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Effects of Calving Season on Stocker and Feedlot Performance

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Abstract

In environments where cool-season forages are the major forage resource, shifting calving season from winter to spring may match up forage nutrient supply with animal nutrient demands and thereby reduce purchased feed cost. However, calf BW at weaning in the fall may be less. The objective of this experiment was to determine the effect of calving season and age at weaning on stocker and finishing phase performance. Cows were assigned to late winter (LW), early spring (ES), or late spring (LS) calving seasons. Steers in the LW and ES groups were weaned at 190 and 240 d of age. Steers in the LS group were weaned at 140 and 190 d of age. Delaying the calving season reduced ($P < 0.01$) the age and BW of the calf at entry into the stocker phase and finishing phases. For the steers grown and developed in Oklahoma, overall stocker gain was similar ($P > 0.10$) among the 6 treatments groups. Steers developed in Montana had greater stocker ADG than steers grown in Oklahoma, and stocker ADG decreased ($P < 0.01$) as weaning age decreased. Steers born in LS produced carcasses that had less ($P < 0.05$) marbling, fat thickness, quality grade, and yield grade than steers born in LW or ES, but had greater ($P < 0.10$) ADG. Finishing steers on pasture with ad libitum access to high-energy feed produced leaner carcasses, but pasture-finished steers were not as efficient in converting feed DM to gain as steers finished in dry lot. In a vertically integrated enterprise, delaying the calving season resulted in more of the BW gain being achieved in the finishing phase.

Key words: calving season, age at weaning. wheat pasture, growth, beef cattle

Introduction

Feed in the form of pasture, as well as hay and purchased supplements, are major input costs in cow-calf production systems, and the kilograms of calf produced represent the major output. In order to increase gross revenues, cow-calf producers can implement management practices that result in greater calf BW at weaning (Julien and Tess, 2002). Two critical decisions that cow-calf producers can make are season of calving and time of weaning. These decisions may also affect postweaning calf performance and carcass traits (Thrift and Thrift, 2004). Changing the calving season to shift the nutrient demands of the cow for different phases of the production cycle to match available forage resources can reduce the need for purchased feeds and decrease costs of production (Bellido et al., 1981; Bagely et al., 1987; Short et al., 1996). Early weaning of steers can reduce the nutritional demands placed on the cow for lactation and improve cow body condition score, BW gain and reproductive performance (Thrift and Thrift, 2004). When early weaned steers are placed in the feedlot directly after weaning, they are more efficient in converting concentrate feed to gain than older steers weaned later in the year and placed in the feedlot (Myers et al., 1999b). However, the majority of the calves produced in the United States do not go directly to the feedlot at weaning. Instead, they go through a stocker phase for 50 to 200 d before entering the feedlot for finishing (Peel, 2003). The objectives of this experiment were to determine the effect of calving season and age at weaning on performance during the stocker and finishing phases and to determine the effect of finishing system on performance and carcass characteristics.

Materials and Methods

This experiment was conducted over a 3-yr period at the USDA-ARS Grazinglands Research Laboratory near El Reno, OK (35° 32′ N 98° 2′ W) and was a part of a larger study

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TABLE 1. Description of the 6 different treatment groups, month of weaning and shipment, and length of winter and spring grazing period.

	Calving season[a]					
	LW	LW	ES	ES	LS	LS
Age at weaning, d	190	240	190	240	140	190
Month of weaning	Aug	Oct	Oct	Dec	Oct	Dec
Month shipped[b]	Nov	Nov	Nov	Jan	Nov	Jan
Stocker phase						
Winter, d	112	112	112	36	112	36
Spring, d	84	84	84	84	84	84
Total, d	196	196	196	120	196	120

[a]LW = late winter, ES = early spring, LS = late spring.

[b]Month in which steers were shipped from Montana to Oklahoma.

(Grings et al., 2005, 2006). All procedures used in this portion of the experiment followed the recommendations of the Consortium (1988) and were approved by the USDA-ARS Grazinglands Research Laboratory Animal Care and Use Committee. The cow-calf portion of the study was conducted at the USDA-ARS Fort Keogh Livestock and Range Research Laboratory near Miles City, MT (46° 22′ N 105° 5′ W). In 1998, 600 spring calving cows were randomly assigned to calve in 1 of 3 seasons as described by Grings et al. (2005). Cross-bred cows were bred by natural service to bulls from a composite herd (1/2 Red Angus, 1/4 Tarentaise, and 1/4 Charolais). Calves were born in late winter (**LW**; average = February 8), early spring (**ES**; average = April 5), or late spring (**LS**; average = May 31). Calves produced in each calving season were weaned at 2 times: 190 and 240 d for LW and ES and 140 and 190 d for LS (Table 1). Cattle assigned to each calving season were managed as a single herd. Steers within each herd were randomly assigned to weaning groups. Steers received pre-weaning vaccines about 3 wks before weaning and booster vaccinations at weaning.

