Beef Session

Moderators: *Tiffany Lee, Travis Hill, Pete Ostrum*

Economics of dry lotting beef cows

R.J. Rasby,[1] MS, PhD; **J.M. Warner**,[2] **S.E. Gardine**,[3] **K.H. Jenkins**,[4] MS, PhD **T.J. Klopfenstein**,[5] MS, PhD
[1]Department of Animal Science, University of Nebraska, Lincoln, NE 68583
[2]Graduate Student, University of Nebraska, Lincoln, NE 68583
[3]Graduate Student, University of Nebraska, Lincoln, NE 68583
[4]Panhandle Research and Extension Center, University of Nebraska, Lincoln, NE 68583
[5]Department of Animal Science, University of Nebraska, Lincoln, NE 68583

Abstract

Three experiments evaluated cow and calf performance in alternative production systems; 1) early weaning on feed use; 2) a sensitivity analysis investigating profit potential of confinement cow management to changes in production prices and weaning rates, and; 3) investigate a winter management system incorporating winter cornstalk residue grazing on cow and calf performance in a summer-calving herd. In experiment 1, cows were limit fed and used two weaning time, early (EW; 91 days old) or conventionally-weaned (CW; 203 days old). Nursing pairs were fed an equivalent amount of DM that the early weaned calf plus the dams were fed. Cows limit-fed in confinement resulted in no negative impact on reproduction and early-weaning did not reduce feed energy requirements. In experiment 2, production parameters were obtained from the summer-calving cowherd in a dry lot year-round. Greater returns were projected as weaning percentage increased and a positive return for systems using distillers grains and crop residues. For experiment 3, two wintering systems on cow-calf performance in a summer-calving cowherd were evaluated. Grazing cow-calf pairs on cornstalks had lower ending weights of cows and gains of calves. Incorporating winter cornstalk grazing into the system were $137 more profitable compared to cows wintered in the drylot.

Key words: beef cows, dry-lotting, production, economics

Résumé

Trois expériences évaluées vache et veau performance dans de nouveaux systèmes de production ; 1. Sevrage précoce sur l'utilisation fourragère ; 2. Une analyse de sensibilité sur la rentabilité potentielle de l'accouchement de la gestion de la vache à l'évolution des prix de production et les taux de sevrage, et ; 3. Enquêter sur un système de gestion de l'hiver l'incorporation de résidus sur le pâturage d'hiver cornstalk veau vache et performance dans un troupeau d'élevage. Dans l'expérience 1, les vaches étaient nourries et limite utilisée deux fois, au début du sevrage (EW ; 91 jours) ou conventionnellement-sevré (CW ; 203 jours). Paires de soins infirmiers ont reçu un montant équivalent de DM que le veau sevré plus tôt les barrages ont été nourris. Limite de vaches-fed en confinement, a donné lieu à aucun impact négatif sur la reproduction et le début-sevrage n'a pas réduit les besoins en énergie. Dans l'expérience 2, les paramètres de production ont été obtenus à partir de l'été-mise bas bouvier dans un terrain sec toute l'année. Un plus grand rendement avait été prévu que le sevrage pourcentage a augmenté et un rendement positif pour les systèmes utilisant des drèches et des résidus de récolte. Pour l'expérience 3, deux systèmes d'hivernage dans les exploitations de la performance dans un été-mise bas bouvier ont été évalués. Paires de vaches-veaux de pâturage sur les tiges ont des poids de vaches et se terminant un gain de veaux. L'intégration de cornstalk hiver dans le système de pâturage ont été de 137 vaches plus rentable par rapport à l'hiver dans le solide.

Introduction

In beef cow-calf production systems, weaning most often occurs when calves reach a conventional age of 6 to 8 month, independent of season of birth.[25,35] Situations like reduced forage availability, decreased milk production by the dam, age of dam, or low cow BCS may arise in which early calf weaning is a viable management strategy. The benefits of sparing available forage,[4,19] enhancing reproduction[11] and reducing cow maintenance energy requirements[24] by early-weaning are well documented. Given that early-weaned calves are inherently efficient at converting feed to gain;[22] early-weaning is often regarded as a more feed efficient management practice by reducing the total feed energy required by a cow-calf pair.[27] Peterson et al[27] measured this efficiency by feeding different diets to pairs and weaned calves and calculated energy intakes with assumed feedstuff energy values. An alternative approach that would minimize variation in diet energy content would be to feed a common diet to all cows and calves at a similar DMI.

Achieving operation profitability requires a clear understanding and analysis of the various economic factors driving profitability. Feed cost has frequently been reported as the greatest variable cost associated with cow-calf production.[16,28] Thus, considerable effort has historically been placed on evaluating methods to reduce harvested or purchased forages and feeds, but the price of forages/feeds relative to other inputs (i.e., grazing costs, land values) varies significantly depending on year and location.

Reproduction, expressed as calves weaned per female exposed for breeding, influences profitability of the cow-calf system because the breeding female incurs all expenses of calf production. Furthermore, Griffin et al[10] noted that seasonal variability exists for cattle prices depending on size and class, potentially creating opportunities for production systems to match the timing of marketing to periods of stronger market prices. Stockton et al[33] documented that moving the calving season changes the timing of production and marketing which may prove economically beneficial.

