Production Systems Comparing Early Weaning to Normal Weaning With or Without Creep Feeding for Beef Steers[1]

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ABSTRACT: A 2-yr study was conducted to determine the effects of three weaning management systems on cow and steer performance. Cow-calf pairs were randomly assigned to one of three treatments, in which the steer calves were 1) early-weaned (yr 1, 177 ± 9 d; yr 2, 158 ± 21 d of age) and placed on a finishing diet (EW), 2) supplemented with grain for 55 d on pasture (yr 1, 177 to 231 d; yr 2, 158 to 213 d of age) while nursing their dams and then placed on a finishing diet (NWC), and 3) on pasture for 55 d while nursing their dams (yr 1, 177 to 231 d; yr 2, 158 to 213 d of age) and then placed on a finishing diet (NW). In yr 2, potential breed differences were evaluated using steers of three breed types: 1) Angus × Hereford (BRI); 2) Angus × Simmental (CON); and 3) Angus × Wagyu (WAG). In yr 1, EW steers gained 100% faster (P = .0001) than the average of NWC and NW steers, and NWC steers gained 32% faster (P = .02) than NW steers before weaning. In the feedlot, EW steers had lower intakes (7.70 vs 8.16 kg/d, P = .008) and better feed conversions (.170 vs .153, P = .002) than the average of NWC and NW steers. Marbling score was improved for EW steers compared with the average of NWC and NW steers (P = .003). In yr 2, EW steers had higher gains (P = .0006) during the entire study than the average of NWC and NW steers, and NWC steers had higher gains (P = .003) than NW steers. The EW steers had lower intakes (7.29 vs 7.68 kg/d, P = .0008) and better feed conversions (.160 vs .141, P = .0001) than the average of NWC and NW steers. The CON steers were heavier at slaughter than BRI steers (P = .01), and BRI steers were heavier than WAG steers (P =.0004). Early weaning improved the percentage of steers grading Average Choice or higher by 40%. The percentage of BRI steers grading Choice or greater was 21% higher and percentage of steers grading Average Choice or greater was 33% higher than CON. Cows with EW steers had higher ADG than cows with NW steers (.38 vs −.17 kg/d, P = .0001) before weaning. Cows with EW steers gained in body condition score (.23 vs .00, P = .04), and cows with NW steers did not change. Early weaning improved feed efficiency and quality grades of beef steers.

Key Words: Weaning, Meat Quality, Systems

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Introduction

In today's value-based marketing system, the competitive ability of the beef industry could be enhanced by raising cattle that produce high quality, uniform beef. Results of two National Beef Quality Audits this decade concluded that the beef industry is falling short in meeting the demands for quality. In 1991, 55% of the carcasses graded Choice or Prime, but, by 1995, the percentage had fallen to 48%, with less than 1% of the carcasses evaluated attaining Prime quality. At the 1994 National Beef Tenderness Conference, researchers pointed out that one out of every four steaks is less than desirable in tenderness and palatability and that every tough carcass affects as many as 542 consumers. The conclusion was that consumers want high-quality beef and that producers must be able to provide it efficiently.

Feed costs account for 54 to 75% of the annual cost of keeping a cow (Taylor, 1984). Energy is the feed component required in the greatest quantity by beef cattle, with about 70% of the energy consumed by a cow going to maintenance (Jenkins and Ferrell, 1983). Maintenance accounts for approximately 50% of the total energy required for the entire beef production system (Ferrell and Jenkins, 1984). Peterson et al. (1987) reported that early-weaned cow-calf

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pairs were 43% more efficient in converting total digestible nutrients into calf gain than were normal-weaned cow-calf pairs.

Programs such as strategic alliances, retained ownership, and value-based marketing offer incentives for cattle feeders and cow-calf producers to produce high-value cattle. Information on alternative management systems that can increase profit and produce high-quality beef are necessary. The objectives of this study were to determine the effects of three weaning management systems and three breed types on 1) steer performance and carcass traits and on 2) cow performance, body condition score (**BCS**), and pregnancy rates.

Materials and Methods

Steers and Diets

This 2-yr study was conducted at the Dixon Springs Agricultural Center located near Simpson, IL. In yr 1, the trial was conducted from July 27, 1994, through May 4, 1995. In yr 2 it was from July 25, 1995, through May 22, 1996. Steers were born from January to April in both years and nursed their dams while grazing endophyte-infected tall fescue (*Festuca arundinacea* Schreb.) and red clover (*Trifolium pratense* L.) pastures until mid-July, when they were randomly assigned to one of three treatments. The steer calves were either 1) early weaned (yr 1, 177 ± 9 d; yr 2, 158 ± 21 d of age) and placed on a finishing diet (**EW**), 2) supplemented with grain for 55 d on pasture (yr 1, 177 to 231 d; yr 2, 158 to 213 d of age) while nursing their dams and then placed on a finishing diet (**NWC**), or 3) on pasture for 55 d while nursing their dams (yr 1, 177 to 231 d; yr 2, 158 to 213 d of age) and then placed on a finishing diet (**NW**). In yr 1, 84 Angus × Hereford steers (**BRI**; 144 ± 9 kg) were placed in 12 pens with four replications of each treatment. In yr 2, 83 Angus × Hereford (154 ± 19 d; 151 ± 5 kg), 40 Angus × Simmental (**CON**; 155 ± 21 d; 160 ± 5 kg), and 44 Angus × Wagyu (**WAG**; 162 ± 24 d; 146 ± 6 kg) steers were used to evaluate potential breed differences. We allocated 24 pens with 8 pens per treatment. There were four pens of BRI steers, two pens of CON steers, and two pens of WAG steers within each treatment. The steers were from over eight sires in each breed group. At the time of early and normal weaning, all steers were weighed and measured at the hip, and dams were weighed and assigned a body condition score (1 to 9 scale). All individual steer and cow weights were taken without withdrawal from feed and water. At the time of normal weaning, dams were palpated to determine pregnancy rates. Only the EW and NW dams were included in the analysis of cow performance because the NWC dams were placed in separate pastures.