After weaning, steers were housed in pens for about 3 wk and fed a silage-based growing diet formulated for ADG of 0.8 to 1.0 kg. After the 3-wk post-weaning recovery period, one third of the calves from each treatment group were shipped 1800 km to El Reno, OK (Table 1). Two-thirds of the steers were retained in Montana and divided into 2 groups. Each group had calves from each of the 6 calving season and weaning combinations. One group of calves stayed in Montana for growth, finishing, and harvesting; the effect of calving season and weaning age on performance was reported by Grings et al. (2006). The remaining calves were housed in 1 of 3 outdoor pens (1,338 m^2) with one pen per calving season. Both weaning ages from a calving season were housed together. Calves were fed (once per day) a growing diet consisting of 60.5% corn silage, 33% chopped alfalfa hay, and 6.5% of a barley-based protein-mineral supplement (DM basis) with urea and soybean meal as the nitrogen sources. The diet contained 40% DM, 13% CP, and 28% ADF and was calculated to yield an ADG of 1 kg. At the end of the growth and development phase (average calendar date = May 21), these calves were transported to El Reno, OK for finishing with the calves transported earlier in November or January.

Stocker Phase in Oklahoma. One third of the steers in each of the 6 treatment groups were assigned to be shipped to Oklahoma (n = 274). Steers were transported by commercial carriers in November or January of each year. The steers that were weaned in August and October were shipped to El Reno in November (average calendar date = November 9) and steers that were weaned in December were shipped to El Reno in January (average calendar date = January 25). Steers shipped in November were weighed individually upon arrival and were given ad libitum access to warm-season grass hay and limit-fed a 20% CP supplement (0.9 kg/calf) for 14 d before beginning the stocker phase of the experiment. Steers that arrived in January were housed in a dry lot for 3 d, fed hay and supplement, and then added to the pastures containing the steers shipped in November. During the winter phase of yr 2, no wheat (*Triticum aestivum*) pasture was available because of a drought. Therefore, steers were confined to a 25-ha dormant warm-season grass pasture with ad libitum access to warm-season grass hay and a self-feeder containing a diet of 63.5% ground corn, 18.0% ground alfalfa hay, 10% cottonseed meal, 5% molasses, 2% limestone, 0.8% sodium bicarbonate, 0.7% magnesium oxide, and 44 mg of monensin (Elanco Animal Health, Indianapolis, IN)/kg of ration. Magnesium oxide was used to limit intake of the mixed ration to approximately 1% of BW. The mixed diet was formulated to contain 14% CP, 1.86 Mcal/kg of NE for maintenance, 1.20 Mcal/kg of NE for gain, and 130 mg of monensin/d. The combination of hay and mixed diet was calculated to yield an ADG (0.8 to 1.0 kg) similar to that anticipated if winter wheat pasture had been available (Phillips et al., 2006).

Wheat pasture was available for grazing during the winter phase (November to March) of yr 1 and yr 3 and steers grazed a single wheat pasture at a stocking rate of 1.0 steer/ha. At the end of the winter phase (all 3 yr), steers were individually weighed and the stocking rate was increased to 3.3 steers/ha. During the spring, steers were managed as a single herd and grazed annual cool-season grasses, predominately winter wheat and *Bromus* sp. until the finishing phase began in June. During both the winter and spring grazing season, steers had ad libitum access to trace mineralized salt block (TM salt block, Champion Choice, Cargill, Minneapolis, MN).

Wheat pastures (mean size = 55 ha) were established in September of each year using clean-tillage farming practices. Wheat (*Triticum aestivum* var. Pioneer 2174) was planted at 100 kg seed/ha and fertilized with 90 kg of N/ha annually. Forage from 5 randomly selected areas (0.5m^2) were clipped to a residual height of 2.5 cm, dried at 65° C for 72 h, and used to estimate the amount of forage available for grazing at the beginning of the grazing period.