Numerous economic factors have led to strengthened land values and stimulated the conversion of pasture and other grasslands to cropland.[41] When such changes in land use are combined with other events that decrease forage availability (i.e., drought), the price of grass and other forages increases and the cowherd must be maintained using alternative resources. However, increased corn and ethanol production in major crop production areas has resulted in a greater abundance of other feedstuffs, primarily residues and distillers grains. Alternative cow-calf production systems involving partial or total intensive management (confinement) of cows utilizing crop residues and distillers grains may be viable alternatives to conventional cow-calf systems. Alternative cow-calf production systems including dry lot and/or corn residue grazing need investigation. Therefore three objectives:

1) Evaluate the impact of calf age at weaning on: a) cow-calf performance and reproduction, and b) the feed utilization by the cow-calf pair of developing a weaned calf to 205 day of age when pair-fed a common diet;
2) Model profitability through the weaning phase of production of an intensively managed cow-calf production system located in the Midwest and evaluate the sensitivity of profitability to changes in annual cow feed costs, feeder cattle prices, replacement female purchase costs, and reproductive rate (number of calves weaned per cow exposed for breeding);
3) Investigate a winter management system incorporating winter cornstalk residue grazing on cow and calf performance in a summer-calving intensively managed cow-calf production system.

Material and Methods

For experiment 1, multiparous (4.6 ± 1 year of age), crossbred (Red Angus × Red Poll × Tarentaise × South Devon × Devon), lactating beef cows (total n = 156) with summer-born calves were utilized in a 2 year experiment conducted at two University of Nebraska-Lincoln Research locations, eastern and western in their feedlot facility. Annual precipitation at the east location is approximately 28 inches (72 mm) and for the west location 13 inches (34 cm). The trial was a randomized complete block design with a 2 × 2 factorial arrangement of treatments. Each year, cows within each location were blocked by pre-breeding BW (heavy, medium, and light), stratified by calf age, and assigned randomly within strata to one of two calf weaning treatments with three replications (pens) per treatment per year per location (total n = 24 pens; 5 to 7 pairs per pen). Location was considered part of the treatment design given the difference in climate, therefore treatment factors included: 1) calf age at weaning; early-weaned (EW) at an average age of 91 ± 18 d or conventional-weaned (CW) at an average age of 203 ± 16 d ; and 2) research location; eastern or western Nebraska. Cows remaining in the herd for two consecutive year were assigned to the same treatments each year. Cows removed upon completion of year 1 of the experiment were replaced with pregnant, multiparous (4 years of age) females of similar genetic composition and calving date from a commercial ranch in southwest Nebraska. Reasons for cow removal from the experiment between the completion of year 1 and the beginning of year 2 included: failure to become pregnant (n = 10), calf death during the calving season (n = 4), undesirable teat or udder conformation (n = 2), poor disposition (n = 1), and death (n = 1).

Prior to the beginning of the experiment each year, cows within locations were managed as a common group while calving in June and July in earthen feedlot pens without access to shade. Cows were vaccinated approximately one month prior to calving against bovine rotavirus, bovine coronavirus, *Escherichia coli*, and clostridium perfringens type C.[a] Post-calving, cows were limit-fed (9.1 kg DM/cow daily) high energy diets (Table 1) to meet nutrient requirements for early-lactation. Within 24 hour of parturition, calving date, calf birth weight, and sex were recorded, male progeny were band castrated, and all calves were vaccinated against clostridium chauvoei, septicum, novyi, sordellii, perfringens types C and D, and haemophilus somnus.[b] All calves received a second vaccination of Vision® 7 Somnus and were vaccinated against infectious bovine rhinotracheitis, bovine viral diarrhea (types 1 and 2), parainfluenza 3, and bovine respiratory syncytial virus[c] concurrent with the time of early-weaning. Upon trial initiation approximately October 6 each year, cow-calf pairs assigned to the EW treatment were separated at an average calf age of 91 days, after which cows and calves were managed and fed independently for the duration of the trial. Cows and calves assigned to the CW treatment remained together throughout the trial and these calves were weaned approximately January 28 at an average calf age of 203 days. Cow BCS (1 = emaciated; 9 = obese) was assessed visually by the same experienced technician across locations at trial initiation and completion.[39] Two-day consecutive cow and

Table 1. Ingredient and nutrient composition of diets fed to all cows and calves from October to January by location and year.[1]

	Yr 1		Yr 2	
Ingredient, %	**EAST[2]**	**WEST[3]**	**EAST[2]**	**WEST[3]**
Corn silage	--	--	40.0	40.0
MDGS[4]	56.5	--	36.5	--
WDGS[5]	--	58.0	--	38.0
Cornstalks	40.0	--	20.0	--
Wheat straw	--	40.0	--	20.0
Supplement[6]	3.5	2.0	3.5	2.0
Calculated composition				
DM, %	61.9	47.0	45.4	39.3
CP, %	19.0	18.8	16.1	15.3
TDN, %	80.0	80.0	78.0	78.4
NE_m, mcal/kg	1.94	1.94	1.87	1.90
NE_g, mcal/kg	1.52	1.52	1.46	1.48
NDF, %	47.3	54.9	47.1	51.1
ADF, %	25.2	21.6	25.3	22.0
Ca, %	0.75	0.77	0.58	0.81
P, %	0.50	0.49	0.44	0.41

[1]All values presented on a DM basis.
[2]EAST = Agricultural Research and Development Center.
[3]WEST = Panhandle Research and Extension Center.
[4]MDGS = modified wet distillers grains plus solubles.
[5]WDGS = wet distillers grains plus solubles.
[6]Supplements contained limestone, trace minerals, vitamins and formulated to provide no greater than 200 mg/cow daily monensin sodium (Elanco Animal Health, Greenfield, IN).

calf BW measurements[33] were recorded to determine cow weight change and calf gain from October to January. Prior to collecting weights at the beginning of the trial, all pairs were limit-fed (20 lb DM/pair daily or 9.09 kg DM/pair daily) a diet (Table 1) for 5 day to minimize variation in gastrointestinal tract fill.[40] At trial completion, both CW (following separation from their dams) and EW calves were limit-fed (approximately 10 lb•calf-1•day-1 or 4.5 kg•calf-1•day-1; DM basis) the same diet for 5 day before taking weights. All cows were limit-fed 15 lb DM (6.8 kg DM) (Table 1) for 5 day prior to weighing.

