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Livestock Science 110 (2007) 148 – 153
LIVESTOCK SCIENCE
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Effects of cow parity on voluntary hay intake and performance responses to early weaning of beef calves☆

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Received 25 May 2006; received in revised form 9 October 2006; accepted 30 October 2006

Abstract

The objective of this study was to investigate the effect of early calf weaning from both primiparous and multiparous beef cows on hay intake and measures of performance. Over two consecutive years, 96 Brahman × British cows (48 cows/year) and their calves were stratified by parity and calving date and randomly assigned to one of two weaning treatments ($n=24$ cows/weaning treatment; 12 primiparous and 12 multiparous). Weaning treatments consisted of normal-weaned (calf remaining with cow throughout the study) or early weaned (calves removed from cow at 86±5 days of age). An estrus synchronization and fixed-timed artificial insemination protocol (CO-Synch + CIDR) was applied to all cows at 21 days after early weaning. Following fixed-timed artificial insemination, cows were put onto bahiagrass (*Paspalum notatum*) pastures (3 pastures/treatment; 4 cows/pasture) for a 60-day period to evaluate voluntary hay intake. During this time, cows were provided free-choice access to grass hay ('Florona' stargrass; *Cynodon nlemfuensis*) and 2.3 kg per head daily of a urea-fortified molasses supplement. Hay intake was determined by subtracting the dried weight of residual hay from the amount offered over the 60-day evaluation period. Cow body weight and body condition score were measured on day 0 and 60. Immediately following the hay intake determination period, all cows were grouped by weaning treatment and exposed to mature Angus bulls for 21 days. Pregnancy determination to artificial insemination and natural service was determined by transrectal utrasonography on two occasions conducted 60 days after artificial insemination and again 40 days after bull removal. Multiparous cows had greater hay dry matter intake ($P<0.001$), body weight ($P<0.001$), and body condition score ($P<0.001$) than primiparous cows throughout the study. Overall, early weaning resulted in greater than a 16% decrease ($P<0.01$) in hay dry matter intake, irrespective of parity. Early-weaned cows had greater ($P<0.01$) body weight and body condition score than normal-weaned cows on day 60, but not day 0. Pregnancy rate to artificial insemination was greater ($P<0.01$) for multiparous compared to primiparous cows. There was a weaning treatment × parity interaction for overall pregnancy rate, whereas early-weaned primiparous, but not multiparous, cows had a greater ($P<0.05$) overall pregnancy rate compared to their normal-weaned contemporaries. These data imply that early calf weaning (90 days of age) will increase body weight and body condition in both multiparous and primiparous cows; however, early-weaning provides a greater advantage to overall pregnancy rate when applied to primiparous versus multiparous cows.

Keywords: Beef; Early weaning; Parity; Pregnancy; Forage intake

☆ Contribution from the Florida Agric. Exp. Stn. This research was supported in part by a grant from the USDA-NRI Tropical–Subtropical Agric. Res. Program.
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doi:10.1016/j.livsci.2006.10.014

1. Introduction

The largest limitation for beef cow maintenance is availability of energy (Jenkins and Ferrell, 1983) and the production efficiency of beef cattle is often restrained by reproductive failure (Dickerson, 1970; Dziuk and Bellows, 1983; Koch and Algeo, 1983). Research has shown that cow body condition score (Richards et al., 1986; Rae et al., 1993), seasonality (Randel, 1984), nursing (Moss et al., 1985; Stevenson et al., 1997), and nutrition (Wiltbank et al., 1962) are all key elements affecting the length of postpartum anestrous. The duration of postpartum anestrus will often dictate the chance of a cow to become pregnant during a limited breeding season (Wiltbank, 1970). The search for management alternatives that are focused on decreasing the intake of supplemental energy feeds without risking productivity is an important consideration toward the sustainability of beef cow-calf production systems. Early calf weaning has traditionally been recommended as a management approach to address shortages in forage as a result of extreme environmental conditions. However, early weaning may also improve the reproductive efficiency of beef cows through its use as a normal, annual management practice. Two- and three-year old primiparous cows may benefit most by early calf weaning due to their limitations in maintaining optimal body condition through lactation (Arthington and Minton, 2004). Our hypothesis was that early calf weaning will result in a greater enhancement of cow performance, by reducing postpartum anestrus and enhancing subsequent pregnancy rate, in two- and three-year old primiparous cows. To test this hypothesis, our objectives were to investigate the effects of early calf weaning from both primiparous and multiparous cows on hay dry matter intake, the period of postpartum anestrus, and fertility as measured by pregnancy rate to both timed-AI and natural service.