Finishing Phase. Steers that were retained in Montana for growth and development (n = 250) were transported to Oklahoma for finishing in May of each year. Upon arrival, calves were placed on tallgrass native grass pasture for 14 d to recover from transportation stress. At the beginning of the finishing phase (average calendar date = June 7), calves were blocked by preweaning groups (LW190, LW240, ES190, ES240, LS140, and LS190) and site of winter and spring growth and development (Montana or Oklahoma), then randomly assigned to 1 of 2 finishing systems — conventional and pasture finishing.

Steers assigned to the pasture finishing system were sorted by previous treatment groups and randomly assigned within group to 1 of 4 (yr 1) or 3 (yr 2 and 3) warm-season grass pastures (yr 1 and 2 = Old World Bluestem *Bothriocloa* spp.; yr 3 = Bermudagrass *Cynodon dactylon*) at a stocking rate of 6.1 steers/ha. Forage availability at the beginning of the grazing season was 3,100 ± 1,280 kg of DM/ha. When approximately 80% of the standing forage had been removed (average calendar date = July 10), a self-feeder containing the same diet as that fed to steers in the conventional finishing system was placed in each pasture. Steers had ad libitum access to the self-feeder until they were removed for harvesting. Self-feeders were weighed weekly to determine feed intake.

The conventional confinement system used 8 (yr 1 and 2) or 4 (yr 3) pens with 5.1 m^2 of surface area/steer. Each pen contained one steer from each of the 12 treatment combinations. Four of the 8 pens were equipped with a Pinpointer (PLM Corp. Cookeville, TN) to determine individual intake (yr 1 only). The other 4 pens contained a trough (0.4 m/calf) for group feeding. In yr 3 an additional 8 smaller pens were used to determine individual intake. These pens had 2.6 m^2 of surface area/steer and were equipped with Calan head gates (American Calan Inc., Northwest, NH). Fresh feed was provided daily and orts were removed weekly (Calan head gates) or monthly (group fed).

Steers fed in confinement were initially fed a diet containing 48% ground alfalfa hay, but the amount of hay was reduced by approximately 13% each week until the diet contained only 8% alfalfa hay. The final finishing diet contained 12.3% CP, 2.06 Mcal/kg NE_m, and 1.34 Mcal/kg NE_g. In yr 1 and 3, the diet contained 33 mg of lasalocid/kg (Alpharma, Fort Lee, NJ), but in yr 2 a combination of 35 mg of monensin/kg and 11.5 mg of Tylan (Elanco Animal Health, Indianapolis, IN) were used. Diet DM was determined weekly by drying a sample in a forced air oven at 60°C for 72 h.

Before entering the feedlot phase of the experiment, all steers were weighed on 2 consecutive days, treated for internal parasites (Cydectin, Fort Dodge Animal Health, Fort Dodge, IA) and implanted (zeronal 36 mg, Ralgro, Schering-Plough Animal Health, Union, NJ). A steer was considered finished when the fat thickness over the 12th to 13th rib was ≥ 1.0 cm, which was estimated visually by experienced personnel. The day before harvesting, steers were removed from the pen or pasture, weighed individually, and shipped the next morning to Amarillo, TX (350 km) for processing. A total of 3 harvesting dates were used in yr 1 and 4 harvesting dates in yr 2 and 3. Hot carcass weight, longissmus muscle, fat thickness over the 12th to 13th rib, marbling score (3.0 = slight, 4.0 = small, and 5.0 = modest), quality score (11 = select, 12 = low choice, and 13 = choice), and yield grade were collected on each carcass by the Cattleman's Carcass Data Service (West Texas A&M University, Canyon, TX).

Statistical Analysis. Data from the stocker phase of the experiment were analyzed using MIXED MODEL procedure of SAS (SAS Inst., Inc., Cary, NC) with year and year × treatment as random effects. The data collected during the stocker phase was divided into 2 sets based on the month of shipment to Oklahoma. The first data set included steers (LW190, LW240, ES190, and LS140) that arrived in Oklahoma in November. When a significant F value ($P < 0.10$) was observed, contrasts were used to determine the effect of calving season or weaning group on BW changes (Steel and Torrie, 1980).The following 3 contrasts were used: 1) contrast of weaning at 190 d vs. 240 d of age, late winter calving season only (LW190 vs. LW240); 2) contrast of weaning in October at 240 d vs. 190 d (LW240 vs. ES190); and 3) contrast of weaning in October at 190 d vs.140 d (ES190 vs. LS140). The second set of data contained steers (ES240 and LS190) that were shipped to Oklahoma in January of each year. All means are presented as least squares means.