From October through January, EW cows within each location were limit-fed 15 lb (6.9 kg) DM/cow daily a diet designed to meet maintenance energy requirements for a nonlactating cow in mid-gestation (Table 1). Concurrently, the EW calves within each location were offered *ad libitum* access to the same diet as the cows. Feed refusals (if present) by the calves were collected, sampled, and DM determination was conducted using a 60°C forced air oven for 48 hour to calculate DMI. The CW cow-calf pairs that remained together were then limit-fed the equivalent amount of DM consumed in total by the EW cows and calves, accomplished by summing the intakes of the two groups. Intakes for the CW cow-calf pairs were adjusted once weekly based on the average consumption of the EW calves from the prior wk. No attempt was made to measure intake between the CW cow and her calf. Consequently, the total DMI between either the separated EW cows and calves or the CW pairs together was intended to be equal by design and increased throughout the experiment due to growth and diet consumption by the EW calf. The ratio of calf BW gain to the total feed energy intake by the cow-calf pair was subsequently calculated as a measurement of the feed efficiency of early weaning. All cattle were maintained in earthen feedlot pens and received their diets as a TMR once daily in concrete fence-line feed bunks with the following bunk space allotments: 2 ft (0.6 m) per EW cow, 1 ft (0.3 m) per EW calf, and 3 ft (0.9 m) per CW cow-calf pair.

Cows were exposed to Simmental × Angus bulls at a bull:cow ratio of 1:10 for 60 d beginning approximately September 26 each year, and breeding occurred in the pens. Cows were vaccinated approximately 1 month prior to the start of the breeding season against infectious bovine rhinotracheitis, bovine viral diarrhea (types 1 and 2), parainfluenza 3, bovine respiratory syncytial virus, and leptospirosis.[d] All bulls passed a breeding soundness examination administered by a licensed veterinarian. Pregnancy was diagnosed via transrectal ultrasonography 60 day after bull removal.

All data were analyzed as a randomized complete block design using PROC MIXED of SAS[e] with pen as the experimental unit. Model fixed effects included calf age at weaning, location, and the weaning × location interaction. Because the proportion of steer and heifer calves was unequal among treatments, calf sex was initially included as a covariate for all variables tested and was subsequently removed if not significant. Block and year were included in all analyses as random effects, and significance was declared at $P \leq 0.05$.

For experiment 2, production data were obtained from Experiment 1. For the Economic Analysis, a Microsoft® Excel[f] spreadsheet budget was constructed to model profitability of the intensively managed cow-calf system. Base production parameters and economic assumptions made are presented in Tables 2 and 3, respectively. An arbitrary number of cows (100) were used as an initial inventory of exposed females each year. Data from experiment 1 were used to establish length of the breeding season and calf age at weaning. Given the efficiency of feed use was not significantly different between nursing pairs and weaned cows and calves, the current analysis evaluated the system in which calves were weaned and marketed at 7 month of age.

Prices for all feeds were entered into the spreadsheet on an as-is basis. Base distillers grains price was calculated as 100% of the value of $3.50/bu corn on a DM basis. Base price for crop residue was $50 per ton ($50 per 907 kg) based on reported values as of September 2015.[37] Additional costs added to feeds included $5 per ton ($5 per 907 kg) for delivery, $15 per ton ($15 per 907 kg) for grinding of baled crop residue, and 5% shrink on all ingredients. Feed prices were converted to a 100% DM basis for calculation of ration costs. Interest was charged to both cows and bulls based on average lifetime value under the assumption that cattle required financing.[13] Base replacement female price was determined using the Midwest average price for bred cows as of September 2015.[6] This price was multiplied by the average female replacement rate to determine the capital cost of the replacement female. The average base cull cow market price was determined using the national 5-yr average price from 2010 to 2014[6] and corresponded to the first week of February as cull animals would be marketed at that time. This price was increased $0.20 per lb ($0.20 per 0.45 kg) to establish the average base cull bull market price. Base market BW for cull cows and bulls were assessed at 1,250 lb (567 kg) and 2,000 lb (907 kg), respectively. Marketing costs were charged at $30 per cow per year. Likewise, expenses for animal health and identification were assessed at $30 per cow per year. Yardage was charged at a common rate for cows and bulls to cover expenses for labor, equipment, utilities/fuel, and land/loans.[12]

Bulls were considered purchased by the cowherd owner at a one-time base cost and maintained in confinement year-round. The average productive life of bulls was considered to be 4 year and a 1:25 bull:cow ratio was assumed. Costs of bull ownership were calculated by dividing initial purchase cost by the number of cows serviced over the bull's lifetime. Feed amounts for bulls were considered to be equal to that for either lactating or nonlactating cows depending on if bulls were in service. Because the cow was considered the productive unit, all bull expenses for feed, yardage, and interest were prorated so each cow was charged 1/25th of the cost of the bull.

Base calf marketing BW was from experiment 1. The average base market price for 450 lb (204 kg) feeder steers was determined using the national 5-yr average price from 2010 to 2014[6] corresponding to the first week of February when calves would be sold. A discount of $0.10 per lb ($0.10 per 0.45 kg) was applied to derive the average base price for heifers. Total revenues from the sale of weaned calves were calculated using the percentage calf crop weaned relative to the number of exposed females, weaning BW, and corresponding prices for steers and heifers assuming each sex comprised 50% of the resulting calf crop. A base value of 85% was assessed for calf crop weaned based on cows exposed for breeding. Total annual costs per cow per year were determined as the sum of feed, interest, and yardage for cows and bulls, bull ownership costs, capital costs of the replacement female, animal health/identification, and marketing less credits for cull animals and manure. Credits for cull animals were calculated by multiplying the value of the cull animal by replacement rate adjusted for death loss. Cows

Table 2. Base annual production inputs for intensively managed system.