Before trial initiation in yr 1, steers were vaccinated with CattleMaster 4 + L5 and Ultrabac 7/Somubac® (SmithKline Beecham, West Chester, PA). Calves received BoviShield 3 (SmithKline Beecham) 1 mo after the time of normal weaning. In yr 2, before trial initiation, steers received Ultrabac 7/Somubac®. At the time of normal weaning, steers were vaccinated with CattleMaster 4 + L5 and Ultrabac 7/Somubac. Two months later, steers received an injection of BoviShield 4 + L5. These vaccinations were to prevent common feedlot diseases.

At the time of normal weaning in yr 1, cows were vaccinated with Vibrio/Leptferm 5 (SmithKline Beecham) and were treated for parasites with Ivomec® (Merck, Rahway, NJ). Prior to the calving season, cows received BoviShield 4. In yr 2, cows received an injection of Cattlemaster 4 + VL5 and Ultrabac 7/Somubac and were treated for parasites with Ivomec before the time of early weaning. Prior to calving in both years, cows received an injection of ScourGuard 3 (SmithKline Beecham). These injections were used to prevent disease in the cow-calf herd.

Steers on the NWC treatment were given ad libitum access to ground corn for 55 d before weaning. Beginning at the time of weaning, steers were given ad libitum access to a grain diet consisting of 63.80% cracked corn, 3.62% soybean meal, and 30.13% chopped hay (DM basis). During the finishing phase, chopped hay was removed in four steps from the finishing diet over a 44-d period. Steers were allowed to consume the high-concentrate diet on an ad libitum basis for the remaining feeding period. Diet composition is shown in Table 1. Steers were finished in an outdoor confinement facility with overhead shading and solid concrete floors. Pens were equipped with self-feeders and automatic waterers.

All steers were implanted with 36 mg of zeranol (Ralgro®, Mallinckrodt Veterinary, Mundelein, IL) and Revalor®-S (120 mg of trenbolone acetate and 24 mg of estradiol; Hoechst Roussel Vet, Somerville, NJ) at 7 and 11 mo, respectively. Slaughter weight was determined by dividing hot carcass weight by .61. No differences in dressing percentage were observed as a result of treatment ($P > .05$); however, CON steers had .75% higher dressing percentage than BRI steers and 1.0% higher dressing percentage that WAG steers. We used carcass weight/dressing percentage as slaughter weight in this study because it reflects the saleable product. Average daily gain, DMI, efficiency (gain:feed), and total concentrate consumed were calculated. Feed intakes are expressed as a daily average over the entire feeding period on a pen basis. In yr 1, two slaughter groups were used to slaughter individual steers at a constant fat end point (1.15 cm, ± .39 actual). In yr 2, four slaughter groups were used to slaughter individual steers at a constant fat end point (1.09 cm, ± .32 actual).

Steers were slaughtered at a commercial packing plant and hot carcass weights were obtained. After carcasses were chilled for 24 h, the following measure-

Table 1. Composition of finishing diets fed to steers

Ingredient	Diet sequence, %[a] 1	2	3	4
Cracked corn	63.80	72.84	77.82	82.81
Soybean meal	3.62	3.57	3.60	3.60
Chopped hay	30.13	19.98	14.99	10.00
Limestone	1.14	1.14	1.14	1.14
Trace-mineralized salt[b]	.57	.57	.57	.57
Potassium chloride	.57	.57	.57	.57
Urea	—	.57	.57	.57
Thiamine, 16,000 mg/kg	.11	.11	.11	.11
Rumensin-60[c]	.02	.02	.02	.02
Tylan-10[d]	.05	.05	.05	.04
Vitamin A, IU/kg	603	603	603	603
Feed analysis				
Crude protein, %	10.24	10.23	10.30	10.36
NE_m, Mcal/kg	1.79	1.89	1.94	1.98
NE_g, Mcal/kg	1.16	1.26	1.31	1.36

[a]DM basis.
[b]Composition (%): NaCl (82 to 87), Fe (≥2.85), Zn (≥2.30), Mn (≥.22), Cu (≥.20), I (≥.01), Se (≥.0086).
[c]Contains 132 g of monensin/kg.
[d]Contains 22 g of tylosin/kg.

ments were obtained by trained University of Illinois personnel: 1) longissimus muscle area (**LMA**) taken by direct grid reading of the longissimus at the 12th rib; 2) subcutaneous fat over the longissimus muscle at the 12th rib (subjectively adjusted for unusual fat distribution); 3) kidney, pelvic, and heart fat was estimated as a percentage of carcass weight; and 4) marbling score (USDA, 1975). Carcass measurements were used to calculate yield and quality grades.