Calving season and weaning assignments created 6 different treatments in a completely randomized design within the 2 locations (Montana or Oklahoma) used for growth and development. Feedlot performance and carcass data were analyzed using a mixed model with treatment, location used for growth and development and finishing system as the fixed effects. Year and year (treatment × location of growth and development × finishing system) were considered random effects. When a significant F value ($P < 0.10$) was observed, contrasts were used to determine the effect of treatment on feedlot performance and carcass characteristics. Observations on steers used to determine individual DM intake formed a separate data set. Because intake data was only collected on steers fed in confinement, the model contained the 6 treatments created by calving season and weaning group combinations and previous stocker location (Montana vs. Oklahoma) as the fixed effects. All means are presented as least squares means.

Results and Discussion

Stocker performance. Previously we reported that providing ad libitum access to a mixed diet in a self-feeder plus ad libitum access to grass hay was a good alternative when no winter wheat pasture was available (Phillips et al., 2006). During yr 2 of the present experiment, wheat pasture was not available, and a mixed diet and hay were used. During the winter of yr 2, steers consumed 3.5 kg/d of mixed diet (fresh weight) and an estimated 3.0 kg/d of hay. Although the overall winter ADG was less during yr 2 (0.86 ± 0.02 kg) as compared to yr 1 and 3 (1.0 ± 0.02 kg) when wheat pasture was available, ADG observed during yr 2 was within the range of ADG anticipated for stocker calves on winter wheat pasture.

Within the 4 treatment groups that arrived in November (LW190, LW240, ES190, and LS140), steers in the late winter (LW190 + LW240) groups gained 27.5 kg during the 14-d receiving period, which was more ($P < 0.01$) than that observed for the steers in the ES190 group (22.8 kg). Steers in the LS140 group gained the least (19.9 kg) amount of BW during the receiving period. These rapid short-term gains are mostly GI tract fill and do not reflect true growth. Steers with greater BW would accumulate GI tract fill faster than steers with less BW because absolute amounts of DMI would be greater. However, the BW gains observed in this study were similar to those reported by Phillips et al. (1986) for calves shipped in the fall from Tennessee to Oklahoma. Steers shipped in January did not go through a receiving period but were placed on wheat pasture shortly after arrival.

Body weight and ADG during the winter and spring for each of the 6 treatments groups are presented in Table 2. Within the four treatment groups shipped in November (LW190, LW240, ES190 and LS140), delaying the calving season decreased ($P < 0.05$) the amount of calf BW at the beginning of the winter stocker phase (Table 2). Steers born later in the year had less BW because they were of younger age when weaned in October. During the 112-d winter stocker phase, ADG was less ($P < 0.01$) for steers born in late spring (LS140) than for older steers born in late winter (LW240) and early spring (ES190; Table 2). During the 84-d spring grazing season, younger steers compensated for less winter ADG and gained BW more rapidly ($P < 0.01$) than older steers. As a result, overall stocker ADG was not different ($P > 0.10$) among steers born in late winter (LW190 and LW240), early spring (ES190), or late spring (LS140).

Steers (ES240 and LS190) that were shipped to Oklahoma in January of each year had a shorter winter stocker period (36 vs. 112 d) than steers in the other 4 treatment groups that were shipped to Oklahoma in November (Table 1). As previously noted, older steers had greater ($P < 0.05$) initial BW and winter ADG than the younger steers, but overall ADG was not different ($P > 0.10$) between the 2 groups (Table 2). Overall gain (kg/calf) was less for the steers shipped in January than those shipped in November largely because the winter grazing period was 76 d shorter.

Steers grown and developed in Montana from weaning until May had a mean winter + spring ADG of 0.95 ± 0.03 kg, which was greater than the 0.72 ± 0.05 kg/d for steers grown and developed in Oklahoma. Within the steers retained in Montana for the winter and spring, steers weaned at 190 d (LW190 + ES190) had an ADG of 0.92 ± 0.01, which was less ($P < 0.01$) than the ADG of 1.03 ± 0.01 kg for steers weaned at 240 d (LW240 + ES240). Steers born in LS and weaned at 190 d (LS190) had a greater ($P < 0.01$) ADG than steers born in LS but weaned at 140 d (LS140; 0.98 vs. 0.88, respectively).