Item	Value	Unit
Total mature cow inventory exposed for breeding	100	cows
Length of breeding season	60	d
Average calf age at weaning	210	d
Average productive bull lifetime	4	year
Cows serviced over bull's lifetime	100	cows/bull
Average cull cow market BW	1,250 (567)	lb (kg)
Average cull bull market BW	2,000 (907)	lb (kg)
Calf crop weaned based on cows exposed	85	%
Average calf weaning BW	450 (204)	lb (kg)
Average female replacement rate	15	%
Cow DMI, nonlactating period[1]	15 (6.8)	lb (kg)/d
Cow DMI, lactating period[1]	23 (10.4)	lb (kg)/d
Bull DMI, breeding period[2]	23 (10.4)	lb (kg)/d
Bull DMI, nonbreeding period	15 (6.8)	lb (kg)/d

[1]Based on feeding a 60:40 distillers grains:crop residue diet (DM basis).

[2]Assuming equal DMI to that of cows during the breeding season.

were credited $50.00 per cow per year from the fertilizer value of manure produced, which is similar to that reported by Anderson et al.[2] Total annual costs per cow per year were multiplied by the number of cows exposed to calculate total costs for the system. Total system costs were subtracted from total revenues to determine net system profit or loss, which was then divided by the number of cows exposed to calculate profit or loss on a per cow per year basis.

System profitability was first modeled using initial base input prices and then under 4 different price and production analyses. In each analysis, two price or production parameters were changed at a time, while remaining parameters were held constant at initial base values. Therefore, projected profitability was influenced solely by the change in the parameters selected. The first analysis evaluated the effect of varying both the cost of replacement females ($1,600 to $3,000 per cow) and the percentage of calves weaned per cow exposed (75 to 95%) on profitability. In the second analysis, both calf marketing price $1.76 to $3.16 per lb ($1.76 to $3.16 per 0.45 kg) and weaning rate (75 to 95%) were varied. The price of distillers grains in relation to different corn price levels (85, 100, or 115% of $2.00 to $5.00 per bu corn) and weaning rate (75 to 95%) were altered in the third analysis. The final analysis evaluated the influence of both distillers grains (85, 100, or 115% of $2.00 to $5.00 per bu corn) and feeder calf prices $1.76 to $3.16 per lb ($1.76 to $3.16 per 0.45 kg) on profitability.

Experiment 3 was conducted at the two locations described in experiment 1 and using the same breed composition of as described in experiment 1 (n= 47 in the east location and n= 29 at west location) lactating beef cows with summer-born calves were utilized in the study. Within each location, cow-calf pairs were blocked by cow BW, stratified by calf age, and assigned randomly to one of two treatments: 1) dry lot feeding (DL) or, 2) cornstalk grazing (CS). Prior to trial initiation, cows were grouped in a single drylot pen within location during the summer calving season (mean calving date: July 9). A distillers and corn residue based diet was limit-fed to cow-calf pairs during this time. Trial initiation corresponded to the beginning of cornstalk grazing within each location (east = Nov 11 and west = Dec 4). Cow-calf pairs assigned to the CS treatment were transported to irrigated cornstalk fields, while cow-calf pairs assigned to DL treatment remained in drylot pens. Drylot pairs within location were limit-fed a common diet (Table 4) formulated to maintain a lactating cow in early gestation. Dry matter offered increased monthly throughout the study to account for the increasing intake of the growing calves.

Stocking rate for cow-calf pairs grazing cornstalks was calculated using estimated residue intakes of the cow and calf assuming 8 lb (3.6 kg) of husk and leaf residue (DM) were available per bushel of corn yield.

A dried distillers grain based pellet (Table 5) was supplemented in bunks (space: 2 linear feet per pair or 0.61

Table 3. Base production input and marketing prices.

Item	Value	Unit
Average bull purchase price	6,000	$/bull
Cattle interest rate	3.5	%
Average cull cow market price	0.74	$/0.45 kg[3]
Average cull bull market price	0.94	$/0.45 kg[3]
Manure value credit	50	$/cow/yr
Animal health and identification expenses	30	$/cow/yr
Marketing expenses	30	$/cow/yr
Cow yardage	0.35	$/cow/d
Bull yardage	0.35	$/bull/d
Average steer calf market price	1.76	$/0.45 kg[3]
Average heifer calf market price	1.66	$/0.45 kg[3]
Average purchase cost of replacement cow	2,300	$/cow
Average WDGS[1] price[2] as-is	51.47	$/907 kg[4]
Average baled crop residue price	50.00	$/907 kg[4]
Average supplement price	400.00	$/907 kg[4]

[1]WDGS = wet distillers grains plus solubles.
[2]Equal to 100% the price of $3.50/bu corn DM basis.
[3]$0.45 kg = $/lb.
[4]$907 kg = $/ton.

Table 4. Ingredient and nutrient composition of diets fed to cow-calf pairs in drylot by location.[1]

	Location	
Ingredient, %	**EAST**	**WEST**
Modified wet distillers grains plus solubles	55.0	
Wet distillers grains plus solubles	–	58.0
Wheat straw	40.0	40.0
Supplement	5.0	2.0
Calculated composition		
DM, %	62.4	47.0
CP, %	19.3	18.8
TDN, %	79.1	81.0
NDF, %	54.0	54.9
ADF, %	31.0	21.6
Ca, %	0.79	0.77
P, %	0.52	0.49

[1]All values presented on a DM basis
[2]Supplements included limestone, trace minerals, and vitamin A, D, E premix

Table 5. Supplement fed to cow-calf pairs grazing cornstalks.