Statistical Analysis

Feedlot performance and carcass characteristics were analyzed as a completely randomized design experiment (Steel and Torrie, 1980) according to the GLM procedure of SAS (1985). Pen was the experimental unit for the performance data. Steer was the experimental unit for the carcass data for both years. There were year × treatment interactions ($P < .05$); therefore, years were analyzed separately. In yr 1, the model included treatment as independent variable and external fat thickness at slaughter was used as a covariate. In yr 2, the model included treatment, breed type, and the interaction as independent variables, and external fat thickness at slaughter was used as a covariate.

Treatment means were compared (Steel and Torrie, 1980) with the following orthogonal contrasts: 1) EW vs NWC and NW and 2) NWC vs NW. In yr 2, breed means were compared (Steel and Torrie, 1980) with the following orthogonal contrasts: 1) BRI vs CON and 2) BRI vs WAG. Significant treatment × breed interaction existed in yr 2. The following contrasts were used: 1) EW vs NWC and NW × BRI vs CON; 2) EW vs NWC and NW × BRI vs WAG; 3) NWC vs NW × BRI vs CON; and 4) NWC vs NW × BRI vs WAG.

Cow was the experimental unit to evaluate cow performance differences between EW and NW. There were no year × treatment interactions, so the data were analyzed together. The model included year, treatment, and the interaction as independent variables.

Results and Discussion

Effect of Early Weaning on Steer Performance

Steer performance traits in yr 1 are presented in Table 2. No differences ($P = .27$) were observed between treatments for initial weights. The EW steers were 19 kg heavier than the average of NWC and NW steers at slaughter ($P = .04$). The EW steers were fed 51 d more than the average of NWC and NW steers ($P = .0001$) when fed to a constant fat end point. No differences ($P = .94$) in finishing days were observed between NWC and NW steers. No differences ($P = .30$) in slaughter age were observed between treatments (440, 444, and 445 d for the EW, NWC, and NW steers, respectively).

The EW steers gained 100% faster ($P = .0001$) than the average of NWC and NW steers, and NWC steers gained 32% faster ($P = .02$) than NW steers before the time of normal weaning. Neville and McCormick (1981) reported that EW calves gained faster and weighed more at time of normal weaning than did control calves. In contrast, Lusby et al. (1981) observed similar weaning weights for calves early-weaned at 6 to 8 wk of age out of first-calf heifers and calves weaned at the normal time. However, they concluded that the calves needed a complete mixed diet or better-quality forage than that used to make

Table 2. Effects of three weaning management systems on steer performance (yr 1)[a,b]

	Treatment[c]				P = Contrast	
Item	EW	NWC	NW	SEM[d]	EW vs NWC and NW	NWC vs NW
No. of pens	4	4	4			
Initial wt, kg	149	140	144	5	.27	.55
Slaughter wt, kg[e]	493	478	470	7	.04	.43
Days in feedlot	264	213	213	2	.0001	.94
ADG, kg						
177–231 d of age	1.44	.82	.62	.05	.0001	.02
231–443 d of age	1.28	1.38	1.38	.02	.002	.88
Overall	1.31	1.27	1.22	.02	.01	.10
Initial ht, cm	98.4	96.0	97.0	.99	.13	.54
Height change, cm						
177–231 d of age	8.2	7.0	5.5	.7	.04	.17
DMI, kg/d[f]	7.70	8.20	8.12	.11	.008	.62
Gain/feed[f]	.170	.155	.151	.003	.002	.39
Total conc., kg/steer[g]	2,033	1,853	1,728	30	.0001	.91

[a]Least squares means.
[b]External fat thickness was used as a covariate (mean = 1.15 cm).
[c]EW = early weaned, NWC = normally weaned with creep, NW = normally weaned.
[d]Greatest standard error of treatment means (SEM) reported.
[e]Calculated as hot carcass weight/.61.
[f]During feedlot phase.
[g]Total concentrate, creep, and feedlot phases included.

adequate gains without milk. Earlier research with Angus calves (Harvey et al., 1975) showed gains to be improved by approximately .30 kg/d when calves were early-weaned compared with calves that remained on their dams. Many studies have shown increased weaning weights of creep-fed calves (Marlowe et al., 1965; Faulkner et al., 1994). Compared with the average of NWC and NW, EW improved ADG throughout the duration of the experiment by 5% (P = .01).

No differences (P = .13) were observed between treatments for initial height. The EW steers had 1.95 cm more height change (P = .04) than the average of NWC and NW steers before the time of normal weaning. No differences (P = .17) were observed between NWC and NW steers.

