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Effects of weaning method on postweaning performance by early weaned beef calves

John R. Jaeger,[†,1] Garrett W. Preedy,[‡] Justin W. Waggoner,[†] Keith R. Harmoney,[†] and KC. Olson[‡]

[†]Western Kansas Agricultural Research and Extension Center – Hays, Kansas State University, Hays, KS 67601, USA
[‡]Department of Animal Science and Industry, Kansas State University, Manhattan, KS 66506, USA

[1]Corresponding author: jrjaeger@ksu.edu

ABSTRACT

Health and performance of early-weaned steers were evaluated during a 56-d weaning period, a 56-d feedlot receiving period, and a 165-d feedlot finishing period. Steers (n = 239; 128 ± 14 d of age) were assigned to a 56-d weaning treatment: drylot weaning (D) or pasture weaning (P). Pasture steers grazed mature, native tallgrass range (89.2% dry matter [DM], 9.08% crude protein [CP]), without supplementation. A concentrate-based diet (18.7% CP and 1.15 Mcal NE_g/kg) was fed to D steers. Later, all steers were transitioned to a receiving, then a finishing diet and fed to a common endpoint. Body weight (BW) after and average daily gain (ADG) during weaning were greater (P < 0.01) for D than for P. Incidence of undifferentiated fever during weaning tended to be greater (P = 0.10) for D steers than for P steers. Conversely, incidence of keratoconjunctivitis was greater (P < 0.01) for P than for D during weaning (40.2% vs. 0%, respectively) and receiving (P < 0.01; 14.3% vs. 1.6%, respectively). At the start and end of receiving, D steers had greater (P < 0.01) BW compared with P steers. Drylot steers had greater (P = 0.03) ADG compared with P steers during receiving. Pasture steers tended to have greater dry matter intake (DMI) (P = 0.09) during receiving than D steers. In contrast, gain:feed (G:F) was improved (P < 0.01) for P steers than for D steers during receiving. Incidence of undifferentiated fever was not different (P = 0.99) between D and P steers during receiving. At start of finishing, D steers were heavier (P < 0.01) than P steers; however, finishing ADG was greater (P < 0.01) for P compared with D. Conversely, hot carcass weight of P steers was less (P < 0.01) compared with D steers. Drylot steers had greater DMI (P < 0.01) than P steers during finishing, whereas P steers had improved G:F (P < 0.01) compared with D steers. There were no differences (P ≥ 0.19) between treatments in DOF, carcass characteristics or United States Department of Agriculture yield grade. Growth and health during a 56-d weaning period and a 56-d receiving period were improved when steers were weaned in a drylot environment and fed a concentrate-based diet compared with non-supplemented steers weaned in a pasture environment. We interpret these data to suggest that, under the conditions of our experiment, steers preconditioned on mature, native, warm-season pasture for 56 d without supplementation were unable to compensate for previous nutrient restriction during finishing.

Key words: beef calves, carcass characteristics, weaning strategy

INTRODUCTION

Early weaning during periods of drought is commonly used by cow-calf producers to reduce grazing pressure on pastures (Rasby, 2007). This practice may result in lower calf value at weaning compared with calves weaned at conventional ages (Story et al., 2000). Retained ownership through a short-term backgrounding period may be used to improve the value of early-weaned calves. Conversely, feeding concentrate-based diets to calves weaned at less than 125 d of age has been associated with excessive fat deposition early in life and decreased carcass weights at harvest compared with feeding concentrate-based diets to calves weaned at greater than 125 d of age (Barker-Neef et al., 2001; Schoonmaker et al., 2002). In addition, Myers et al. (1999a) reported that early-weaned calves consumed more total concentrate during the finishing period than calves weaned at conventional ages, a circumstance that would increase total feeding costs and could negatively affect profit margins during times of high grain prices.

Postweaning growing programs based on either pasture or high-roughage diets fed in confinement are a viable means to reduce the use of concentrates without negatively affecting returns. Myers et al. (1999b) achieved similar days on feed (DOF) without affecting harvest body weight (BW) by grazing early-weaned calves for 82 d before placement into a feedlot compared with early-weaned calves fed a high-concentrate diet from weaning to harvest. Additionally, Bailey et al. (2016) reported that calves weaned in a pasture environment for 28 d before feedlot placement had reduced BW gain during the weaning and receiving periods compared with drylot-weaned calves; however, pasture-weaned steers achieved full compensation of BW by harvest with no differences in finishing dry matter intake (DMI), DOF, or carcass characteristics. Similarly, Mathis et al. (2008) reported that calves preconditioned on native range weighed less at the end of a 45-d preconditioning period but gained more BW during the first 75 d of finishing than calves preconditioned in a drylot.