Ingredient, %	
Dried distillers grains plus solubles	94.06
Limestone	5.49
Pelleting binder (urea formaldehyde polymer and calcium sulfate)	0.21
Vitamin A,D,E	0.12
Trace mineral[3]	0.11

[1]All values presented on a DM basis
[2]Fed at 5.3 lb (2.4 kg) per pair per d (DM)
[3]Cobalt, Copper, Manganese, Zinc, Iodine, Limestone Carrier

linear meters per pair) to pairs wintered on cornstalks at a rate of 5.3 lb (range of 3.7 lb to 7.1 lb; 2.4 kg; range 1.6 to 3.2 kg) DM/pair daily. The amount supplemented each day was calculated to provide the pairs on cornstalks the same energy intake of the DL pairs. Estimated DM intake of the cow and calf and estimated digestibility values of the cornstalk residue throughout the grazing period were used to calculate supplementation rate. Supplemental feed was only fed to grazing pairs if snow cover prevented grazing. The trial was completed when winter cornstalk grazing ended on April 13. Weaning of the calves also coincided with the completion of the corn residue grazing season.

Cow BW and body condition score (BCS) were recorded over two consecutive days at trial initiation and completion to determine changes in BW and BCS (feeding pre-weighing criteria described in experiment 1). Calf weights were also collected over two consecutive days at trial initiation and completion to calculate gain (feeding pre-weighing criteria described in experiment 1).

Cows were exposed to bulls (approximately 1 bull: 10 cows) from Sept 25 to Nov 30 for a 66 day breeding season at both locations. All bulls were examined for breeding soundness and approved by a licensed veterinarian prior to breeding season.

Results include 2 years of data from the east location and 1 year of data from the west location. Data was analyzed as a randomized block design using the mixed procedure of SAS. The model included pen or paddock as the experimental unit, wintering system as the fixed effect, and block as a random effect. Significance was declared at $P \leq 0.05$.

Results and Discussion

Experiment 1

Early-weaned calves across both year had a daily DMI of 9.0 lb (4.1 kg; east) and 8.6 lb (3.9 kg; west) per calf from October through January (Table 6). This amount was adjusted weekly, and added to the 15 lb/d (6.9 kg/d DM) fed to the EW cows to derive the total amount fed daily to the CW pairs. The combined total intake of the EW cows and calves was about 24 lb (11.0 kg). The CW pairs consumed 24 lb (10.9 kg DM/d). As a result, on average approximately 19.0 lb•pair-1•day-1 (8.7 kg•pair-1•day-1) of TDN was supplied to both EW and CW treatments, respectively, regardless if pairs were separate or together. Unlike Peterson et al,[27] the same diet was fed in the current study to all cows and calves regardless of weaning treatment within each year and location. This was done to eliminate potential variation in the energy value of the diet. A review of the literature indicates that this method to compare the feed efficiency between early- and conventional-weaned pairs has not been previously attempted.

In the current experiment, DMI of the EW calves was comparable to, but slightly lower than reported in previous studies for calves of similar BW and age.[22,23] Previous research has focused on feeding grain-based finishing diets to young calves upon early-weaning in an effort to increase DMI, and thus energy intake. Our diets contained more forage (40%, DM basis) from either crop residue or corn silage than the diets in the aforementioned studies.

As intended, cow BW was not different ($P \geq 0.05$) among treatment means in October (Table 7). The weaning age by location interaction was not significant for cow BW change, but EW cows gained more BW ($P < 0.01$) than their CW counterparts, and cows at west location outgained those at east ($P < 0.01$). Our observation for cow BW change in response to early-weaning agrees with previous data. Angus × Brahman cows gained less BW compared to cows whose calves were weaned 60 d earlier.[25] Early calf removal improved cow BW at the time of conventional-weaning in two additional studies using crossbred cows.[21,22] Similarly, total BW gain was greater for mature cows and first-calf heifers when calves were weaned at 108 compared to 205 d of age.[30] This positive change in cow BW from early weaning is logical given calf removal diverts intake energy from lactation towards maintenance and gestation.

There was no weaning age by location interaction or weaning age effect for January cow BCS ($P = 0.60$) or BCS change ($P = 0.38$; Table 8) although did not respond in a

Table 6. Daily DMI lb ± SD (kg ± SD) by location and weaning treatment across year.

	EAST[1]		WEST[2]	
Item	**EW[3]**	**CW[4]**	**EW[3]**	**CW[4]**
Cow	15.2 ± 0.11 (6.9 ± 0.05)	--	15.2 ± 0.07 (6.9 ± 0.03)	--
Calf	9.0 ± 2.25 (4.1 ± 1.02)	--	8.6 ± 2.09 (3.9 ± 0.95)	--
Cow-calf pair	--	24.0 ± 2.5 (10.9 ± 1.13)	--	23.8 ± 2.2 (10.8 ± 1.00)
Total	24.2 (11.0)	24.0 (10.9)	24.0 (10.9)	23.8 (10.8)

[1]EAST = Agricultural Research and Development Center.
[2]WEST = Panhandle Research and Extension Center.
[3]EW = early-weaned at 91 d of age.
[4]CW = conventionally-weaned at 203 d of age.

Table 7. Performance of cows by location and weaning treatment.

