However, when the experiment was terminated on October 22, seed heads were proliferating on the ryegrass and regrowth was diminished due to rising temperature, thereby reducing the capacity of the pasture to provide high quality feed for the additional period and thus further extending the time required to meet this target weight.

The higher growth rates of steers grazing ryegrass alone compared with those for the combined pasture (1.02 *vs* 0.86 kg/d) were to be expected based on the generally higher quality of temperate compared with tropical grasses (Stobbs 1973). Growth rates on ryegrass alone compared favourably with those previously reported by Robbins *et al.* (1980; 0.8 kg/d) and Robbins and Bushell (1987; 0.91 kg/d) where high stocking rates were employed (5.4–6.2 beasts/ha). Walker *et al.* (1996), investigating a similar system of combined grazing of temperate and tropical pasture, also found that higher production in dairy cows was associated with an increased proportion of the total grazing area as ryegrass. This difference in quality between temperate and tropical species was accentuated in the present experiment by the late stage of maturity of the carryover pangola grass, the deterioration of quality in tropical grasses following maturation being well established (Stobbs 1974). The tropical pasture had high herbage mass in winter–spring but, compared with ryegrass, lower proportion of green leaf (22 *vs* 43%) which was of lower digestibility (60 *vs* 77%) and CP concentration (12 *vs* 26%).

There was no interaction, in terms of liveweight performance, between autumn grazing treatments and those applied as grazing systems in the following winter–spring period. Based on the findings of Hovell *et al.* (1978) that lambs exhibiting compensatory growth had enhanced nitrogen retention and higher protein requirements, it could be expected that previously unsupplemented steers would show higher compensation on ryegrass alone than on the combined pasture. That this did not happen may indicate that protein was not limiting in the diet on either pasture system. For instance, the concentration of ammonia-N in rumen fluid was similar for steers confined to ryegrass or pangola just prior to sampling, and indicated sufficient ammonia for optimum microbial activity in the rumen (Satter and Slyter 1974). However, it is possible that the earlier ryegrass grazing period contributed to the higher concentrations found in steers from the pangola pastures even though it had last been grazed 4 d prior to sampling. An additional consideration here is that compensating animals have an increased feed intake compared with their non-compensating counterparts. Ryan *et al.* (1993) identified this increased intake as the major mechanism contributing to compensatory growth. Aligned with this increased intake is a reduced maintenance requirement (see Nicol and Kitessa 1995) thereby allowing more energy and nutrients to become available for growth. Through these mechanisms, compensating animals may be less affected by the lower quality of the tropical pasture during recovery, providing herbage mass is adequate, as was the case in our study. Alternatively, animals were able to achieve a much higher intake when on the ryegrass phase of the rotation. Growth rates for the previously unsupplemented steers were similar for ryegrass and the combined pasture (LR, 1.17 *vs* LRP, 1.05 kg/d) in winter–spring, although the low animal numbers may have contributed to this lack of a significant effect.

Despite the slightly lower growth rates on the combined pasture than on ryegrass only, the major constraint to meeting target liveweights by the end of winter appears to be the treatments imposed in autumn. Steers supplemented in autumn achieved a final liveweight in excess of 420 kg regardless of winter–spring pasture type, while unsupplemented steers reached only 362–373 kg, despite compensatory growth occurring. This has important implications for pasture rationing. It is not necessary to carry steers on ryegrass only in winter–spring to achieve satisfactory compensation and combinations of ryegrass and carryover tropical pasture can be used depending on resources available.

The success of any systems approach such as this is dependent upon adherence to appropriate principles of grazing management to maximise animal performance and pasture growth. The height of the residual ryegrass pasture was kept above 6 cm and at all times the herbage mass was maintained in excess of 2200 kg/ha DM, which is greater than the low critical herbage mass of 1500 kg/ha DM recommended by Nicol and Nicoll (1987). Thus, it is improbable that herbage mass limited animal performance and steers were able to express their full growth potential. Similarly, pasture presentation yield of pangola grass remained high throughout although the proportion of green leaf was low (22%), as stated earlier. Nevertheless, the steers grazing pangola grass had access to a high allocation of leaf (33 kg green leaf DM/100 kg LWt/d) and it is this allocation of leaf on tropical pastures, rather than the percentage leaf in total DM, which is important in determining animal production (Stobbs 1973; Chacon and Stobbs 1976; Ehrlich and Cowan 1996).

In developing an appropriate feed plan, past experience and computer models such as GRAZFEED (1996) can be used as aids. Our efforts to predict growth rates using GRAZFEED were unsatisfactory. The model underestimated gains on the mixed pasture (46–56%) and overestimated gains on ryegrass (6–30%). GRAZFEED does not have provisions for mixed pasture grazing and separate simulations had to be run for both pasture types, and the average used as predicted growth rate. This probably accounted for the poor growth predictions on the mixed pasture.

The results of this grazing study demonstrate some basic principles for devising a practical feed plan aimed at meeting a production target. The key aspects of the feed plan were the growth rates achieved during autumn grazing, the degree to which compensatory growth could be exploited, and the combination of irrigated temperate pasture and carryover tropical pasture. Optimising economic efficiency depends on achieving the appropriate balance of these aspects. Our results indicated that some nutritional inputs such as higher green leaf allowance, supplements or special purpose pastures, would normally be required in autumn to achieve high overall liveweight gains, but this would reduce the compensatory growth effect. Furthermore, the results indicate that carryover tropical pasture could be used effectively in conjunction with sown temperate pasture to offset the high costs involved with this pasture improvement, with only small reductions in growth rate.

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