Despite reduced BW gain during the weaning and receiving periods, pasture-weaned cattle may, in some circumstances, achieve full compensation of BW by harvest with no differences in finishing DMI, DOF, or carcass quality compared with drylot-weaned cattle. Beef producers who retain ownership of calves through finishing may be able to employ a low-cost preconditioning program involving grazing to minimize costs, while simultaneously experiencing similar finishing performance and DOF relative to a high-cost preconditioning

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program involving confinement feeding. Therefore, the objective of our experiment was to measure finishing performance and carcass characteristics of early-weaned steer calves that had previously been subjected to a 56-d weaning period in either a pasture or a drylot environment.

MATERIALS AND METHODS

The Kansas State University Institutional Animal Care and Use Committee reviewed and approved all animal handling and animal care practices used in our experiment. All animal procedures were conducted in accordance with the Guide for the Care and Use of Animals in Agricultural Research and Teaching (FASS, 2010). Animal care practices used in our experiment were approved by the Kansas State University Animal Care and Use Committee (protocol no. 2978.1). The experiment was conducted at the Commercial Cow/Calf Unit of the Department of Animal Science and Industry, Manhattan, Kansas and the Western Kansas Agricultural Research and Extension Center, Hays, Kansas.

Animals, Experimental Design, and Treatments

Angus x Hereford steers originating from the commercial cow-calf herds of Kansas State University (n = 123; initial BW = 132 ± 26.4 kg; 113 ± 13 d of age; Source 1) in Manhattan, KS and the Western Kansas Agricultural Research Center (n = 116; initial BW = 194 ± 23.4 kg; 144 ± 15 d of age; Source 2) in Hays, KS were used in this experiment. All steers were castrated and dehorned and vaccinated against clostridial diseases (UltraBac 7; Zoetis, Parsippany, NJ) at approximately 60 d of age. At weaning, steers were stratified by source and assigned randomly to 1 of 2 weaning treatments: drylot weaning for 56 d (D) at the Western Kansas Agricultural Research Center or pasture weaning for 56 d (P) on native-tallgrass pastures at the Kansas State University Commercial Cow-Calf Unit.

Steers from both sources were weighed individually and given initial vaccinations against respiratory pathogens (Bovi-Shield Gold 5; Zoetis, Parsippany, New Jersey) and clostridial pathogens (UltraBac 7; Zoetis, Parsippany, NJ) as they were separated from dams. Calves were also given an injection of trace minerals (Multimin 90; Multimin USA Inc., Fort Collins, CO), treated for internal and external parasites (Dectomax Injectable; Zoetis, Parsippany, New Jersey), and given a growth-promoting implant (Ralgro; Intervet Inc., Merck Animal Health, Summit, NJ) at the time of maternal separation. Steers were re-vaccinated 14 d after maternal separation.

After initial processing, all steers were transported via motor carrier for a common shipping duration of 4 h to their designated weaning locations. Steers from both sources that were assigned to D were transported to the Western Kansas Agricultural Research Center feedlot, where they were stratified by source and assigned randomly to 1 of 8 pens. Pens (minimum area = 200 m2/calf; linear bunk space = 0.46 m/calf) afforded ad libitum access to water via automatic water troughs.

Steers assigned to D were fed a diet formulated to promote a 1-kg average daily gain (ADG) at a DMI of 2.5% of BW during the weaning phase of the experiment (Table 1). Feed was delivered once daily at 0700 h; bunks were evaluated each morning at 0630 h. Bunks were managed using a slick-bunk management method to minimize feed refusals (Pritchard and Bruns, 2003). If all feed delivered to a pen was consumed, delivery at the next feeding was increased to approximately 102% of the previous delivery. Diet samples were collected from bunks weekly and frozen at −20 °C. Samples were composited at the conclusion of the experiment and submitted to a commercial laboratory (SDK Laboratories, Hutchinson, KS) for analysis of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), Ca, P, and S (Table 1). DMI was estimated by dividing the total feed DM delivered to each pen during the weaning period by the average aggregate BW of all steers in the pen during the weaning period.

Table 1. Composition of the total mixed ration weaning diet fed to drylot steers weaned at 128 days of age for a 56-day period

Ingredient composition	% Dry matter
Sorghum silage	13.1
Sorghum grain	57.4
Dried distillers grains	20.1
Soybean meal	5.1
Supplement*	4.3
Nutrient composition†	**Dry matter basis**
Crude protein, %	18.7
Acid detergent fiber, %	13.2
Neutral detergent fiber, %	18.1
Ca, %	0.87
P, %	0.39
S, %	0.41
NE_m, Mcal/kg	1.87
NE_g, Mcal/kg	1.15

*Supplement contained ammonium sulfate, limestone, urea, salt, Rumensin (300 mg/head/day), Tylan (90 mg/head/day), and a trace-mineral premix.
† Analysis conducted by SDK Laboratories, Hutchison, KS.