	EAST[1]		WEST[2]			P-value		
Item	EW[3]	CW[4]	EW[3]	CW[4]	SEM	Wean[5]	Loc[6]	W × L[7]
Cow BW, lb (kg)								
October	1,202 (545)	1,179 (535)	1,228 (557)	1,213 (550)	115 (52)	0.26	0.08	0.85
January	1,206 (547)	1,166 (529)	1,303 (591)	1,232 (559)	104 (47)	0.02	<0.01	0.51
Cow BW change, lb (kg)	4 (2)	-13 (-6)	75 (34)	20 (9)	22 (10)	<0.01	<0.01	0.15
Cow BCS[8]								
October	5.5	5.5	5.2	5.2	0.3	1.00	<0.01	0.59
January	5.4	5.3	5.6	5.6	0.4	0.60	0.03	0.60
Cow BCS change[8]	-0.1	-0.2	0.4	0.4	0.2	0.38	<0.01	0.38
Pregnancy, %	89.9	85.4	92.5	95.2	6	0.88	0.25	0.50

[1]EAST = Agricultural Research and Development Center.
[2]WEST = Panhandle Research and Extension Center.
[3]EW = early-weaned at 91 d of age.
[4]CW = conventionally-weaned at 203 d of age.
[5]Fixed effect of calf age at weaning.
[6]Fixed effect of location.
[7]Calf age at weaning × location interaction.
[8]BCS on a 1 (emaciated) to 9 (obese) scale.

similar manner by location. Why BCS did not respond in a similar manner as did BW is interesting. Calf removal has been frequently reported to either enable females to gain BCS or minimize the extent of BCS losses.[3,21,22] Other researchers have also demonstrated that removing the energy need for lactation improves BCS.[18,30] In most studies, early-weaned cows received *ad libitum* access to grazed pasture, such that forage quantity or quality was sufficient to support BCS improvements. In our study, cows were limit-fed to meet requirements, and BCS data indicate that energy intakes were adequate for maintenance.

There was no weaning age by location interaction (P = 0.50) for cow pregnancy rate nor were there effects of either location or calf weaning age (Tables 7 and 8). The dates for early-weaning coincided with the start of the breeding season, and approximately two week after the onset of breeding in year 1 and 2, respectively. Previous[15] and more recent data[3,4] indicate that early-weaning prior to the breeding season may increase cycling activity and conception rates in thin primiparous cows, and can reduce the duration of postpartum anestrus.[11] This agrees with work by Story et al[34] in which early-weaning did not influence pregnancy rates when cows were at a BCS of at least 5.0 before calving.

The conception rates in the current experiment also add to a limited body of research demonstrating the reproductive performance of cows when limit-fed high energy diets throughout the entire breeding season. Several trials[14,29,31,36] have found that limit-feeding high energy diets comprised of corn or ethanol co-products to cows in late-gestation or early-lactation does not hinder reproductive performance. In many of these trials the limit-feeding period ended at the start of the breeding season.

By design, calf BW was similar among treatments in October at the time of early-weaning (Table 4). Weaning age by location interactions were observed (P < 0.01) for both calf ADG and ending January BW. At the west location, EW calves gained more resulting in greater ($P \leq 0.05$) January BW than CW calves. At the east location, calves that nursed their dams had improved ($P \leq 0.05$) gain and ending BW over those weaned at 91 d of age. A weaning age by location interaction existed (P < 0.01) for calf BW per d of age at conventional-weaning in January. Suckling calves had greater ($P \leq 0.05$) BW per d of age at the east location, whereas EW and CW calves were not different at the west location. Gains of early-weaned calves prior to a traditional weaning age appear to be strongly dependent on the diet fed. Several studies have reported that early-weaned calves have increased ADG and BW at a conventional-weaning time when fed grain-based finishing diets.[5,8,34] Likewise, early-weaned calves supplemented on pasture had similar gains and BW to those nursing cows.[3,30] In our study, diets were formulated to provide adequate energy and protein intakes to allow the EW calf to gain BW at a rate comparable to that of the CW calves.

The ratio of calf BW gain to the total feed energy intake by the cow-calf pair may be an appropriate expression of the feed efficiency of early-weaning. It is a comparison of calf gain as a result of either direct diet consumption by the calf or the partitioning of feed between the cow and her calf plus the conversion of cow feed energy intake to milk production. Because diet energy levels were equal between weaning treatments, and DMI was measured for all animals, this relationship can be accurately described. Consistent with calf BW and ADG, a weaning age by location interaction was observed (P < 0.01) for cow-calf pair G:F (Table 8). Total pair G:F was greater ($P \leq 0.05$) for CW than EW pairs at the east location, while weaned and nursing pairs were not different at the west location. In contrast, Peterson et al[27] reported that early-weaned pairs converted feed energy into calf

Table 8. Performance of calves by location and weaning treatment.

	EAST[1]		WEST[2]			*P*-value		
Item	EW[3]	CW[4]	EW[3]	CW[4]	SEM	Wean[5]	Loc[6]	W × L[7]
Initial age[8], d	91	91	91	89	--	--	--	--
Ending age[9], d	205	205	206	202	--	--	--	--
Calf BW[10], lb (kg)								
October	280 (127)	278 (126)	289 (131)	267 (121)	9 (4)	0.13	0.92	0.22
January	474[b,c] (215)	509[a] (231)	498[a,b] (226)	461[c] (209)	11 (5)	0.90	0.19	<0.01
Calf ADG, lb (kg)	1.7[b,c] (0.78)	2.1[a] (0.93)	1.9[b] (0.84)	1.7[c] (0.77)	0.22 (0.1)	0.09	0.02	<0.01
BW•d•age[11], lb (kg)	2.3[b] (1.04)	2.5[a] (1.15)	2.4[a,b] (1.08)	2.2[b] (1.04)	0.67 (0.03)	0.16	0.17	<0.01
Pair G:F[12]	0.090[c]	0.109[a]	0.098[b]	0.091[b,c]	0.007	0.06	0.09	<0.01

[1]EAST = Agricultural Research and Development Center.
[2]WEST = Panhandle Research and Extension Center.
[3]EW = early-weaned at 91 d of age.
[4]CW = conventionally-weaned at 203 d of age.
[5]Fixed effect of calf age at weaning.
[6]Fixed effect of location.
[7]Calf age at weaning × location interaction.
[8]Age at the time of early-weaning across both yr.
[9]Age at the time of conventional-weaning across both yr.
[10]Actual weights.
[11]Weight per d of age at January conventional-weaning time.
[12]Calf gain per lb (kg) of total pair feed TDN intake.
[a-c]Within a row, least squares means without common superscripts differ at $P \leq 0.05$.