Winter stocker ADG observed in the present experiment falls within the range (0.8 to 1.2 kg) expected for stocker steers grazing winter wheat pasture from November through March in central Oklahoma (Mader et al., 1983; Horn et al., 1995; Hersom et al., 2004). Daily BW gains during the spring portion of the winter wheat grazing season (March to May) should equal or exceed winter ADG (Ford, 1984; Vogel, 1985; Phillips and Albers, 1999). In this experiment, spring ADG were about half of winter ADG because we doubled the length of the spring grazing season to take advantage of other annual cool season grasses — *Bromus* sp. and forbs that were present in the wheat pastures. Although this technique will lessen spring ADG, BW is greater upon entering the feedlot and the amount of time and feed need to reach finished BW are less as compared to calves placed in the feedlot a month earlier (Phillips et al., 1991, 2001, 2004). Delaying the start of the finishing period until June also allowed warm-season grass pastures to accumulate sufficient biomass so that intensive early grazing could be used as part of the system to finish cattle on pasture (Phillips et al., 2004).

The amount of wheat forage available for grazing can greatly influence forage DMI and stocker performance (Vogel et al., 1987; Pinchak et al., 1996). However, in the present experiment, the amount of wheat forage available for grazing averaged more than 1,700 kg DM/calf at the initiation of grazing in the winter. Using a conservative estimate for daily DMI

TABLE 2. Least squares means for BW and stocker phase BW gains of steers which were born in Montana in late winter (LW), early spring (ES), or late spring (LS) and weaned at 2 ages, then shipped to Oklahoma for growth and development.[a]

	LW190	LW240	ES190	ES240	LS140	LS190	SE
No. of steers	39	51	60	30	58	36	—
Initial BW, kg[bcde]	301	282	243	287	193	242	9.5
Winter ADG, kg[bd]	0.92	0.99	0.99	1.11	0.91	1.09	0.06
Spring ADG, kg[cd]	0.32	0.35	0.43	0.51	0.56	0.59	0.08
Overall ADG, kg[b]	0.66	0.72	0.74	0.71	0.76	0.76	0.05
Total BW gain, kg	132	140	146	87	150	94	12.7
Final BW, kg[cde]	433	422	391	372	342	333	13.6

[a]Treatments are a combination of calving season (LW, ES, and LS) and age at weaning (140 d, 190 d, and 240d); e.g., LW190 = late winter calving season and weaned at 190 d of age. Treatment groups LW190, LW240, ES190, and LS140 were shipped to Oklahoma in November for a 196-d stocker period, and treatment groups ES240 and LS190 were shipped to Oklahoma in January for a 120-d stocker period.

[b]Contrast of weaning at 190 d vs. 240 d of age, late winter calving season only (LW190 vs. LW240), $P < 0.05$.

[c]Contrast of weaning in October at 240 d vs. 190 d of age (LW240 vs. ES190), $P < 0.01$.

[d]Contrast of weaning in October at 190 d vs.140 d of age (ES190 vs. LS140), $P < 0.01$.

[e]Contrast of weaning in December at 190 d vs.140 d of age (ES240 vs. LS190), $P < 0.05$.

of 2.5% of BW, 1,700 kg of forage DM/ha would support one steer for 120 d (Vogel, 1985; Vogel et al., 1987; Phillips et al., 1996). Ford (1984) established that as long as forage available for grazing was greater than 200 kg DM/calf, DMI would not limited. Because calves were managed as a single herd each year, the amount of forage available for grazing was equal across treatment groups.

Finishing performance. Morbidity (< 1%) and mortality (<1%) were very low during both the stocker and finishing phases and were not of sufficient magnitude for statistical evaluation of treatment effects. Feedlot performance was similar ($P > 0.10$) between steers born in late winter and weaned at 190 (LW190) and 240 (LW240) d of age, but steers born in late winter (LW190 + LW240) had greater ($P < 0.05$) initial and final BW, but less ($P < 0.05$) feedlot ADG than steers born in early spring (ES190 + ES240; Table 3). As initial feedlot BW decreased, rate of gain during the feeding period and the number of days on feed increased ($P < 0.10$), but final feedlot BW decreased ($P < 0.01$). In previous work we had observed an increase in both stocker and feedlot ADG with increasing initial BW (Phillips et al., 1991), but those calves contained Brahman breeding and their pre-weaning ADG had been restricted. Because older steers are usually heavier than younger steers upon entry into the finishing phase and have greater amount of empty body protein and alimentary tracts, maintenance requirements are greater (DeHann et al., 1995; Owens et al., 1995). As a result, older calves are less efficient in converting DM to gain than younger steers (Meyers et al., 1999a,b; Schoomaker et al., 2002), but older steers are fed for a shorter period of time and produce greater carcass BW than younger steers. In contrast, Janovick-Guretzky et al. (2005) reported that spring-born calves weaned in the fall and subjected to a 274-d growth and development period prior to beginning the finishing phase had greater ADG and DMI, but less feed efficiency as compared to a peer group placed in the feedlot immediately after weaning. When no stocker or growth and development phase is used between weaning and entering the finishing phase, ADG during the finishing phase was greater for steers weaned at 270 d of age as compared to steers weaned at 150 or 210 d of age (Story et al., 2000).

