Efficiency of Calf Production from Twin-bearing Beef Cows on an Intensive Pasture System in Subtropical Australia

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ABSTRACT : Forty-two single-bearing and 42 twin-bearing mature Angus×Hereford cows were allocated, seven per cell to 3 replications of 2 stocking rates (3.2 cows/ha; medium stocking rate [MSR], and 3.8 cows/ha; high stocking rate [HSR]) to graze summer-active and winter-active pastures from late pregnancy to the weaning of their calves. Cow liveweights and growth of calves were recorded as well as estimates of pasture quantity and forage intake. Pasture quantity did not differ in the paddocks grazed by single- and twin-bearing cows during pregnancy, nor effectively did forage intake. Subsequently, intake was higher during mid-lactation especially with twin-rearing cows (25% higher than single-rearing cows at the MSR; 9% at the HSR). However, quantity of pasture decreased for twin-rearing cows and was less than that available to single-rearing cows as lactation progressed. Liveweights of twin-rearing cows decreased by 16% from late pregnancy to weaning at the MSR, and by 14% at the HSR, compared to decreases of 1% for single-rearing cows. Twin calves were lighter at birth, had slower growth rates, and were lighter at weaning than single calves. In spite of weaning smaller calves twinning increased the output (kg of calf weaned) per cow and per ha, and increased the efficiency (kg calf weaned per unit of forage eaten by the cow) over single calf production by 46% at the MSR and by 58% at the HSR. Twinning also increased the marginal returns from investment in high input pastures required by the enterprise. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 12 : 1735-1740)***

Key Words : Twinning, Forage Intake, Pastures, Calf Growth, Efficiency, Beef Cattle

INTRODUCTION

Single births and long gestation in cattle restrict reproductive output relative to other farm animals. Cattle have a low natural rate of twinning of around 2-3% of births (Gordon, 1996), compared to sheep having 10-80% multiple births (Terrill, 1975) or pigs with litters typically of 7-12 (Gordon, 1997). A branding rate of around 0.8-0.9 calves annually per beef cow mated is common for the intensively farmed areas of Australia (Gleeson et al., 2003). Additionally, the cow as the breeding unit, has a high overhead metabolic demand with from 50 to 70% of the energy available from ingested feed being used in her own maintenance (SCA, 1990). Feed-cost savings of 24% per breeding cow were obtained by inducing twinning through embryo transfer in an U.S. study (Guerra-Martinez et al., 1990). However, Farquharson (1990) determined that twinning, resulting from transferring an additional embryo into a pregnant cow, was un-profitable under Australian conditions due to the high cost of embryo transfers, even when pasture-feed costs are low. An alternative approach, using controlled multiple ovulation through a vaccination procedure (O'Shea et al., 1994), appeared feasible and was estimated to be less costly under Australian pastoral conditions. This latter approach was investigated following the demonstration by Bindon et al. (1988) that immunisation of cows against native ovine *inhibin* caused an increase in ovulation rate by altering the hormonal system controlling follicle development and ovulation. To facilitate this process, the *inhibin* gene was cloned to produce recombinant *inhibin* immunogens (Forage et al., 1993). Thus a study was initiated to assess the effectiveness of prototype recombinant *inhibin* formulations as a vaccine to induce multiple ovulations and to quantify the production advantages of twinning. The production potential was assessed in groups of cows induced to calve twins by the supplemental embryo transfer procedure, mentioned above, while awaiting the outcome of studies on the efficacy of the vaccine in similar cows at the same site. This paper reports on the efficiency of producing weaned calves (at 7 months of age) from twin rearing cows compared to that from single rearing cows grazing pastures in a subtropical region of Australia characterised by moist summer-growing periods (October to April, 700 mm rainfall) separated by cooler drier periods (May to September, 300 mm rainfall).