During the creep-feeding phase, NWC steers consumed 2.00 kg/d. In the feedlot, EW steers had .46 kg/d lower intake (P = .008) and .02 unit better gain:feed (P = .002) ratio compared with the average of NWC and NW steers. The EW steers consumed 242.5 kg more total concentrate (P = .0001) than the average of NWC and NW steers, and no differences (P = .91) were observed between NWC and NW steers. Harvey and Burns (1988a,b) also reported that early-weaned calves were very efficient in their use of concentrate for gain.

There were significant treatment × breed interactions (P < .05) for performance traits in yr 2. The effects of treatment and breed on performance traits are shown in Table 3. The EW steers were 19 kg heavier at slaughter compared with the average of NWC and NW steers (P =.004), and there were no differences (P = .22) between NWC and NW steers. This agrees with findings in yr 1, in which EW steers were also 19 kg heavier.

Slaughter weight for normally weaned BRI and CON steers did not differ, but early-weaned CON steers weighed approximately 10% more at slaughter than did early-weaned BRI steers (P = .01). Normally weaned CON steers did not realize their full growth potential during the pasture phase and did not realize compensatory growth during the feedlot phase of the study. Drouillard et al. (1990) reported that the performance of cattle during a given phase of production frequently is influenced by the rate of growth during previous phases. Cattle that have received suboptimal nutrition may compensate by growing faster and(or) more efficiently when sufficient nutrients become available, or poor nutrition may result in permanent “stunting” of an animal.

The EW steers were fed 46 d more than the average of NWC and NW steers (P = .0001), and the NWC steers were fed 17 d fewer than NW steers (P = .0002) when fed to a constant fat end point. No differences (P = .25) in slaughter age were observed between EW and NWC steers (429 and 428 d, respectively). The NWC steers were 12 d younger (P = .02) than NW steers at slaughter. No differences (*P* = .11) were observed for finishing days and slaughter age between the BRI and CON steers. The WAG steers were fed 12 d more (*P* = .003) and were 20 d older (*P* = .0001) at slaughter than BRI steers.

The EW steers had an ADG that was .32 kg/d higher (*P* = .0001) before the time of normal weaning than that of the average of NWC and NW steers, and NWC steers gained .22 kg/d more (*P* = .0001) than the NW steers. These treatment results are similar to those of yr 1. These findings are also in agreement with Peterson et al. (1987), who reported that calves weaned at 110 d of age were heavier at normal weaning (222 d of age) than calves that had remained with their dams. No differences (*P* = .23) in ADG were observed between EW vs NWC and NW steers

Table 3. Effects of three weaning management systems and three breed types on steer performance (yr 2)[ab]

	Treatment[cd]									
	EW			NWC			NW			
Item	BRI	CON	WAG	BRI	CON	WAG	BRI	CON	WAG	SEM[e]
No. of pens	4	2	2	4	2	2	4	2	2	
Initial wt, kg	154	164	152	152	160	147	147	155	140	4
Slaughter wt, kg[f]	459	507	435	453	476	427	453	456	424	11
Days in feedlot	264	265	275	210	214	218	224	228	241	6
ADG, kg										
158–213 d of age	1.00	1.07	1.05	.88	.87	.73	.60	.63	.61	.06
213–432 d of age	1.20	1.37	1.04	1.21	1.27	1.12	1.22	1.18	1.04	.04
Overall	1.15	1.30	1.04	1.14	1.19	1.03	1.10	1.07	.96	.04
Initial ht, cm	92.1	94.0	92.8	92.4	93.9	91.1	91.5	94.1	90.6	1.0
Height change, cm										
158–213 d of age	12.9	13.9	13.0	14.7	14.2	14.9	12.7	11.6	13.8	.6
213–432 d of age	19.3	19.9	18.2	17.9	19.8	15.7	20.1	22.1	18.9	1.1
Overall	32.2	33.8	31.3	32.5	34.0	30.6	32.8	33.7	32.7	1.0
DMI, kg/d[g]	6.95	8.00	6.91	7.87	8.33	7.39	7.80	7.58	7.11	.18
Gain/feed[g]	.166	.163	.151	.145	.142	.140	.141	.142	.135	.004
Total conc., kg/steer[h]	1,828	2,122	1,901	1,779	1,918	1,701	1,750	1,740	1,709	58

	P =							
	Contrast							
Item	EW vs NWC and NW	NWC vs NW	BRI vs CON	BRI vs WAG	EW vs NW × BRI vs CON	EW vs NW × BRI vs WAG	NWC vs NW × BRI vs CON	NWC vs NW × BRI vs WAG
Initial wt, kg	.009	.03	.01	.06	.61	.50	.85	.62
Slaughter wt, kg	.004	.22	.01	.0004	.01	.75	.17	.85
Days in feedlot	.0001	.0002	.54	.003	.78	.93	.99	.28
ADG, kg								
158–213 d of age	.0001	.0001	.51	.38	.40	.15	.65	.07
213–432 d of age	.23	.07	.10	.0001	.008	.80	.10	.15
Overall	.0006	.003	.07	.0001	.005	.77	.17	.50
Initial ht, cm	.19	.54	.02	.33	.87	.20	.40	.76
Height change, cm								
158–213 d of age	.29	.0001	.67	.16	.02	.51	.42	.35
213–432 d of age	.93	.0009	.09	.02	.25	.68	.96	.47
Overall	.58	.25	.11	.09	.74	.98	.66	.19
DMI, kg/d	.0008	.003	.008	.001	.0005	.04	.01	.37
Gain/feed	.0001	.19	.65	.002	.78	.12	.58	.87
Total conc., kg/steer	.0001	.07	.007	.63	.004	.11	.07	.65