Steers from both sources assigned to P were transported to the Kansas State University Commercial Cow-Calf Unit, where they were stratified by source and assigned randomly to 1 of 8 previously non-grazed, native-tallgrass pastures (97 ± 40 hectares). Upon arrival, steers were confined to a single earth-floor pen (minimum area = 200 m2/calf) and allowed ad libitum access to native tallgrass prairie hay (89.2% DM, 9.08% CP) via 2 ring feeders (diameter = 3 m) for 4 d. On the afternoon of d 4, steers were released into assigned pastures. Each pasture provided continual access to surface water and was stocked at 3.2 ha/steer for the 56-d duration of the weaning phase of the experiment. Additional cattle of similar age and weight were added to pastures to achieve the desired stocking density. Pasture forage quality was estimated by clipping all plant material from within randomly-placed sampling frames (0.25 m2; n = 2/pasture) at a height of 1 cm on 7 August, 4 September, and 2 October. Samples were composited within pasture and submitted to a commercial laboratory (SDK Laboratories, Hutchinson, KS) for analysis of DM, CP, NDF, and ADF (Table 2).

Steers assigned to both D and P were monitored daily for symptoms of respiratory disease and infectious keratoconjunctivitis. Steers with clinical signs of bovine respiratory disease (BRD), as judged by animal caretakers, were removed from pens or pastures and evaluated.

Steers were assigned a clinical illness score (scale: 1 to 4; 1 = normal, 4 = moribund), weighed, and assessed for febrile response. Steers with a clinical illness score > 1 and a rectal temperature > 40.0 °C were treated with therapeutic antibiotics according to label directions (first incidence = Baytril, Bayer Animal Health, Shawnee Mission, KS; second incidence = Resflor Gold, Merck Animal Health, Summit, NJ). Steers were evaluated 72 h following treatment and re-treated if clinical signs of BRD persisted. Steers showing signs of infectious keratoconjunctivitis (i.e., corneal ulcers or obvious eye irritation) were treated using oxytetracycline (LA 200; Zoetis Inc., Kalamazoo, MI). Steers were evaluated 14 d following treatment and re-treated if clinical signs of disease persisted.

Following the 56-d weaning period, all steers were weighed at their respective weaning sites, implanted with Revalor IS (Intervet Inc.; Merck Animal Health, Summit, NJ) and transported via motor carrier for 4 h to the Western Kansas Agricultural Research Center for a 56-d feedlot receiving period. At that time, steer assigned to P were stratified by source and assigned randomly to 1 of 8 pens, adjacent to those assigned to D (minimum area = 200 m^2/calf; linear bunk space = 0.46 m/calf).

To establish a common gut-fill between treatments, all steers were fed the weaning diet (Table 1) at a pre-determined percentage of aggregate pen BW for 7 d. Steers were weighed on d 7; this BW was used as both the ending BW of the weaning phase of the experiment and the initial BW of the receiving phase of the experiment.

Thereafter, all steers were fed a common growing diet once daily at 0700 h (Table 3). Bunks and feed delivery were managed according to procedures described for the D treatment during the weaning phase of the experiment. Bunk samples were collected and analyzed as during the weaning phase of the experiment. DMI was estimated by dividing the total feed DM delivered to each pen during the receiving period by average aggregate full BW of all steers in the pen during the receiving period. Cattle health was monitored as during the weaning phase of the experiment. Steers were weighed individually on d 28 and d 56 of the receiving period.

At the beginning of the finishing period of the experiment, steers were implanted with Component TE-IS (Elanco Animal Health) and adapted to a finishing diet over a period of 21 d (Table 4). Diet samples were collected from bunks weekly and frozen at −20°C. Samples were composited at the conclusion of the experiment and submitted to a commercial laboratory (SDK Laboratories, Hutchinson, KS) for analysis of DM, CP, NDF, ADF, Ca, P, and S. Bunk management and feed delivery during finishing was as described for the weaning phase of the experiment. Subcutaneous fat over the 12th rib was measured in all steers via ultrasound (Aloka SSD-500V, 3.5 MHz general-purpose transducer array; Aloka Co., Ltd, Wallingford, CT) on d 90 of the finishing phase of the experiment. Using this measurement, steers were assigned to 1 of 5 harvest dates based on projected time to reach an average carcass endpoint of 11.5 mm of fat depth over the 12th rib. Final live BW was collected within 48 h of harvest.