2. Materials and methods

2.1. Animals, care and diet

The animals utilized in these experiments were cared for by acceptable practices as outlined in the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1999). The study was conducted over two consecutive years at the University of Florida–IFAS, Range Cattle Research and Education Center, located in southwest Florida, United States. The study utilized a total of 96 Brahman × British crossbred cows (48/year) within a completely randomized design with a 2 × 2 factorial arrangement of treatments. Cows and their calves were stratified by parity (primiparous and multiparous) and calving date and randomly allotted to weaning treatments ($n = 12$ cows/parity × weaning treatment × year). Weaning treatments consisted of early- or normal-weaned. The average calf age at early weaning was 86 ± 5 days of age. Normal-weaned calves represented a typical management schedule observed on beef cow/calf production systems, whereas calves remain with their dams until 6 to 9 months of age. Therefore in the current study, normal-weaned calves remained with their dams throughout the course of the study.

On day 21 after early weaning all cows were estrous synchronized and inseminated artificially at a predetermined fixed time using the CO-Synch + CIDR protocol. All cows received a single i.m. injection of GnRH (100 µg of Gonadorelin; OvaCyst; Phoenix Scientific, Inc., St. Joseph, MO, United States), and were implanted with an intravaginal progesterone-releasing device containing 1.38 g of progesterone (CIDR, Pfizer Animal Health, New York NY, United States). Seven days later the CIDR was removed, and each cow received a single 25 mg i.m. injection of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$; Lutalyse; Pfizer Animal Health, New York, NY, United States). Sixty hours later, all cows were inseminated artificially with semen obtained from a single collection from an Angus bull, and received a second injection of 100 µg of GnRH. Following fixed-timed artificial insemination, all cows were placed into study pastures for 60 days. Cows were maintained on 1.2 ha bahiagrass pastures (*Paspalum notatum*; 3 pastures/treatment; 4 cows/pasture). Cows were provided free-choice access to stored hay ('Florona' stargrass; *Cynodon nlemfuensis*) and 2.3 kg/hd daily of urea-fortified supplemental molasses (16% crude protein). Nutrient composition of hay, supplemental molasses, and mineral are provided in Table 1.

Table 1
Nutrient composition of hay, supplement, and pasture

Item	CP [a]	TDN [b]	Ca	P
	% (dry matter basis)			
Hay	5.9	52.5	0.48	0.14
Molasses supplement [c]	21.0	82.1	1.15	0.04
Pasture	8.0	55.2	0.45	0.10

All values are the means of duplicate analyses. Analysis was conducted by wet chemistry using a commercial laboratory (Dairy One Forage Laboratory, Inc., Ithaca, NY). All cows were provided free choice access to a complete salt-based trace mineral supplement that contained 12% Ca, 12% P, 7.8% Na, 0.18% Zn, 0.10% Mn, 699 ppm Cu and 89 ppm Co.

[a] Crude protein.
[b] Total digestible nutrients.
[c] Urea-fortified sugarcane molasses.