ADG 43% more efficiently. The use of different diets among treatments, an inconsistent manner in which cows were fed (i.e., *ad libitum* vs restricted intake), and the lack of accounting for gastrointestinal fill when weighing may represent limitations with these data. Data from Moe et al[20] indicate that the efficiency of the conversion of ME towards lactation and maintenance in the cow is similar. In agreement, energy balance studies with primiparous cows,[9] reported that the efficiency of conversion of ME to lactation energy was 72%. The efficiency of transferring ME to tissue energy and then to lactation energy was 78%. This is verified from other previous data.[20,38] If the efficiency of energy use for lactation or maintenance in the cow is similar, then the conversion of total feed energy intake to calf gain, between early and conventional weaning, is mainly a function of calf performance.

Experiment 2

For the year-round intensively managed cow-calf system, modeled profitability was -$346 per cow per year under base price levels. This suggests that if 450 lb (204 kg) steers are priced at $1.76 per lb ($1.76 per 0.45 kg) and base inputs and prices held constant, revenue generated is clearly not sufficient to overcome system costs. However, the costs of replacement females, the value of calves, feed prices, and reproductive rates collectively have the greatest influence on cowherd economics irrespective of production system. Thus, these factors were evaluated in the current analysis.

Replacement females represent a significant capital investment, and the cost to bring replacements into the cowherd has important ramifications on system profitability.[17] The purchase price for replacement cows dictates interest expense and the share of the capital cost of the replacement that is allotted to the remaining cows in the herd. The difference between the capital cost of the replacement and the cull cow credit value is depreciation. At base price levels, the capital cost of the replacement represents ≥ 30% of the total annual cow cost. Therefore, replacement cow purchase values were priced against different weaning rates to evaluate profitability (Table 9). Regardless of cow purchase price, profitability was most negative at 75% calf crop and improved as calf crop percentage increased. This is because weaned of exposed percentage directly influences gross revenue. As replacement cow price decreased from $3,000 to $1,600 per cow, profitability improved regardless of weaning percentage largely because the capital cost of the replacement female declined. This indicates that while female replacement cost is an important determinant of profitability, overall profit potential may be less sensitive to changes in replacement cost.

Various calf marketing prices were priced against different weaning rates to evaluate profitability when all other input parameters and price levels were held constant at base (Table 10). As observed with replacement cow prices, projected profitability was the least at 75% calf crop, and improved as percentage weaned per cow exposed increased regardless of calf price level. Likewise, irrespective of weaning rate, profitability improved as calf prices increased. This indicates that potential profitability of an intensively managed system will largely be a function of the price received for calves because of the direct effect it has on gross revenue.

Returns to any intensively managed cow-calf system which relies on harvested forages and feeds to meet cowherd nutrient requirements are strongly dependent on feed price. For the system analyzed in the current study, primary feed ingredients include distillers grains and baled crop residue, and total feed expenses represented ≥ 50% of total annual expenses. Distillers grains represent the majority of the diet and the price of distillers grains has historically been a function of corn price. Distillers grains were priced at either 85, 100, or 115% of corn price (DM basis), when corn was priced from $2.00 to $5.00 per bu. This indicates that if 450 lb (204 kg) steer calves are priced at $1.76 per lb ($1.76 per 0.45 kg), revenues from calves are not sufficient to cover production costs in an intensively managed system, even if distillers grains are priced in relation to $2.00 per bu corn.

Table 9. Projected profitability ($ per cow per yr) by replacement cow purchase price and percentage of calves weaned per cow exposed[1].

	% weaned of exposed				
Price, $/cow	**75**	**80**	**85**	**90**	**95**
3,000	-540	-502	-463	-425	-387
2,900	-523	-485	-447	-408	-370
2,800	-507	-468	-430	-392	-353
2,700	-490	-452	-413	-375	-336
2,600	-473	-435	-396	-358	-320
2,500	-456	-418	-380	-341	-303
2,400	-440	-401	-363	-325	-286
2,300	-423	-385	-346	-308	-269
2,200	-406	-368	-329	-291	-253
2,100	-389	-351	-313	-274	-236
2,000	-373	-334	-296	-258	-219
1,900	-356	-318	-279	-241	-202
1,800	-339	-301	-262	-224	-186
1,700	-322	-284	-246	-207	-169
1,600	-306	-267	-229	-191	-152

[1]All other prices and inputs held at base values.

Table 10. Projected profitability ($ per cow per year) by calf marketing price and percentage of calves weaned per cow exposed.[1]

	% weaned of exposed				
Price, $1lb[2] ($/0.45 kg)	**75**	**80**	**85**	**90**	**95**
3.16	51	121	191	261	331
2.96	-17	49	114	180	245
2.76	-84	-23	38	99	160
2.56	-152	-95	-39	18	74
2.36	-219	-167	-115	-63	-11
2.16	-287	-239	-192	-144	-97
1.96	-354	-311	-268	-225	-182
1.76	-422	-383	-345	-306	-268

[1]All other prices and inputs held at base values.
[2]Steer price only, heifer price discounted $0.10 per 1.0 lb (0.45 kg).