Steers were transported approximately 3 h to a commercial abattoir on their respective harvest dates where they were harvested under the supervision of the United States Department of Agriculture (USDA) and in compliance with the Humane Slaughter Act of 1978. Animal identification, packer sequence number, and hot carcass weights were recorded during the harvest process. After a 48-h chill (2 °C), carcasses were cut at the 12th and 13th rib interface and allowed approximately 15 min to bloom. Carcasses were then graded for yield and quality. Carcass measurements were collected using digital-imaging software which included 12th-rib fat thickness, 12th-rib longissimus-muscle area, USDA yield grade, USDA quality grade, and marbling score (USDA, 2017). Kidney-pelvic-heart fat was measured gravimetrically after dissection.

Growth and finishing performance and carcass characteristics were analyzed using a mixed model with a 1-way treatment structure as a completely-randomized design (PROC MIXED; SAS Inst. Inc., Cary, NC). Pen or pasture was the experimental unit. Class factors included treatment, pen or pasture, and source. The model statement included terms for the fixed effects of treatment, source, and treatment × source. The random statement had terms for pen (or pasture) within treatment and source × pen (or pasture) within treatment. Data describing DMI and gain:feed (G:F) were analyzed using a mixed model with a 1-way treatment structure as a completely-randomized design (PROC MIXED; SAS Inst. Inc., Cary, NC). Class factors included treatment and pen. The model statement included a term for the fixed effect of treatment only. The random statement was pen within treatment.

Table 2. Nutrient composition of dormant native range forage consumed by 128 days of age pasture-weaned steers during the 56-day weaning period

Sampling date	Nutrient content, dry matter basis*		
	Crude protein, %	Neutral detergent fiber, %	Acid detergent fiber, %
08/07/2013	6.7	60.6	41.0
09/04/2013	6.1	61.1	40.3
10/02/2013	4.8	66.3	46.3

*Analysis conducted by SDK Laboratories, Hutchison, KS.

Table 3. Composition of the receiving diet consumed by steers for 56 days following a 56-day weaning period in drylot, and provided a concentrate total mixed ration, or on dormant native range

Ingredient composition	% Dry matter
Sorghum silage	13.1
Sorghum grain	57.5
Dried distillers grains	25.9
Supplement*	3.5
Nutrient composition†	**Dry matter basis**
Crude protein, %	17.6
Neutral detergent fiber, %	13.8
Acid detergent fiber, %	11.4
Ca, %	0.91
P, %	0.43
S, %	0.44
NEm, Mcal/kg	1.92
NEg, Mcal/kg	1.19

*Supplement contained ammonium sulfate, limestone, urea, salt, Rumensin (300 mg/head/day), Tylan (90 mg/head/day), and a trace-mineral premix.
†Analysis conducted by SDK Laboratories, Hutchison, KS.

Table 4. Composition of the finishing diet consumed by steers following a 56-day receiving period and a 56-day weaning period in drylot, and provided a concentrate total mixed ration, or on dormant native range

Ingredient composition	% Dry matter
Sorghum silage	13.1
Sorghum grain	72.3
Dried distillers grains	11.7
Supplement*	2.2
Nutrient composition†	**Dry matter basis**
Crude protein, %	16.3
Neutral detergent fiber, %	15.5
Acid detergent fiber, %	11.2
Ca, %	0.50
P, %	0.38
S, %	0.26
NEm, Mcal/kg	1.92
NEg, Mcal/kg	1.19

*Supplement contained ammonium sulfate, limestone, urea, salt, Rumensin (300 mg/head/day), Tylan (90 mg/head/day), and trace minerals.
†Analysis conducted by SDK Laboratories, Hutchison, KS.

Health data were analyzed using a model with a one-way treatment structure as a completely-randomized design (PROC GLIMMIX; SAS Inst. Inc., Cary, NC). Pen or pasture was the experimental unit. Class factors included treatment, pen or pasture, and source. The model statement included terms for the fixed effects of treatment, source, and treatment × source. The random statement had terms for pen (or pasture) within treatment and source × pen (or pasture) within treatment.

When protected by a significant F-test ($P < 0.05$), Least Squares treatment means were separated using the method of Least Significant Difference. Means were considered different when $P \leq 0.05$. Tendencies were discussed when $0.05 < P \leq 0.10$.