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MATERIALS AND METHODS

Animals and treatments

Eighty-four pregnant, multiparous Angus x Hereford cows, were selected from a larger group of 126 with

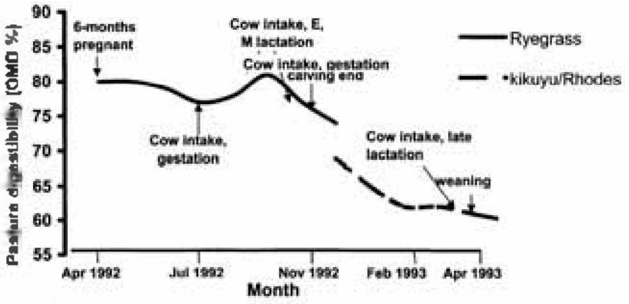

Figure 1. Grazing management and experimental sampling of single- and twin-bearing/rearing cows.

pregnancy status (single or twin) confirmed by realtime ultrasound imaging by day 100 of gestation using an Aloka 210 D×II machine fitted with 3.5 or 5 MHz probes (Aloka Co., Ltd. Tokyo, Japan). Forty-two single-bearing cows were allocated (balanced for liveweight and expected calving date) to three replications of 7 cows at 2 stocking rates (3.2 and 3.8 cows/ha; medium stocking rate [MSR] and high stocking rate, [HSR] respectively), as were 42 twin-bearing cows allocated to 3 reps of 2 stocking rates. Short-rotation ryegrass (*Lolium multiflorum*, cultivar Concord) pastures were established during the cooler drier months and were maintained by irrigation and nitrogen fertilisers during this period. Cows grazed these pastures for the last 6 months of pregnancy until September 1992, when calving was complete, and for 2 months of early lactation (November), by which date growth of these pastures had ceased and were unsuitable for further grazing. Cows and their suckled calves then grazed kikuyu/Rhodes grass (*Pennisetum clandestinum*/*Chloris gayana*, cultivar Pioneer) pastures, maintained by rainfall, until April 1993 when the calves were weaned. This pattern is given in Figure 1 relative to the estimated digestibility of the two pasture associations.

Measurements

Liveweights and fat depths : Cows and calves were weighed each month to monitor liveweights and growth rates, and to assist their management within stocking rates and parity groups. At the time of insertion of CRDs for forage intake estimates (see below), the fat cover, at the 12/13th rib, was estimated by realtime ultrasound imaging using the Aloka 210 D×II with a 5 MHz probe (Aloka Co.,Ltd. Tokyo, Japan). This was to estimate the "energy balance" of each cow during lactation.

Pasture quantity : Pasture quantity was measured using a rising plate meter (Earle and McGowan, 1979) before and after grazing of each replication of ryegrass paddocks as a grazing management guide. Also, as a guide, pasture quantity, using a dry-weight-rank technique (Haydock and Shaw, 1975), was estimated each 3-weeks in kikuyu/Rhodes grass paddocks during summer.

Forage intake : Forage intake was estimated from faeces organic matter (OM) output, determined from Cr_2O_3 dilution, released from a controlled release device (CRD: Captec model CCA, Nufarm Pty Ltd. NZ.) positioned in the rumen (Ellis et al., 1982). The estimate of faeces OM (derived from above), in combination with an estimate of digestibility of the pasture, determined *in vitro* (Alexander and McGowan, 1961) was used to estimate the forage intake of the cow as described by Barlow et al. (1988). Intakes of cows were estimated in the last 30 days of gestation, in early lactation (20 days post calving-ryegrass), mid (80 days post calving-ryegrass) and late (180 days post calving -kikuyu/Rhodes) lactation, as indicated in Figure 1. Forage intake of calves was not determined, since this study was designed to examine the relationship of cow forage intake with output of calf growth.

Milk yield : Milk yield of each cow was estimated from the milk consumed by calves using a weigh-suckle-weigh technique (Williams et al., 1979) at 08:00 h following a 16-h separation of cows and calves. The estimations were completed on three occasions-early, mid and late lactation.

Statistical analyses

Data were analysed using linear mixed models in GenStat® (Payne and Arnold, 1997), with birth type, stocking rate and lactation time included as factors in the statistical model, which also included the first-order interactions. Interactions were rarely significant and occurred in one case only (see "Forage intake"). Standard errors of differences (s.e.d) are provided for the results in each table, allowing readers to assess the significance of various comparisons.