The absolute amount of DM consumed each day (10.3 ± 0.3 kg) by steers in pens where individual intake was measured did not differ ($P > 0.10$) among the 6 treatment groups. However, younger steers consumed more ($P < 0.01$) DM when expressed as a percentage of average BW than older steers because they had less average BW. Steers in the LS group had less ($P < 0.01$) average BW (423 kg vs. 463 kg), but greater ($P < .05$) DMI (2.38% vs. 2.25% of BW) than observed for steers in the ES group. Steers in the LW group had greater ($P < 0.01$) BW (442 kg) and less ($P < 0.05$) DMI (2.10% of BW) than the steers in the ES group. These observations are similar to those reported by Hersom et al. (2004). The overall gain:feed ratio was 0.1212 ± 0.0215 and was not different ($P > 0.10$) among treatment groups. The feed efficiencies observed in this experiment were less than those reported by Hersom et al. (2004) for steers from Oklahoma and by Phillips et al. (2006) for

TABLE 3. Least squares means of BW, performance, and carcass traits for steers born in Montana in late winter (LW), early spring (ES), and late spring (LS), weaned at 2 ages, back-grounded in Montana and Oklahoma, then finished in convention confinement feedlots or on pasture plus feed in Oklahoma.[a]

	LW190	LW240	ES190	ES240	LS140	LS190	SE
No. of steers	77	93	100	87	99	101	—
Feedlot performance							
Initial BW, kg[cd]	432	429	386	376	338	338	6.4
Final BW, kg[cd]	565	564	541	539	520	523	9.1
Total gain, kg/calf	134	135	155	163	182	185	7.7
ADG, kg[c]	1.13	1.13	1.20	1.25	1.26	1.27	0.04
Days in feedlot, d[cd]	120	122	132	134	146	149	8.4
Age at slaughter, d[cd]	602	606	562	560	517	519	5.0
Carcass traits							
Hot carcass weight, kg[cd]	347	347	331	327	317	319	6.4
Dressing percentage	61.44	61.39	61.24	60.75	60.98	61.12	0.36
Marbling score[bd]	437	435	412	427	403	394	14
Quality grade[d]	12.0	11.9	11.8	11.9	11.6	11.3	0.13
Yield grade[d]	2.88	2.75	2.81	2.82	2.56	2.54	0.10
Longissmus area, cm^2[c]	82.6	82.7	81.9	79.7	81.1	80.8	1.10
Fat thickness, cm[d]	1.20	1.13	1.23	1.17	1.06	1.03	0.07

[a]Treatments are a combination of calving season (LW, ES, and LS) and age at weaning (140 d, 190 d, and 240 d); e.g., LW190 = late winter calving season and weaned at 190 d of age. Half of the steers were back-grounded in Montana and half in Oklahoma, but all steers were finished in Oklahoma during the summer in conventional feedlots and on pasture plus ad libitum access to high-energy feed.

[b]Slight^{00} = 300, small^{00} = 400, and modest^{00} = 500; e.g., 450 = small^{50}.

[c]Contrast of steers born in LW (LW190 + LW240) differed from those born in ES (ES190 + ES240), $P < 0.05$.

[d]Contrast of steers born in ES (ES190 + ES240) differed from those born in LS (LS140 + LS190), $P < 0.05$.

steers from Florida fed in the same facilities used in this experiment.

Carcass evaluation. Mean dressing percentage was 61.2 ± 0.3% and was not different ($P > 0.10$) among the 6 treatment groups (Table 3). Younger steers produced less ($P < 0.01$) hot carcass weight than older steers because final BW was less. Although carcass traits were not different ($P < 0.10$) between steers born in LW and ES, steers born in LS produced carcasses that had less ($P < 0.05$) marbling, fat thickness, quality grade, and yield grade than calves born in LW or ES (Table 3). Marbling scores and quality grade may have been improved if LS steers had been fed for a longer period of time to increase hot carcass weight (Myers et al., 1999a,b; Hersom et al., 2004). Hot carcass weight is a function of final BW and can be increased by extending the feeding period or by increasing BW upon entry into the finishing period (Phillips et al., 1991; Pusillo et al., 1991). Hot carcass weight is an important factor in determining the dollar value of the carcass (Pyatt et al., 2005).