RESULTS AND DISCUSSION

Weaning Performance

BW after and ADG during the 56-d weaning period were greater ($P < 0.01$) for D than for P (Table 5). The observed differences in performance during the weaning period reflect the differences in overall diet nutrient composition. The ration fed to D steers contained 18.7% CP and 13.2% ADF. Whereas the forage quality consumed by P steers ranged from 6.7% to 4.8% CP and 41.0% to 46.3% ADF. Likewise, Bailey et al. (2016) also reported greater BW gains for steers weaned in a drylot environment for 28 d than for steers weaned on dormant, native range for 28 d. However, these researchers reported compensatory gain by pasture-weaned steers during the subsequent finishing period, resulting in similar BW and no differences in DOF between pasture- and drylot-weaned steers.

Incidence of undifferentiated fever during the weaning phase of our experiment tended to be greater ($P = 0.10$) in D steers than in P steers (6.7% and 0% for D and P, respectively; Table 5). Similarly, Walker et al. (2007) reported increased morbidity

Table 5. Postweaning growth and health performance of early-weaned steers managed in pasture or drylot weaning environments

Item	D*	P†	SEM	*P*-value
Weaning body weight, kg	163.6	162.8	2.30	0.82
Final body weight, kg	222.6	165.5	2.61	< 0.01
Average daily gain, kg	0.93	0.04	0.019	< 0.01
Dry matter intake, % body weight/day	2.22	—	—	—
Gain:Feed	0.247	—	—	—
Incidence of undifferentiated fever, %	6.7	0.0	2.71	0.10
Incidence of keratoconjunctivitis, %	0.0	40.2	3.17	< 0.01

*Steer calves were weaned in a drylot environment and fed a concentrate-based diet for 56 days.
†Steer calves were weaned in a pasture environment and not supplemented for 56 days.

in drylot-weaned steers compared with pasture-weaned steers. Identical vaccination, health, and handling (i.e. trucking) protocols were applied to both treatments in our experiment, the relatively higher occurrence of respiratory disease in D steers was unexpected. Step et al. (2008) indicated that preconditioned calves were less susceptible to disease during the postweaning period than calves sold through auction markets immediately following separation from dams.

Incidence of infectious bovine keratoconjunctivitis (i.e., pinkeye) during the weaning phase of our experiment was greater ($P < 0.01$) for P steers (40.2%) than for D steers (0%; Table 5). Although increased expression of infectious bovine keratoconjunctivitis often coincides with the advancement of summer due to increased infestation of the face fly (*Musca autumnalis*; Cheng, 1967) and annual peak of solar ultraviolet radiation that may increase bacterial eye infections (Hughs and Pugh, 1970; Webber and Selby, 1981), steers housed in mature pastures expressed a higher rate of infectious bovine keratoconjunctivitis than steers housed in a drylot environment. Snowder et al. (2005) reported that infectious bovine keratoconjunctivitis was affected by season and physical irritation such as dust, grasses, or weeds. The late-season pasture conditions of the current study, having an abundance of mature forage, likely presented a greater risk for corneal lesions than drylot conditions which ultimately led to a greater incidence of infectious bovine keratoconjunctivitis.

Receiving Performance

Steers assigned to D had greater ($P < 0.01$) BW throughout the 56-d receiving period than steers assigned to P (Table 6). Steers assigned to D were 57.1 kg heavier than steers allocated to P at the end of the 56-d weaning period (Table 5), and maintained this advantage throughout the receiving period and were 65.3 kg heavier than steers allocated to P at the end of this 56-d period (Table 6). Steers assigned to D also exhibited greater ($P = 0.03$) ADG from d 1 to 28 of the receiving period than steers assigned to P (1.39 kg/d vs. P 1.26 kg/d, respectively). In contrast, Bailey et al. (2016) reported that pasture-weaned calves had lesser ADG during the first 30 d of the receiving period. Also, in contrast to our results, Bailey et al. (2012) observed that ADG of pasture-weaned calves was less than that of drylot-weaned calves from d 30 to 60 of the receiving period.

Table 6. Growth and health performance, during a 56-d feedlot receiving period, of early-weaned steers managed in pasture or drylot weaning environments

Item	D*	P†	SEM	*P*-value
Initial body weight, kg	222.6	165.5	2.61	< 0.01
End body weight, kg	299.9	234.6	3.30	< 0.01
Average daily gain, kg/day	1.39	1.26	0.038	0.03
Dry matter intake, % body weight/day	2.47	2.51	0.017	0.09
Gain:feed	0.189	0.214	0.006	<0.01
Incidence of undifferentiated fever, %	2.5	2.5	1.53	0.99
Incidence of keratoconjunctivitis, %	1.6	14.3	2.56	< 0.01

*Steer calves were weaned in a drylot environment and fed a concentrate-based diet for 56 days.
†Steer calves were weaned in a pasture environment and not supplemented for 56 days.