[a]Least squares means.
[b]External fat thickness was used as a covariate (mean = 1.08 cm).
[c]EW = early weaned, NWC = normally weaned with creep, NW = normally weaned.
[d]BRI = Angus × Hereford, CON = Simmental × Angus, WAG = Wagyu × Angus.
[e]Greatest standard error of treatment means (SEM) reported.
[f]Calculated as hot carcass weight/.61.
[g]During feedlot phase.
[h]Total concentrate, creep, and feedlot phases included.

after the time of normal weaning. The NWC steers tended to exhibit an ADG .05 kg/d higher (P = .07) after the time of normal weaning than did NW steers. The EW steers had an ADG .08 kg/d higher (P = .0006) overall compared with the average of NWC and NW steers, and NWC steers had an ADG .08 kg/d higher (P = .003) overall than NW steers. Drouillard et al. (1990) reported that higher rates of gain during the preweaning period were associated with greater efficiencies and rates of gain during the finishing period.

No breed type differences in ADG (P > .38) were observed before the time of normal weaning. Data from Anderson et al. (1978) suggest that creep-feeding "exotic" steer calves was necessary to take advantage of preweaning growth potential. No differences in ADG were observed between BRI and CON steers (P = .10), but BRI steers gained .14 kg/d more (P = .0001) between normal weaning and slaughter than WAG steers. The BRI steers had an ADG .06 kg/d lower (P = .07) overall than CON steers and had an ADG .12 kg/d higher (P = .0001) overall than WAG steers. Findings of Lunt et al. (1993) support the previous observation that Angus steers are higher-performing than Wagyu steers.

There was a significant treatment × breed interaction of EW vs NW × BRI vs CON for ADG from normal weaning to slaughter (P = .008) and overall (P = .005). These results are the same as for those observed previously for slaughter weight.

No differences (P = .19) were observed in initial height between treatments or in height change (P = .29) between EW vs NWC and NW steers. The NWC steers had 1.9 cm more height change (P = .0001) before the time of normal weaning than NW steers, but NW steers had 2.6 cm more height change (P = .0009) than NWC after the time of normal weaning. No differences (P = .25) were observed in height change overall between NWC and NW steers.

The BRI steers were 2 cm shorter (P = .02) than CON steers when the study began. No differences (P = .67) in height change were observed between BRI and CON steers before the time of normal weaning. The CON steers had (P = .09) 1.5 cm more height change after the time of normal weaning. No differences (P = .11) were observed between BRI and CON steers for overall height change.

No differences were observed in initial height (P = .33) or height change before the time of normal weaning (P = .16) between BRI and WAG steers. The BRI steers had 1.5 cm more height change (P = .02) after the time of normal weaning than WAG steers and had (P = .09) an overall height change of 1 cm more. There was a significant treatment × breed interaction of EW vs NW × BRI vs CON for height change before the time of normal weaning (P = .02).

During the creep-feeding phase, NWC steers consumed 2.17 kg/d. In the feedlot, EW steers had an intake that was .39 kg/d lower (P = .0008) and feed conversions .02 unit (gain:feed) better (P = .0001) than the average of NWC and NW steers. According to Lipsey et al. (1978), fast-gaining cattle are more efficient when fed to similar physiological maturity compared with slow-gaining cattle because they spend a lower proportion of their energy intake on maintenance. The NWC steers had an intake .36 kg/d higher (P = .003) than NW steers, and no differences (P = .19) were observed in efficiency. Lancaster et al. (1973) reported that the feed consumption of conventionally grown steers increased dramatically (2.6 kg/d more feed in the finishing phase) compared with steers grown on an accelerated production system.

The BRI steers had an intake .43 kg/d lower (P = .008) than CON steers, and WAG steers had an intake .40 kg/d lower (P = .001) than BRI steers. No differences (P = .65) were observed between BRI and CON steers in feed conversions, but the BRI steers were .009 unit more efficient (P = .002) than WAG steers. Gregory et al. (1994) found that breeds with the least weight to maintain tended to be more efficient in live weight gain when evaluated in a time-constant (0 to 207 d) period. Findings of Lunt et al. (1993) also gives further evidence that Angus steers require less feed per unit of gain than Wagyu steers.

The EW steers consumed 183 kg more total concentrate (P = .0001) than the average of NWC and NW steers, and NWC steers tended (P = .07) to consume more concentrate (66 kg) than the NW steers. The BRI steers consumed 141 kg less total concentrate (P = .007) than CON steers, and no differences (P = .63) were observed between BRI and WAG steers.