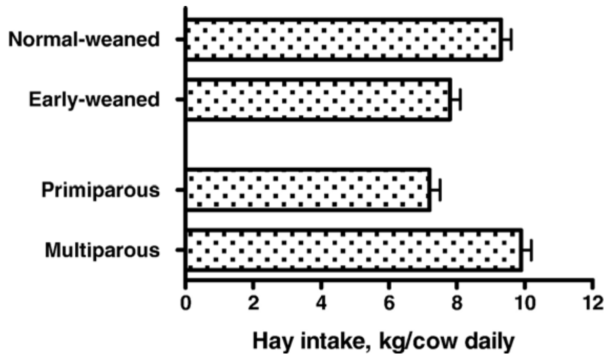

Fig. 1. Effect of cow parity and weaning treatment on voluntary hay dry matter intake. Each hay bale was weighed prior to placement in the pasture and samples collected for dry matter determination. At the end of a 60-day hay intake evaluation, the hay residue from each pasture was collected and divided into dry and wet fractions. These fractions were weighed individually, mixed, and samples were collected for dry matter determination. Intake was calculated as the difference between hay dry matter offered less residual hay dry matter remaining. Early- versus normal-weaned ($P<0.01$) and primiparous versus multiparous ($P<0.01$).

Pregnancy was diagnosed by transrectal ultrasonography (7.5-MHz transrectal transducer; Aloka 500 V; Corometrics, Wallingford, CT, United States) on day 60 after artificial insemination to determine the presence of a viable fetus, thereby assessing artificial insemination pregnancy rates. All cows were then grouped by weaning treatment and put onto two separate pastures. Each group was exposed to two mature Angus bulls for 21 days. Forty days after bull removal, pregnancy to natural service was again confirmed by transrectal ultrasonography.

2.2. Sample collection and analyses

The percentage of cows cycling at the time of early weaning was determined by the measurement of blood progesterone concentration in two samples collected 10 days apart, beginning 11 days after early weaning. When either of 2 blood samples had concentrations of progesterone ≥1 ng/mL, the cow was considered to be cycling (Perry et al., 1991). Concentrations of progesterone were determined by radioimmunoassay (Seals et al., 1998) using DPC kits (Diagnostic Products Corp., Los Angeles, CA, United States) in a single assay with an intra-assay CV of 9%. Sensitivity of the assay was 0.01 ng/tube and 0.1 mL of plasma volume was assayed. Cow body weight and body condition score (1 to 9 scale, determined as the mean of two independent technicians; Kunkle et al., 1999) were collected at the time of early weaning and 81 days later at the conclusion of the hay dry matter intake determination period. For determination of hay consumption, each hay bale was weighed prior to placement in the pasture and samples collected for dry matter determination. At the end of the 60-day hay intake evaluation, the hay residue from each pasture was collected and divided into dry and wet fractions. These fractions were weighed individually, mixed, and samples were collected for dry matter determination. Intake was calculated as the difference between hay dry matter offered less residual hay dry matter remaining.

2.3. Statistical analysis

Analysis of initial and final body weight and body condition score, and hay intake were achieved by ANOVA for a completely randomized design using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) (Littell et al., 1996). The model statement contained the effects of cow parity, weaning treatment, and year and all possible interactions. With the exception of hay intake, data were analyzed using cow (parity × weaning treatment × year) as the random effect. For hay intake the random effect in the model was pasture (parity × weaning

Table 2
Effect of beef cow parity and time of weaning on body weight and body condition score (least square means)

	Multiparous	Primparous	SEM	P=	Early-weaned[a]	Normal-weaned[a]	SEM	P=
BW, kg[b]								
Initial (day 0)	460	342	10.0	<0.01	405	397	10.0	0.39
Final (day 60)	456	360	9.1	<0.01	426	389	9.1	<0.01
Change	−4.1	18.1	2.7	<0.01	21.8	−7.7	2.7	<0.01
BCS[c]								
Initial (day 0)	5.1	4.3	0.1	<0.01	4.7	4.7	0.1	0.59
Final (day 60)	5.0	4.3	0.2	<0.01	5.2	4.1	0.2	<0.01
Change	−0.1	0	0.1	0.70	0.5	−0.6	0.1	<0.01

[a] Early-weaned cows had their calves removed 21 days prior to the initial day 0 sample collection and averaged 86±5 days of age. Normal-weaned cows remained with their calves throughout the course of the study.
[b] Cow body weight collected following a 16 hour feed and water withdrawal period.
[c] Cow body condition score values are the mean of two technician's scores using a nine-point scale, where 1=emaciated and 9=obese.