Steers assigned to P had greater DMI ($P < 0.01$; expressed as a percentage of BW) and improved G:F ($P < 0.01$) during the receiving period than steers assigned to D (Table 6). Bailey et al. (2016) reported greater DMI and G:F by drylot-weaned calves than by pasture-weaned calves during receiving; however, those researchers did not express intake as a proportion of BW. Given the differences in initial receiving BW between drylot- and pasture-weaning treatments, DMI as a percentage of BW may have been similar in both studies.

Incidence of undifferentiated fever was not different ($P = 0.99$) between D and P during the receiving phase of our trial (Table 6). Step et al. (2008) indicated that preconditioned, ranch-direct calves were less susceptible to disease during receiving than market-sourced calves with no known health history. Preconditioning management was applied to both of our treatments before feedlot arrival. During the weaning phase of our experiment, incidence of keratoconjunctivitis was greater ($P < 0.01$) for steers assigned to P (14.3%) than for steers assigned to D (1.6%) during the receiving period. We speculated that there were significant residual effects of the pasture environment on corneal health that lasted well into the receiving period.

Finishing Performance

At the beginning of the finishing period, steers assigned to D were 65 kg heavier ($P < 0.01$) than steers assigned to drylot (Table 7). During the finishing period, P steers gained BW at a greater rate ($P < 0.01$) and had more favorable ($P < 0.01$) G:F than D steers; however, harvest BW was 29 kg heavier for D steers. Similarly, Bailey et al. (2016) reported improved finishing ADG by steers weaned on dormant native range for 28 d than by steers weaned in a drylot environment and fed a concentrate-based diet for 28 d; however, harvest BW were not different between treatments in that study. Likewise, Mathis et al. (2008) also reported that pasture-weaned steers had greater finishing ADG than drylot-weaned steers through the first 75 d on feed; however, over the entire finishing period, there were no differences in ADG between treatments.

Table 7. Finishing performance of early-weaned beef steers managed in pasture or drylot weaning environments

Item	D*	P†	SEM	*P*-value
Initial body weight, kg	300	235	5.3	< 0.01
Harvest body weight, kg	584	555	10.98	< 0.01
Weight gain, kg	283.8	319.8	8.50	< 0.01
Average daily gain, kg/day	1.75	1.96	0.036	< 0.01
Dry matter intake, kg/day	12.33	12.11	0.018	< 0.01
Gain:feed	0.143	0.161	0.003	< 0.01
Days on feed	163	166	4.4	0.50

*Steer calves were weaned in a drylot environment and fed a concentrate-based diet for 56 days.
†Steer calves were weaned in a pasture environment and not supplemented for 56 days.

Table 8. Carcass characteristics of early-weaned beef steers managed in pasture or drylot weaning environments

Item	D*	P†	SEM	*P*-value
Hot carcass weight, kg	362	344	6.2	0.03
Dressing percent, %	62.4	62.0	0.38	0.36
Marbling score‡	46.3	45.8	1.33	0.67
USDA yield grade	3.4	3.3	0.08	0.61
12th-rib fat thickness, mm	13.5	12.9	0.41	0.23
Longissimus area, cm^2	80.0	78.1	1.81	0.19

*Steer calves were weaned in a drylot environment and fed a concentrate-based diet for 56 days.
†Steer calves were weaned in a pasture environment and not supplemented for 56 days.
‡Marbling score: 30 = Slight^{00}, 40 = Small^{00}, 50 = Modest^{00}.

Steers assigned to D had slightly greater average daily DMI ($P < 0.01$) than steers assigned to P during the finishing phase of our experiment (Table 7), whereas P steers had improved G:F ($P < 0.01$) compared with D steers. The number of DOF was not different ($P = 0.50$) between treatments. Likewise, following a 28 d weaning period on dormant native range or in a drylot and fed a concentrate-based diet, Bailey et al. (2016) observed no treatment differences in finishing DMI, or DOF among steer calves; however, these researchers did observe an improved G:F for steers weaned on pasture. In contrast, Myers et al. (1999c) reported reduced DOF by grazing early-weaned calves for 82 d before feedlot placement compared with early-weaned calves fed a high-concentrate diet from weaning to harvest. Pasture-weaned steers in that study gained 0.48 kg/d over the 82-d grazing period, whereas pasture gains in our experiment were only 0.04 kg/d. Similar to our experiment, Mathis et al. (2009) also noted differences in final BW between steers preconditioned at high or low rates of gain.