RESULTS AND DISCUSSION

Pasture quantity and quality

There was no measurable difference in pasture quantity between paddocks grazed by single- or twin-bearing cows (i.e pregnant) up to the end of calving (September), but differences ($p<0.01$) occurred post-calving during the period that cows grazed short rotation ryegrass (August-November). These differences remained between groups on kikuyu/Rhodes grass pastures until weaning in April (Figure 2), with availability declining in paddocks grazed by all groups between February and April. There were no significant differences in pasture quantity due to stocking rate. Hence, during lactation, single-rearing cows had greater amounts of forage available to them than did twin-rearing cows. Digestibility of selected forage did not differ between paddocks of single or twin rearers (i.e. lactating cows) but changed between seasons, and species types.

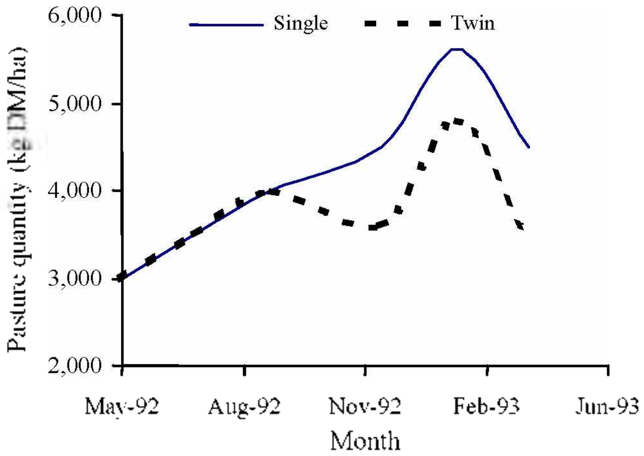

Figure 2. Mean pasture quantity in paddocks grazed by single- and twin-rearing cows, averaged across MSR and HSR as there were no significant differences due to stocking rate.

from autumn (March; 65.3%-kikuyu/Rhodes grass) to spring (September; 81.5%-ryegrass), when calving was complete and cows returned to kikuyu/Rhodes grass paddocks.

Forage intake

Intakes of organic matter (g OM/100 kg liveweight) were lower ($p<0.01$) for both single- and twin-bearing cows during the final 30 days of pregnancy than during lactation (Table 1). Within stocking rate, there was no difference in forage intake between pregnant cows, whether single- or twin-bearing, although both single and twin-bearers had lower intakes at the lower (MSR) stocking rate than those at the HSR (Table 1). This contrasts with the results of Ferret et al. (1998), also using the Cr_2O_3 dilution technique, showing that ryegrass hay intake of twin-bearing ewes was lower than that of single bearing ewes during the final trimester of pregnancy. During lactation, there was a significant interaction between stocking rate, stage of lactation and single- or twin-rearing status in forage intake of these cows. At mid lactation, within MSR, twin-rearing cows had 25% higher ($p<0.01$) intakes than single-rearing cows whereas the difference between groups at the HSR was only 9% (Table 1). Thus the cows suckling twins at the HSR were apparently unable to increase their consumption as much as those at the MSR, suggesting that they may not have been able to sufficiently increase their grazing time to achieve the increased intake from a lower quantity of forage (Figure 2). By late lactation, twin-rearing cows at the HSR had increased their foraging ability and had an 18% higher intake than single-rearing cows at the HSR. The pattern of intake changes from late pregnancy, through lactation, indicate how parity and stocking rate affected cows differently, with the twin-rearing cows having a reduced ability at the HSR for meeting increased nutrients and energy required early in lactation for maintaining their milk output over 7 months and returning to a desired liveweight for re-conception. Intake during early lactation was 180% above that during pregnancy for single-rearing cows at HSR, but declined through to the end of lactation to be only 70% above that at pregnancy. The comparable decline for twin-rearing cows at HSR was from 165 to 100%. At the MSR the decline was proportionally less, being from 180 to 110% for single-rearing cows and from 190 to 130% for twin-rearing cows. The interactions between stocking rate and rearing status preclude ascribing a pattern of intake, but lighter (see Table 2) twin-rearing cows had higher intakes than single-rearing cows (per unit of liveweight) at both stocking rates toward the end of lactation.