There were significant treatment × breed interactions of EW vs NW × BRI vs CON (P = .0005), EW vs NW × BRI vs WAG (P = .04), and NWC vs NW × BRI vs CON (P = .01) for intake. There was also a significant treatment × breed interaction of EW vs NW × BRI vs CON (P = .004), and there tended to be a treatment × breed interaction of NWC vs NW × BRI vs CON (P = .07). These interactions in intake and total concentrate are primarily related to differences in harvest weight.

No treatment × breed interactions were observed for carcass characteristics (P > .15). Carcass traits for yr 1 are presented in Table 4. The EW steers had (P = .11) an 11-kg heavier carcass weight than the average of NWC and NW steers, thus indicating that the EW does not result in lighter weight cattle at slaughter. Lusby et al. (1990) observed similar slaughter weights for calves early-weaned and full-fed a 90% concentrate diet and calves that remained with their dams until normal weaning. No differences (P = .97) in carcass weight were observed between NWC and NW steers. The LMA was not enhanced (P = .65) by treatment. Additionally, no differences (P = .18) were observed when LMA was expressed as square cen-

Table 4. Effects of three weaning management systems on carcass quality (yr 1)[ab]

	Treatment[c]				P = Contrast	
Item	EW	NWC	NW	SEM[d]	EW vs NWC and NW	NWC vs NW
No. of steers	27	28	28			
Carcass wt, kg	301	290	289	6	.11	.97
≤250 kg, %	15	10	8	6	.43	.88
LMA[e]						
cm^2	74.5	73.6	74.0	1.26	.65	.83
cm^2/kg HCW[f]	.25	.26	.26	.01	.18	.77
Est. KPH, %[g]	1.8	1.5	1.8	.1	.09	.03
Avg. yield grade	2.86	2.74	2.79	.04	.07	.50
Yield Grade 1, %	7	6	1	4	.43	.42
Yield Grade 2, %	52	63	69	8	.13	.58
Yield Grade 3, %	37	31	30	7	.37	.94
Yield Grade 4, %	4	0	0	2	.14	.74
Marbling score[h]	1,198	1,144	1,120	18	.003	.34
≥Choice, %	100	96	100	2	.49	.14
≥Avg. Choice, %	93	68	68	8	.01	.99
≥Prime, %	15	11	0	5	.15	.15

[a]Least squares means.
[b]External fat thickness was used as a covariate (mean = 1.15 cm).
[c]EW = early weaned, NWC = normally weaned with creep, NW = normally weaned.
[d]Greatest standard error of treatment means (SEM) reported.
[e]Longissimus muscle area.
[f]Hot carcass weight.
[g]Kidney, pelvic, and heart fat.
[h]1,100 = Modest^{00}.

timeters per kilogram of carcass weight. The EW steers had (*P* = .09) 9% more kidney, pelvic, and heart fat than the average of NWC and NW steers, and NWC steers had 20% less (*P* = .03) than NW steers.

The EW steers had (*P* = .07) a .09-unit higher yield grade than the average of NWC and NW steers, and no differences (*P* = .50) were observed between NWC and NW steers. No differences were observed (*P* = .13) in the percentage of steers assigned Yield Grades 1, 2, 3, or 4. Sixty-six percent of the steers received Yield Grade 2.9 or better.

The EW steers had a 66-unit higher (*P* = .003) marbling score than the average of NWC and NW steers. No differences (*P* = .34) were observed between NWC and NW steers in marbling score. The EW improved (*P* = .01) percentage of steers grading Average Choice or higher by 37% compared with the average of NWC and NW. Fluharty et al. (1997) reported that steers fed a 90% concentrate and 16% CP diet had higher quality grades than calves weaned at 205 d of age. Feeding a high concentrate from an early age did not increase marbling score when calves were slaughtered at approximately 1 yr of age in the study by Lusby et al. (1990).

Carcass traits for yr 2 are shown in Tables 5 and 6. The EW steers had a 9-kg heavier carcass (*P* =.04) than the average of NWC and NW steers, and there were no differences (*P* = .42) observed between NWC and NW steers. The LMA was not affected (*P* = .59) by treatment. When LMA was expressed as square centimeters per kilogram of carcass weight, EW steers had .003 cm^2 less (*P* = .05) LMA than the average of NWC and NW steers. The EW steers had 12% more kidney, pelvic, and heart fat (*P* = .0005) than the average of NWC and NW steers, and NWC steers had 16% more (*P* = .001) than NW steers. Differences in kidney, pelvic, and heart fat are reflected in differences in yield grades.

The EW steers had a .09-unit higher yield grade (*P* = .03) than the average of NWC and NW steers, and NWC steers had a .10-unit higher yield grade (*P* = .03) than NW steers. The NW steers had nine percentage units more (*P* = .02) Yield Grade 1 than NWC steers. No differences (*P* = .13) were observed in the percentage of yield grade 2. Sixty-eight percent of the steers rated Yield Grade 2.9 or better. The EW steers tended to have 11 percentage units higher (*P* = .07) percentage of Yield Grade 3 than the average of NWC and NW steers.