Carcass Characteristics

Hot carcass weight was 18 kg greater ($P = 0.03$) for D than for P (Table 8). Yield grade, marbling score, and 12th-rib fat thickness did not differ ($P \geq 0.19$) between treatments. In contrast, previous researchers have reported that early-weaned beef calves fed a high concentrate diet display greater marbling scores than their conventionally weaned contemporaries or calves not provided a high concentrate diet (Meyer et al., 2005; Arnett et al., 2009; Mathis et al., 2009). When finished to a common backfat thickness endpoint, it appeared that the nutritional restrictions that P steers were subject to during the 56-d weaning period did not alter carcass quality but decreased hot carcass weight. Similarly, Hersom et al., 2004 and Sharman et al., 2010 reported that the type of growing program employed prior to finishing had minimal effects on marbling score when treatments were fed to a common 12th-rib fat thickness endpoint.

Implications

Growth and health during weaning and receiving were improved when steers were weaned in a drylot environment and fed a concentrate-based diet for 56 d compared with when steers were weaned in a pasture environment for 56 d. The drylot-weaned steers in our experiment were heavier at the end of the weaning period, receiving period and finishing period, compared with pasture-weaned steers.

The compensatory effects on ADG during the 56-d receiving period, subsequent to a 28-d period of nutritional restriction during weaning, could only be sustained for the first 28 d. Conversely, during the finishing period, pasture-weaned steers again exhibited greater weight gain, ADG, and G:F compared with their drylot-weaned contemporaries. There were no differences in DOF, dressing percent, longissimus area, marbling score, or USDA Yield Grade when fed to a common degree of 12th-rib fat; however, hot carcass weights were heavier for steers weaned in a drylot environment for 56 d than steers weaned in a pasture environment for 56 d. Under the conditions of the current study, the improved performance during receiving and finishing by steers weaned in a mature, warm-season forage pasture environment was insufficient to overcome the 56-d weaning period gain by drylot-weaned steers which had greater harvest BW and hot carcass weight. We conclude, in light of the incidence of keratoconjunctivitis and significantly reduced performance during the weaning period, weaning beef steers in dormant forage pastures during the fall is not a viable option to maximize performance.

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Conflict of interest statement

None declared.

LITERATURE CITED

Arnett, A. M., M. E. Dikeman, M. J. Daniel, K. C. Olson, J. Jaeger, and J. Perrett. 2009. Effects of vitamin a supplementation and weaning age on serum and liver retinol concentrations, carcass traits, and lipid composition in market beef cattle. *Meat Sci*. 81:596–606. doi:10.1016/j.meatsci.2008.10.017.

Bailey, E. A., J. R. Jaeger, J. W. Waggoner, G. W. Preedy, L. A. Pacheco, and K. C. Olson. 2012. Effect of weaning method on welfare and performance of beef calves during receiving. *Proc. West. Sec. Amer. Soc. Anim. Sci*. 63:25–29.

Bailey, E. A., J. R. Jaeger, J. W. Waggoner, G. W. Preedy, L. A. Pacheco, and K. C. Olson. 2016. Effects of fence-line or drylot weaning on the health and performance of beef calves during weaning, receiving, and finishing. *Prof. Anim. Sci*. 32:220–228. doi:10.15232/pas.2015-01456.

Barker-Neef, J. M., D. D. Buskirk, J. R. Black, M. E. Doumit, and S. R. Rust. 2001. Biological and economic performance of early-weaned angus steers. *J. Anim. Sci*. 79:2762–2769. doi:10.2527/2001.79112762x.

Cheng, T. H. 1967. Frequency of pinkeye incidence in cattle in relation to face fly abundance. *J. Econ. Entomol*. 60:598–599. doi:10.1093/jee/60.2.598.

Federation of Animal Science Societies. 2010. *FASS guide for the care and use of animals in agricultural research and teaching*, 3rd ed. Champaign (IL): Federation of Animal Science Societies.

Hersom, M. J., G. W. Horn, C. R. Krehbiel, and W. A. Phillips. 2004. Effect of live weight gain of steers during winter grazing: I. Feedlot performance, carcass characteristics, body composition, and energy requirements of beef steers. *J. Anim. Sci*. 82:262–272. doi:10.2527/2004.8272059x.

Hughes, D. E., and G. W. Pugh, Jr. 1970. A five-year study of infectious bovine keratoconjunctivitis in a beef herd. *J. Am. Vet. Med. Assoc*. 157:443–451.

Mathis, C. P., S. H. Cox, C. A. Löest, M. K. Petersen, and J. T. Mulliniks. 2009. Pasture preconditioning calves at a higher rate of gain improves feedlot health but not post-weaning profit. *Prof. Anim. Sci*. 25:475–480. doi:10.15232/S1080-7446(15)30746-4.