Location effects. Steers that were retained in Montana after weaning for growth and development had less ($P < 0.05$) ADG during the finishing period and less ($P < 0.05$) final BW than calves shipped to Oklahoma for growth and development, but dressing percentage, marbling score, and quality grade were greater ($P < 0.05$; Table 4). As observed earlier, DMI by steers backgrounded in Montana or Oklahoma was a function of BW. Steers backgrounded in Oklahoma had greater ($P < 0.01$) average BW (476 kg vs. 445 kg) and DMI (10.6 kg/d vs. 9.6 kg/d) than steers backgounded in Montana, but when DMI was expressed as a percentage of average BW there was no difference ($P > 0.10$; 2.25 ± 0.04%) between the 2 locations.

Within each geographical region, the month of entry into the feedlot can affect DMI and ADG (Hicks et al., 1990; Pusillo et al., 1991). Daily DMI is less during the warmer, more humid summer months as compared to the cooler months (Hicks et al., 1990). The finishing phase in the present experiment was conducted during the warmest months of the year for this location. Selection criteria for cow-calf enterprises in the Northern Plains would favor animals that are more tolerant of cold temperatures. Transporting these calves from the northern plains to the southern plain for grazing in the winter may take advantage of their cold tolerance, but finishing these calves during the summer may subject them to ambient temperatures that would lead to heat stress, which would lower DMI and performance.

Finishing system. Finishing system did not interact with calving season

TABLE 4. Least squares means and pooled standard errors for BW, performance, and carcass traits for steers back-grounded in Montana and Oklahoma before being finished in Oklahoma and for steers finished in convention confinement feedlots or on pasture plus feed.

Item	Montana[a]	Oklahoma	*P* value	Feedlot[a]	Pasture	*P* value	SE
Number of steers	250	264	—	280	234	—	—
Feedlot performance							
Initial BW, kg	381	385	0.28	379	387	0.01	4.5
Final BW, kg	538	546	0.04	542	543	0.83	5.4
Total gain, kg/steer	157	161	0.16	163	155	0.01	5.4
ADG, kg	1.16	1.24	0.01	1.26	1.14	0.01	0.03
Days in feedlot, d	136	132	0.03	131	137	0.01	6.8
Age at slaughter, d	561	561	0.79	562	560	0.51	0.51
Carcass traits							
Hot carcass weight, kg	331	332	0.50	334	329	0.03	4.5
Dressing percent, %	61.43	60.87	0.01	61.67	60.63	0.01	0.24
Marbling score[b]	425	411	0.04	429	407	0.01	12.6
Quality grade	11.9	11.7	0.03	11.9	11.7	0.01	0.10
Yield grade	2.71	2.76	0.41	2.77	2.70	0.24	0.07
Longissmus area, cm^2	81.7	81.3	0.62	82.6	80.2	0.01	0.84
Fat thickness, cm	1.13	1.14	0.86	1.21	1.06	0.01	0.66

[a]Steers were grown and developed over the winter and spring in Montana or Oklahoma, but all steers were finished in Oklahoma in conventional confinement feeding (Feedlot) or on pasture with had ad libitum access to high energy diet (Pasture).

[b]Slight^{00} = 300, small^{00} = 400, and modest^{00} = 500; e.g., 450 = small.

($P > 0.10$). However, steers finished on pasture had less ($P < 0.05$) ADG, hot carcass weight, dressing percentage, marbling score, quality grade, longissmus muscle, and fat thickness than steers finished in confinement (Table 4). Steers finished in confinement consumed more ($P < 0.10$) feed DM (1,114 vs.1,064 kg/calf) than steers fed on pasture but had less ($P < 0.01$) daily feed DMI (9.2 vs. 10.7 kg/d). Daily DMI for steers fed on pasture did not include the first 33 d when the feedlot diet was not available and was not use to calculate feed efficiency. Steers fed in confinement were more ($P < 0.01$) efficient in converting DM to gain than steers calves fed on pasture (0.14 vs. 0.11 kg/kg DM). The warm-season grass pastures used in this experiment were able to provide enough forage for a 33-d grazing period each year before self-feeders were required to meet DMI needs. During this period when steers were not consuming the feedlot diet, ADG were less than those observed in dry lot. As a result, overall ADG for the finishing period were diluted. However, finishing cattle on grass utilizing the intensive early stocking strategy followed by ad libitum access to a high energy diet fed on pasture offers an alternative market for warm-season grasses, disposes of animal waste at no cost, and could increase net return per animal over finishing cattle in confinement (Phillips et al., 2004, 2006).