The EW steers had a marbling score 45 units higher (*P* = .004) compared with the average of NWC and NW. No differences (*P* = .89) in marbling score were observed between NWC and NW steers. Deutscher and Slyter (1978) and Faulkner et al. (1994) observed an improvement in quality grade for creep-fed calves compared with controls. In this study, NWC

Table 5. Effects of three weaning management systems on carcass quality (yr 2)[ab]

	Treatment[c]				P = Contrast	
Item	EW	NWC	NW	SEM[d]	EW vs NWC and NW	NWC vs NW
No. of steers	48	55	64			
Carcass wt, kg	283	276	272	4	.04	.42
≤250 kg, %	15	15	13	5	.77	.78
LMA[e]						
cm^2	75.4	74.5	75.0	1.0	.59	.71
cm^2/kg HCW[f]	.27	.27	.28	.01	.05	.14
Est. KPH, %[g]	2.3	2.2	1.9	.1	.0005	.001
Avg. yield grade	2.71	2.67	2.57	.04	.03	.03
Yield Grade 1, %	12	5	16	4	.70	.02
Yield Grade 2, %	49	66	57	7	.13	.23
Yield Grade 3, %	39	29	27	5	.07	.83
Marbling score[h]	1,168	1,124	1,122	13	.004	.89
≥Choice, %	95	87	91	4	.16	.39
≥Avg. Choice, %	81	58	58	6	.003	.99
≥Prime, %	15	10	2	4	.06	.15

[a]Least squares means.
[b]External fat thickness was used as a covariate (mean = 1.08 cm).
[c]EW = early weaned, NWC = normally weaned with creep, NW = normally weaned.
[d]Greatest standard error of treatment means (SEM) reported.
[e]Longissimus muscle area.
[f]Hot carcass weight.
[g]Kidney, pelvic, and heart fat.
[h]1,100 = Modest[00].

calves were slow at getting started on creep feed and were fed for a shorter period of time than Faulkner et al. (1994). This may account for the lack of response in quality grade in this study. No differences (*P* = .16) were observed in the percentage of steers grading Choice or higher. The EW improved percentage of steers grading Average Choice or higher by 40% (*P* = .003) over the average of NWC and NW. The EW improved (*P* = .06) the percentage of steers grading Prime or higher by 150% over the average of NWC and NW. No differences (*P* = .15) were observed in the percentage of steers grading Prime or higher between NWC and NW.

The BRI steers had carcasses that were 13 kg lighter (*P* = .01) than those of CON steers; however, the carcass weights of the BRI steers were 16 kg heavier (*P* = .0005) than those of WAG steers (Table 6). The CON steers had LMA 6.2 cm more (*P* = .0001) than those of BRI steers, and no differences (*P* = .41) were observed between BRI and WAG steers. When LMA was expressed as square centimeters per kilogram of carcass weight, CON steers had .01 cm^2 more LMA (*P* = .02) than BRI steers. Additionally, the WAG steers had .02 cm^2 more LMA (*P* = .0007) than BRI steers, because the WAG steers had lighter carcass weights. No breed differences in kidney, pelvic, and heart fat (*P* = .27) were observed. The heavier carcass weights and larger LMA of the CON steers resulted in a yield grade .19 unit more desirable (*P* = .0002) than BRI steers. No differences (*P* = .17) in yield grade were observed between BRI and WAG steers. The CON steers attained (*P* = .07) Yield Grade 1 carcasses 10 percentage units more than BRI steers. No differences (*P* = .70) in the percentage of Yield Grade 1 were observed between BRI and WAG steers. No breed differences (*P* = .26) in percentage of Yield Grade 2 were observed. The BRI steers had 14 percentage units more (*P* = .04) Yield Grade 3 carcasses than CON steers and 12 percentage units more (*P* = .06) than WAG steers. Sixty-nine percent of the steers were graded with a Yield Grade 2.9 or better. Studies have shown that carcass cutability varies among cattle types (Koch et al., 1982; Lunt et al., 1985). In general, these studies have concluded that carcasses of European breeds have higher yields of major cuts than those from English or *Bos indicus* cattle.

No breed differences (*P* = .11) were observed for marbling score. The BRI steers improved (*P* = .0006) percentage of steers grading Choice or higher by 21% over CON steers and improved (*P* = .04) percentage of steers grading Average Choice or higher by 33%. No differences (*P* = .84) were observed in percentage of steers grading Choice or higher or the percentage of steers grading Average Choice or higher between BRI and WAG steers. No breed differences (*P* = .62) were observed for percentage of steers grading Prime or

Table 6. Effects of three breed types on carcass quality (yr 2)[ab]

Item	Breed[c] BRI	CON	WAG	SEM[d]	P = Contrast BRI vs CON	BRI vs WAG
No. of steers	83	40	44			
Carcass wt, kg	278	291	262	4	.01	.0005
≤250 kg, %	11	6	29	6	.46	.01
LMA[e]						
cm^2	73.2	79.4	72.2	1.1	.0001	.41
cm^2/kg HCW[f]	.26	.27	.28	.01	.02	.0007
Est. KPH, %[g]	2.1	2.1	2.2	.1	.88	.27
Avg. yield grade	2.73	2.54	2.67	.04	.0002	.17
Yield Grade 1, %	7	17	9	4	.07	.70
Yield Grade 2, %	53	57	63	8	.69	.26
Yield Grade 3, %	40	26	28	5	.04	.06
Marbling score[h]	1,148	1,120	1,146	15	.11	.89
≥Choice, %	97	80	97	4	.0006	.98
≥Avg. Choice, %	72	54	71	7	.04	.84
≥Prime, %	8	10	9	4	.62	.79