Mathis, C. P., S. H. Cox, C. A. Löest, M. K. Petersen, R. L. Endecott, A. M. Encinias, and J. C. Wenzel. 2008. Comparison of low-input pasture to high-input drylot backgrounding on performance and profitability of beef calves through harvest *Prof. Anim. Sci*. 24:169–174. . doi:10.15232/S1080-7446(15)30832-9.

Meyer, D. L., M. S. Kerley, E. L. Walker, D. H. Keisler, V. L. Pierce, T. B. Schmidt, C. A. Stahl, M. L. Linville, and E. P. Berg. 2005. Growth rate, body composition, and meat tenderness in early vs. traditionally weaned beef calves. *J. Anim. Sci*. 83:2752–2761. doi:10.2527/2005.83122752x.

Myers, S. E., D. B. Faulkner, F. A. Ireland, L. L. Berger, and D. F. Parrett. 1999a. Production systems comparing early weaning to normal weaning with or without creep feeding for beef steers. *J. Anim. Sci*. 77:300–310. doi:10.2527/1999.772300x.

Myers, S. E., D. B. Faulkner, F. A. Ireland, and D. F. Parrett. 1999b. Comparison of three weaning ages on cow-calf performance and steer carcass traits. *J. Anim. Sci*. 77:323–329. doi:10.2527/1999.772323x.

Myers, S. E., D. B. Faulkner, T. G. Nash, L. L. Berger, D. F. Parrett, and F. K. McKeith. 1999c. Performance and carcass traits of early-weaned steers receiving either a pasture growing period or a finishing diet at weaning. *J. Anim. Sci*. 77:311–322. doi:10.2527/199C9.772311x.

Pritchard, R. H., and K. W. Bruns. 2003. Controlling variation in feed intake through bunk management. *J. Anim. Sci*. 81(E Suppl. 2):E133–E138.

Rasby, R. J. 2007. Early weaning beef calves. In: Olson K. and L. Hollis, editors. *Veterinary clinics of North American food animal practice, Volume 23, Number 1: Cow calf nutrition and management*.. Philadelphia (PA): Elsevier Saunders; p. 29–40.

Schoonmaker, J. P., S. C. Loerch, F. L. Fluharty, H. N. Zerby, and T. B. Turner. 2002. Effect of age at feedlot entry on performance and carcass characteristics of bulls and steers. *J. Anim. Sci*. 80:2247–2254. doi:10.1093/ansci/80.9.2247.

Sharman, E. D., P. A. Lancaster, G. G. Hilton, C. R. Krehbiel, W. A. Phillips, and G. W. Horn. 2010. Effect of forage energy intake and supplementation on marbling deposition in growing beef cattle. *Proc. West. Sec. Amer. Soc. Anim. Sci*. 61:44–49.

Snowder, G. D., L. D. Van Vleck, L. V. Cundiff, and G. L. Bennett. 2005. Genetic and environmental factors associated with incidence of infectious bovine keratoconjunctivitis in preweaned beef calves. *J. Anim. Sci*. 83:507–518. doi:10.2527/2005.833507x.

Step, D. L., C. R. Krehbiel, H. A. DePra, J. J. Cranston, R. W. Fulton, J. G. Kirkpatrick, D. R. Gill, M. E. Payton, M. A. Montelongo, and A. W. Confer. 2008. Effects of commingling beef calves from different sources and weaning protocols during a 42-day receiving period on performance and respiratory disease. *J. Anim. Sci*. 86:3146–3158. doi:10.2527/jas.2008-0883.

Story, C. E., R. J. Rasby, R. T. Clark, and C. T. Milton. 2000. Age of calf at weaning of spring-calving beef cows and the effect on cow and calf performance and production economics. *J. Anim. Sci.* 78:1403–1413. doi:10.2527/2000.7861403x.

USDA. 2017. *United States Standards for Grades of Carcass Beef*. https://www.ams.usda.gov/sites/default/files/media/CarcassBeefStandard.pdf.

Walker, K. H., L. R. Fell, L. A. Reddacliff, R. J. Kilgour, J. R. House, S. C. Wilson, and P. J. Nicholls. 2007. Effects of yard weaning and training on the behavioral adaptation of cattle to a feedlot. *Livest. Sci.* 106:210–217 doi:10.1016/j.livsci.2006.08.004.

Webber, J. J., and L. A. Selby. 1981. Risk factors related to the prevalence of infectious bovine keratoconjunctivitis. *J. Am. Vet. Med. Assoc.* 179:823–826.