Table 1. Least squares means for daily forage intake (g OM/100 kg liveweight) of cows during the 3rd trimester of pregnancy and 3 stages of their subsequent lactation at high (HSR)-3.8 cows/ha, and medium (MSR)-3.2 cows/ha stocking rates

Stocking rate	Rearing status	Pregnancy late	Lactation Early	Mid	Late
MSR	Single	1,070	2,990	2,085	2,230
MSR	Twin	1,030	3,030	2,615	2,360
HSR	Single	1,250	3,485	2,245	2,150
HSR	Twin	1,280	3,390	2,450	2,535
SED		---------------------- 72.4 --------------------			

SED is the average standard error of differences between means.

Liveweight and condition

There was no significant difference between liveweights of single- and twin-bearing cows in late pregnancy, but by early lactation twin-rearing cows at the HSR were

Table 2. Least squares means for cow liveweight (kg) at selected times according to stocking rate and rearing status, and liveweight change (%) from late pregnancy to weaning

Stocking rate	Rearing status	Late pregnancy (kg)	Lactation (kg) Early	Late	Weaning (kg)	ΔLiveweight (%)
MSR[1]	Single	572	583	560	565	-1
MSR	Twin	599	557	532	501	-16
HSR	Single	584	570	588	568	-3
HSR	Twin	567	503	510	488	-14
SED		16.9	11.9	11.9	11.3	

[1] See Table 1 for definition.

SED is the average standard error of differences between means.

Table 3. Fat depth (mm) at the 12/13th rib site on cows during lactation according to stocking rate and rearing status

Stocking rate	Rearing status	Time of lactation		
		Early	Mid	Late
MSR[1]	Single	26	22	15
MSR	Twin	14	12	10
HSR	Single	27	25	20
HSR	Twin	8	9	7
SED		---------------------- 1.0 ------------------		

[1] See Table 1 for definition.

SED is the average standard error of differences between means.

Table 4. Calf birthweight, growth rate and weaning liveweight according to stocking rate and rearing status

Stocking rate	Rearing status	Birth weight (kg)	Growth rate (g/day)	Weaning liveweight (kg)
MSR[1]	Single	40	985	274
MSR	Twin	31	720	205
HSR	Single	37	945	265
HSR	Twin	31	750	209
SED		0.83	21.8	6.6

[1] See Table 1 for definition.

SED is the average standard error of differences between means.

Table 5. Milk yield (kg/day) of cows estimated from calf consumption during lactation according to stocking rate and rearing status

Stocking rate	Rearing status	Time of lactation		
		Early	Mid	Late
MSR[1]	Single	8.5	10.0	8.4
MSR	Twin	13.0	12.7	7.6
HSR	Single	6.6	11.0	7.0
HSR	Twin	11.5	9.2	6.8
SED		-------------------- 0.79 --------------------		

[1] See Table 1 for definition.

SED is the average standard error of differences between means.

Table 6. Efficiency of daily calf growth from birth to weaning in single- and twin-rearing systems according to stocking rate

Stocking rate	Rearing status	Calf growth (kg/ha)	Forage consumed by cows[1] (kg OM /ha)	Efficiency * (%)
MSR[2]	Single	3.2	45.7	6.9
MSR	Twin	4.6	45.5	10.1
HSR	Single	3.6	55.6	6.5
HSR	Twin	5.7	55.7	10.2

[1] Forage consumed daily by cows per hectare according to stocking rate.

* A measure of calf growth per 100 kg of organic matter intake by the cow = 100 [calf growth rate (from Table 4)×stocking rate×1 for single or×2 for twin]/forage consumed.

[2] See Table 1 for definition.