[a]Least squares means.
[b]External fat thickness was used as a covariate (mean = 1.08 cm).
[c]BRI = Angus × Hereford, CON = Simmental × Angus, WAG = Wagyu × Angus.
[d]Greatest standard error of treatment means (SEM) reported.
[e]Longissimus muscle area.
[f]Hot carcass weight.
[g]Kidney, pelvic, and heart fat.
[h]1,100 = Modest^{00}.

higher. Gregory et al. (1994) reported large differences among breed groups for carcass traits. This was due, at least in part, to Angus steers finished at lighter weights than Simmental steers, and consequently Angus steers had lighter carcasses. Additionally, they found that breeds ranked similarly in ribeye area per unit of carcass weight and that estimated kidney, pelvic, and heart fat percentage differences generally were small. When marbling score was evaluated, Angus was higher than Simmental.

Health of Steers

Differences is steer health can be found in Table 7. The EW steers had a 91% lower respiratory morbidity (P = .001) compared with the average of NWC and NW steers, and NWC had 84% lower respiratory morbidity (P = .0001) than NW steers. The high percentage of treated NW steers may be attributed to weather effects and lack of prior consumption of a high-concentrate diet. No differences (P = .15) were

Table 7. Health of steers as affected by three weaning management systems (yr 1 and 2)[a]

Item	Treatment[b] EW	NWC	NW	SEM[c]	P = Contrast EW vs NWC and NW	NWC vs NW
Respiratory morbidity, %	1.2	3.6	22.8	3.1	.001	.0001
Digestive morbidity, %	1.2	0	0	.7	.15	.99
Digestive mortality, %	1.2	0	0	.6	.15	.99
Accidental mortality, %	1.2	1.2	0	1.0	.61	.37

[a]Least squares means.
[b]EW = early weaned, NWC = normally weaned with creep, NW = normally weaned.
[c]Greatest standard error of treatment means (SEM) reported.

Table 8. Effects of three weaning management systems on cow performance (yr 1 and 2)[a]

Item	Treatment[b]			
	EW	NW	SEM[c]	P =
No. of cows	70	92		
Initial wt, kg	405	394	7	.30
Time of normal weaning wt, kg	425	385	7	.0001
ADG, kg	.38	−.17	.04	.0001
Initial BCS[d]	3.9	4.0	.1	.47
Time of normal weaning BCS[d]	4.2	4.0	.1	.25
BCS Change[d]	.23	.00	.08	.04
Pregnancy, %	78	67	.10	.10

[a]Least squares means.
[b]EW = early weaned, NW = normally weaned.
[c]Greatest standard error of treatment means (SEM) reported.
[d]Body condition score (1 = emaciated, 9 = extremely fat).

observed between experimental treatments for steers with digestive morbidity. In yr 1, one steer died of polio. In yr 2, two steers died owing to accidental causes, and seven steers died from heat stress.

Effect of Early Weaning on Cow Performance

No treatment × year interactions were observed for cow performance traits ($P > .10$). Cow performance traits for yr 1 and 2 are presented in Table 8. No differences ($P = .30$) in initial weight were observed between treatments. At the time of normal weaning, cows with EW steers were 40 kg heavier than cows with NW steers ($P = .0001$). Cows with EW steers had an ADG .55 kg/d higher than cows with NW steers ($P = .0001$) before the time of normal weaning.

Richardson et al. (1978) and Neville and McCormick (1981) showed that dams of early-weaned calves gained more between early weaning and normal weaning than did cows that weaned twin calves at 205 d. Peterson et al. (1987) indicated that cows with EW calves consumed 45.3% less total digestible nutrients from hay than cows with normally weaned calves and that EW cow-calf pairs were 43.0% more efficient in converting TDN into calf gain than were normally weaned cow-calf pairs.

No differences ($P = .47$) in initial BCS were observed between treatments. Cows with EW steers had .23 unit higher BCS ($P = .04$) than cows with NW steers at the time of normal weaning. The EW tended ($P = .10$) to improve pregnancy rates compared with NW. In this study, the cows were already bred at EW. This difference may be due to embryonal loss from the combined stress of lactation and endophyte (Porter and Thompson, 1992).

Implications

Early weaning increased overall gain, decreased daily intake, improved efficiency, increased total concentrate consumed, and improved quality grades of steers in this study. Steers of British breed type had lower gain and reduced daily intake, consumed less total concentrate, had lighter carcass weights, reduced longissimus muscle area, had more undesirable yield grades, and improved quality grades than steers of Continental breed type. Steers of Wagyu breed type had more days finishing, lower gain, lower intake, more undesirable efficiencies, and lighter carcass weights than steers of British type in this study. Cow performance and pregnancy rate were improved by the early weaning of beef steers.

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