We have previously shown that steers finished under a conventional feeding system produced carcasses with greater quality grades, yield grades, and fat thickness over the ribs than steers finished on pasture using intensive early stocking followed by ad libitum access to a high-energy diet (Phillips et al., 2004, 2006). Differences in carcass weights between these 2 finishing systems were due primarily to lower ADG during the first 30 d of the finishing period when warm-season grass was the only dietary component for cattle on pasture. To increase body fat and marbling score, steers finished on pasture could be fed longer, but that would increase feed DM inputs and age at harvest. Increased age at harvest may be acceptable for calves from later calving seasons (ES and LS) but not for calves born in LW. Calves born in ES and LS were less than 600 d of age at harvest, whereas calves born in LW were over 600 d of age at harvest. Age at harvest could affect carcass price and could restrict the exportation of the carcass to counties that have established an age limit of 20 mo on imported beef.

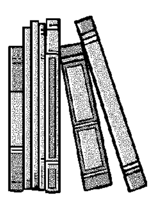
Cattle fed on pasture during the summer months may be exposed to greater heat stress from solar radiation than those fed in a feedlot with cover to provide shade (Mader, 2003). Under conditions of greater solar radiation, steers with genetic tolerance to heat stress should perform better than temperate breeds (Phillips et al., 2006). Within the present experiment, finishing steers on pasture during the summer in the southern plains was not as efficient as finishing cattle in confinement, in contrast to previous reports (Phillips et al., 2004). Geographic origin of calves, initial BW, breed, and mature BW appear to be important factors in determining the efficiency of finishing cattle on pasture.

In vertically integrated beef production systems, changes in the rate of animal gain in one segment can affect production efficiency in the next segment. For example, calves that are restricted in growth during the stocker phase would be expected to gain BW more rapidly during the feedlot phase than steers that had not been restricted (Phillips et al., 2004). Thus, reduced performance in one segment would be mitigated by above average performance in the next production phase through compensatory gain (Phillips et al., 2001, 2004; Capitan et al., 2004). At the cow-calf level, reproductive efficiency is also critical to profit making. Early weaning removes lactation stress, enhances both BW gain and body condition of cows preparing for the next breeding season, and may increase conception rates (Thrift and Thrift, 2004). It is also thermodynamically more efficient to provide nutrients directly to the calf rather than feeding the cow to produce milk for the calf, if nutrient rich feed sources are available.

In the present study, no compensatory gain was anticipated between steers of differing BW or age because calf growth rates were not restricted. However, calf BW gain was shifted from the cow-calf enterprise to the feedlot, and the season and length of the finishing period was altered, which in turn can affect feedlot performance (Hicks et al., 1990). By using different calving seasons, length of stocker phase, initiation date of the finishing period, and finishing system, harvest date, high-energy feed input, and number of days in the feedlot were in turn altered. However, changing weaning age did affect total BW gain during the stocker phase.

Implications

Cow-calf producers may alter the season of calving to influence investment of forage to meet the nutrient demands of the cow and calf. In the Northern Great Plains, shifting the calving season from winter to spring may reduce cow herd annual feed cost, but can result in less calf BW at weaning in the fall. If savings in feed cost were greater than the reduction in gross returns from the sale of less calf BW, then the practices is economical. Steers with less BW at time of shipment to the Southern Great Plains for the next production phase would have lower transportation cost ($/calf) than heavier calves because more calves can be shipped per load. Body weight gains for the stocker phase by calves shipped to Oklahoma were similar regardless of beginning BW, which was varied by changing the season of calving and time of weaning. However, stocker phase BW gains for calves retained in Montana for growth and development varied with weaning age. Younger calves had less BW upon entering the feedlot and were fed longer than older calves with greater BW. Regardless of where the steers were backgrounded during the winter and spring, finishing steers on pasture with ad libitum access to high-energy feed produced leaner carcasses, but pasture-finished steers were not as efficient in converting feed DM to gain as steers finished in dry lot. Therefore, we conclude that each system studied herein provides economic advantages depending upon market variations in both sale receipts and input costs and that those advantages vary both temporally (i.e. annually) and spatially (i.e., regionally) and flexible management strategies will be required to capture these economic advantages on a continuing basis.



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