SED not appropriate for comparisons in this table (see text-Production effficiency).

significantly ($p<0.01$) lighter than twin-rearing cows at the MSR, and significantly ($p<0.01$) lighter than single-rearing cows at either MSR or HSR (Table 2). The effect of twin-rearing can be seen also in the decrease ($p<0.01$) in fat cover of cows at either stocking rate and at all stages of lactation (Table 3). Twin-rearing cows at the HSR had only 30%, 36% and 35% of the fat cover at the 12/13th rib of single-rearing cows at early, mid and late lactation stages respectively (Table 3). Twin-rearing cows at the MSR, had 54%, 55% and 66% of the fat cover of single-rearing cows for corresponding stages of lactation. By late lactation, and at weaning, there was no difference between liveweights of twin-rearing cows on HSR or MSR, but twin-rearing cows were lighter than single-rearing cows across stocking rates (Table 2). These differences reflect not only the energy and nutrient demands on cows of their suckling of twins but also the subsequent effect of their increased foraging on reducing the quantity of pasture available to graze subsequently. Thus, the higher stocking rate did not reduce liveweight of single-rearing cows from early lactation to weaning whereas for twin-rearing cows there was a linear ($p<0.05$) decline of their liveweight during lactation (Table 2).

The reproductive difficulty facing twin-rearing cows is that their lowered liveweight and body condition at calving delays their return to oestrus, and this delay can be quite prolonged (Robinson, 1996). In most cases cows were given standard hormonal synchronisation treatments after calving to prepare them for the next mating as soon as possible. Thus the ability to measure the effects of twin versus single calving and rearing on post-partum return to oestrus was limited in this study. However, data collected following one of the matings supported the expected detrimental effect in twinning cows. While the trend was not significant, it is likely that differences would be larger under less favourable conditions, highlighting the need for optimal nutrition to avoid such problems.

Calf growth was affected by twinning, but not by stocking rate. Twin calves were lighter at birth ($p<0.01$), had slower growth rates and were lighter at weaning than single-born calves (Table 4). Weaning weight of twin calves was 77% of that of single calves which is in accord with the 82% reported by Suzuki et al. (1998) for calves from Japanese Black-Holstein cows that had slightly higher milk yields than the Angus×Hereford crossbred cows in this study.

Milk consumption

There was no significant trend for changes in milk consumption of single calves during lactation at the MSR stocking rate whereas twin-suckled calves consumed less ($p<0.01$) milk in late, than in early, lactation (Table 5). At HSR, both single- and twin-suckled calves consumed less ($p<0.01$) milk during late than in mid lactation. For twin-rearing cows, their greater suckling activity and higher total milk yield could delay oestrus expression following calving beyond that associated with a reduced liveweight and body condition in single-rearing cows (Stevenson et al., 1997).

Production efficiency

The efficiency of each rearing status (Table 6) was calculated as the output of total calf growth (birth to weaning; Table 4) as a function of the forage eaten by the dam, estimated from the intakes measured on 4 occasions (Table 1) at both stocking rates. These two measures were significantly different between rearing systems; hence the efficiency was calculated on mean figures for each rearing system. Thus, the calculation of SED's for the comparisons in Table 6 (as done for the other tables) was not appropriate. Twinning increased the efficiency of calf growth per unit of forage organic matter eaten by 46% at the MSR and by 58% at the HSR. The cost of producing winter forage was estimated at (AUD) 11 ¢/kg OM at the time of the study, inflated somewhat by costly irrigation. Using the efficiency ratios listed in Table 6, the marginal return on pasture investment at the MSR was $1/cow/100 kg of forage consumed by single-rearing cows and $4 for twin-rearing cows, although the variable costs for embryo transfers reduce the difference between systems in gross margin returns.

CONCLUSION

Twinning increased the efficiency of weaner calf production per breeding unit, per unit of forage eaten and per hectare. Consequently, twinning also increased gross margins from the high input-cost pastures which were necessary to supply the energy and nutrients required for a high level of production. The profitability of twin-rearing beef cattle is dependent on reliable and low cost techniques to achieve twin births as well as efficient pasture utilisation. Whilst twinning, using surrogate dams, may be attractive to increase numbers of valuable progeny from superior females, the value of these progeny has to exceed that of commercial cattle to ensure positive enterprise gross margins. In addition, whether twinning cows can sustain an annual calving, especially using *anti-inhibin* vaccines, requires longer-term studies with repeated matings. The application of twinning for commercial beef production also needs to account for increased management complexities (such as litter size diagnosis and additional supervision at calving), incurring extra costs which also affect profitability.

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