Table 3
Effect of beef cow parity and time of weaning on measures of reproductive performance

Item	Multiparous	Primiparous	P=	Early-weaned [a]	Normal-weaned [a]	P=
Pregnancy to AI, %	58.7	30.4	<0.01	52.2	37.0	0.14
Cycling at synchronization, %	70.2	29.8	0.15	46.8	53.2	0.55
Calving interval, days	411±6.8	444±6.5	<0.01	424±6.1	431±5.7	0.37

AI = artificial insemination.
[a] Early-weaned cows had their calves removed 21 days prior artificial insemination. Average calf age at early weaning was 86±5 days of age. Normal-weaned cows remained with their calves throughout the course of the study.

treatment × year). Since weaning treatment was applied directly to the cow, cow was the experimental unit for all analyses except hay intake when pasture was used as the experimental unit.

Procedures GLM and CATMOD of SAS were used to analyze all categorical data. Within each model, analyses were conducted to ensure that no biases existed among treatments based on initial body weight and body condition score. The model used to analyze pregnancy rates, cows cycling at the onset of breeding, and calving interval included cow parity, weaning treatment, and year and all 2-way interactions, with body condition score as a regression covariate.

During the course of the experiment, two cows were removed from the study. One was removed due to illness and the other was removed after she allowed another calf to begin nursing her once her personal calf was removed as a result of the early weaning treatment.

3. Results

3.1. Hay intake, cow body weight, and cow body condition score

There were no significant parity × weaning treatment interactions ($P > 0.10$) for cow body weight, body condition score, or hay intake. Irrespective of weaning treatment, multiparous cows consumed 38% more ($P < 0.01$) hay than primiparous cows (Fig. 1). When compared as a percentage of cow body weight, hay intake did not differ among cow parity (0.98 and 0.95% for multiparous and primiparous cows, respectively). Irrespective of cow parity, early-weaned cows consumed 16% less ($P < 0.01$) hay (Fig. 1) and gained more body weight and body condition score over the 60-day sampling period than normal-weaned cows (Table 2). Although multiparous cows were heavier ($P < 0.01$) and possessed a greater ($P < 0.01$) body condition score on both day 0 and 60, they lost more ($P < 0.01$) body weight over this period of time compared to primiparous cows (Table 2).

3.2. Reproductive performance

There were no parity × weaning treatment interactions associated with cow pregnancy rate to artificial insemination or calving interval ($P > 0.20$). Although not statistically significant ($P = 0.15$), there was a numerical advantage for a greater percentage of multiparous cows to attain postpartum estrus prior to the start of the estrous synchronization protocol (10 days after early weaning) compared to primiparous cows (Table 3); however, there were no differences ($P = 0.55$) among early- and normal-weaned cows. The percentage of cows becoming pregnant to artificial insemination was greater ($P < 0.01$) for multiparous compared to primiparous cows, and tended ($P = 0.14$) to be greater for early-weaned compared to normal-weaned cows (Table 3). There tended ($P = 0.08$) to be a weaning treatment × parity interaction for overall pregnancy rate, whereas early-weaned, primiparous cows had a greater ($P < 0.05$) overall pregnancy rate when compared to normal-

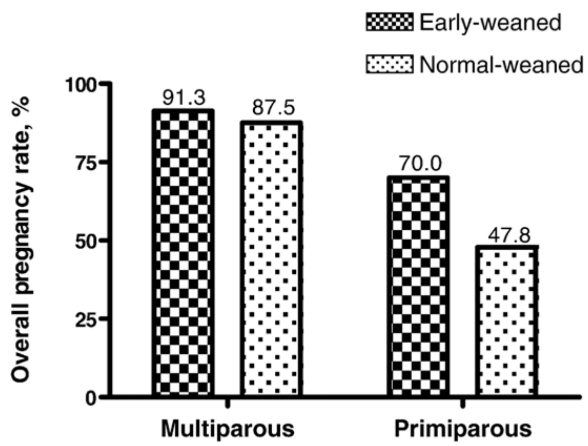

Fig. 2. The effect of cow parity and weaning treatment on overall pregnancy rate. Overall pregnancy rate is the sum of cows pregnant to timed artificial insemination and natural bull exposure. Pregnancy determined by transrectal ultrasonagraphy performed 40 days following bull removal. Early-weaned cows had their calves removed 21 days prior to artificial insemination at an average age of 86±5 days. Normal-weaned cows remained with their calves throughout the course of the study.

weaned, primiparous cows (Fig. 2). However, there was no difference ($P=0.66$) in overall pregnancy rate among early- and normal-weaned multiparous cows (Fig. 2). Calving interval was greater ($P<0.01$) for primiparous compared to multiparous cows but was not affected ($P=0.37$) by weaning treatment (Table 3).

4. Discussion

4.1. Hay intake, cow body weight, and cow body condition score

The cow-based energy costs associated with raising a calf are important to the efficiency of a beef cow-calf production system. The decrease in voluntary hay intake in response to early calf weaning is an important observation in this study (Fig. 1). Considering that total feed costs can account for as much as 70% of annual cow maintenance costs, this reduction in hay intake has important economic relevance. Similar to these results, Marston and Lusby (1995) noted that lactating cows consume greater amounts of forage than gestating cows. Johnson et al. (2003) reported that each kg increase in milk yield was associated with a 0.33 and 0.37 kg increase in forage dry matter intake for early and late lactation, respectively. Further, supplemental energy is widely viewed to be more beneficial for primiparous compared to multiparous cows. Hansen et al. (1982) reported that the postpartum anestrous period of primiparous heifers was reduced when a high-level of nutrition was provided. However, the authors did not obtain a similar response from the same cows during their second and third lactation (multiparous).

As would be expected, multiparous cows were heavier ($P<0.01$) than primiparous cows at both the start (day 0) and conclusion (day 60) of the feeding period. This response is due to the fact that the primiparous cows had not yet achieved full mature body weight by two years of age. Irrespective of parity, early weaning resulted in greater body weight gain. We associate this response with the removal of energy demands associated with lactation in the early-weaned cow. In a previous study (Arthington and Minton, 2004), normal-weaned primiparous cows were shown to require 59% more energy than non-weaned primiparous cows to maintain a similar amount of body condition.

4.2. Reproductive performance

The improved artificial insemination and overall pregnancy rate of multiparous versus primiparous cows is likely due to their greater initial body condition score. Cow body condition score has a well-known impact on the attainment of pregnancy in beef cows. A nearly 30% reduction in overall pregnancy rate was reported in beef cows that had a body condition score of 4 versus 5 (Rae et al., 1993). The cows surveyed in that study consisted mainly of Brahman-influenced genetics (*Bos indicus*), similar to the cows utilized in the current study. In *Bos taurus* cattle, pregnancy rates to artificial insemination were shown to increase by 23% for every unit increase in body condition score (Lamb et al., 2001).

Early-weaning resulted in a tendency ($P=0.14$) for more cows to become pregnant to fixed-timed artificial insemination, even though there were no differences ($P=0.55$) among weaning treatments relative to the percentage of cows cycling prior to estrous synchronization. These data imply that the removal of the calf, via early-weaning, resulted in an improved response to estrous synchronization. This response is likely due to a prolonging of postpartum anestrus as a result of calf suckling, which has been reported to be an important component of lengthened postpartum anestrus in beef cows (Williams, 1990; Lamb et al., 1997; Stevenson et al., 1997). Lucy et al. (2001) reported that the overall response to the CIDR+$PGF_{2\alpha}$ treatment would depend on the proportion of cattle that are cycling at the start of the breeding season. Taken together, these data suggest that early calf weaning may improve responses to estrous synchronization in postpartum anestrus cows.

Age and parity have a marked effect on postpartum anestrus (Short et al., 1990). In the current study, primiparous cows had a greater ($P<0.05$) reproductive benefit to early weaning, as measured by overall pregnancy rate, than multiparous cows. This response is the result of multiple factors; however two factors are likely the main contributors, 1) hastened postpartum anestrus as a result of discontinued suckling stimulus, and 2) improved BCS of early-weaned primiparous cows. Similar to these results, Laster et al. (1973) reported that, when compared to cows suckling calves, early-weaned primiparous cows experienced a 26% overall increase in pregnancy rate compared to an increase of only 7.9% in multiparous cows.

As beef producers consider the economic implications of early weaning, the value of the early-weaned calf must be a factor. Considering the dairy industry's methods of weaning and rearing calves, it is reasonable to expect that early-weaned beef calves (70 to 90 days of age) can perform as well as normal-weaned calves. However, performance responses are highly dependent upon the presence of high quality forage (Arthington and Kalmbacher, 2003) or adequate concentrate supplement (Vendramini et al., 2006). The optimal system for rearing early-weaned calves will be dependent upon the forage and feed resources available within the region of operation and season at which early weaning would be performed. Once early-weaned calves are reared to an age of normal weaning (6 to 9 months) they have an increased opportunity to gain body weight more efficiently and produce carcasses of greater quality grade than their early-weaned contemporaries during subsequent growing and finishing periods (Myers et al., 1999; Arthington et al., 2005).

5. Conclusions

The use of early calf weaning (approximately 90 days of age) will reduce the cow's energy requirements associated with lactation and result in an increase in cow body weight and body condition score. Due to the reduction of forage dry matter intake, early-weaning may provide a savings of 135 kg of hay/lactating cow over a 90-day breeding season. The reproductive benefits of early-weaning are greatest for primiparous cows as measured by overall pregnancy rate.

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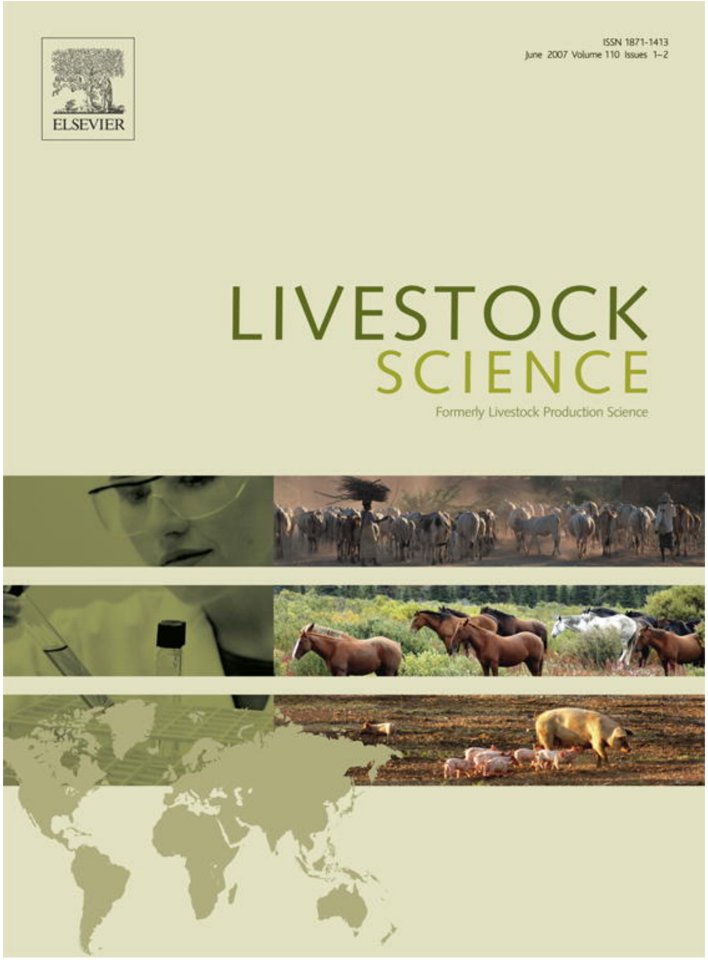
ISSN 1871-1413
June 2007 Volume 110 Issues 1–2
ELSEVIER
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SCIENCE
Formerly Livestock Production Science