The price of calves has the greatest impact on gross revenue of the system, and distillers grains represent the greatest component of overall feed costs. Perhaps evaluating the response in profitability to concomitant changes in both calf and distillers grains price will provide the most information regarding economic feasibility of the intensively managed system (Table 11). In this analysis, the price of distillers grains as a proportion of corn price was varied against steer calf prices of $1.76 to $3.16 per lb ($1.76 to $3.16 per 0.45 kg) with all remaining inputs and values constant at base levels. As expected, projected profitability improves as calf price increases, irrespective of distillers grains price. Collectively, these data suggest that under the assumptions made in this study, positive returns to an intensively managed cow-calf system may be realized if calves are priced above $2.36/lb ($2.36 per 0.45 kg) and the price of corn is $3.50 per bu or less.

Additional expenses contribute to total annual cow costs in any production system. Changes in such costs were not evaluated in the current analyses, but have critical effects on economic outcomes. For example, bulls represent a significant investment for a cowherd and add $60 per cow per year in ownership cost alone at the base bull purchase price used in the current study. Expenses for cattle marketing and animal health/identification each represent an additional $30 per cow per year, but must be accounted for in an operation budget. Yardage is an important consideration in intensively managed cow-calf systems. At $0.35 per d, yardage charged per cow unit is approximately $133 annually if cows are in intensive management year-round. It is necessary to include yardage in a cowherd economic analysis, or otherwise directly account for those costs that are included in a yardage value (labor, equipment, utilities/fuel, land/loans). The value used in the current study ($0.35 per day) may be greater than usually assessed for many operations, but is consistent with that reported for commercial feedlots[12] and intensively managed cowherds.[2]

While economic analyses of conventional cow-calf production systems are common in the literature,[1,26,33] studies involving alternative intensively managed systems are limited. Certainly, this is because intensively managed systems have historically been less common. Three year of data directly comparing intensively managed and conventional cow-calf production in North Dakota indicated that total net cost per pair per year was approximately $22 greater for intensively managed pairs.[2] This equated to a $0.23 advantage for total cost per 1 lb (0.45 kg) of calf weaned for the conventional system. In another recent analysis, Close[7] estimated production costs and returns for total intensive management systems at 3 different price levels ($2.20, $2.70, or $3.50 per lb or 0.45 kg) for 550 lb (250 kg) calves sold at weaning. If aged cows were purchased as replacements and produced 2 calves, returns above costs were reported from $88 to $800 per cow per year depending on calf price received. If young females were purchased as replacements, producing 7 calves on average, profitability per cow per year ranged from -$22 to $693.

Table 11. Projected profitability ($ per cow per year) by distillers grains price as a proportion of corn price and calf marketing price[1].

Corn Price, $/bu	Calf price, $1 lb[2] ($/0.45 kg)							
5.00	1.76	1.96	2.16	2.36	2.56	2.76	2.96	3.16
115%	-552	-476	-399	-323	-246	-170	-93	-17
100%	-483	-407	-330	-254	-177	-101	-24	52
85%	-414	-337	-261	-184	-108	-31	45	122
4.50								
115%	-499	-423	-346	-270	-193	-117	-40	36
100%	-437	-360	-284	-207	-131	-54	22	99
85%	-375	-298	-222	-145	-69	8	84	161
4.00								
115%	-446	-370	-293	-217	-140	-64	13	89
100%	-391	-314	-238	-161	-85	-8	68	145
85%	-335	-259	-182	-106	-29	47	124	200
3.50								
115%	-393	-316	-240	-163	-87	-10	66	143
100%	-344	-268	-191	-115	-38	38	115	191
85%	-296	-219	-143	-66	10	87	163	240
3.00								
115%	-340	-263	-187	-110	-34	43	119	196
100%	-298	-222	-145	-69	8	84	161	237
85%	-257	-180	-104	-27	49	126	202	279
2.50								
115%	-287	-210	-134	-57	19	96	172	249
100%	-252	-176	-99	-23	54	130	207	283
85%	-217	-141	-64	12	89	165	242	318
2.00								
115%	-234	-157	-81	-4	72	149	225	302
100%	-206	-129	-53	24	100	177	253	330
85%	-178	-102	-25	51	128	204	281	357

[1]All other prices and inputs held at base values.
[2]Steer price only, heifer price discounted $0.10 per 0.45 kg.

While these data suggest that strong profits may be realized, there are several important distinctions between the current analysis and the analysis by Close.[7] In that analysis, costs for yardage, capital cost of replacement females, and marketing expenses were not included when calculating total annual cow costs. However, of greater importance, Close[7] assumed a calf weaning BW of 550 lb (250 kg) as compared to 450 lb (204 kg) based on published data in the current analysis, and calf prices were greater than this analysis resulting in greater projected revenue.

This analysis is one of only few conducted on a total intensively managed cow-calf system relying principally on feed resources from corn and ethanol production. It provides a model for producers to estimate profitability of such a system when production and price parameters are known.

Experiment 3

Cow-calf pairs at the eastern location grazed from November 11 to April 19 (160 d). An ammoniated corn stalk bale was fed approximately 147 lb (67 kg) DM per pair due to snow cover. The cornfield at the east location produced a grain yield of 217 bu per acre. Estimated removal of available corn residue was 32%. At west location, the grazing period was 133 days (Dec 4 to April 15) and the average yield for the cornfield was 245 bu per acre. Cow-calf pairs removed approximately 20.0 % of the available residue.

Drylot cow-calf pairs were limit-fed 28 lb (12.7 kg) DM during this trial. Drylot cows had a greater ending BW and BCS compared to cows grazing cornstalks. Cows wintered on cornstalks lost BW and had a 0.7 unit (Table 12) decrease in BCS, while cows in the drylot gained BW and had a 0.5 unit increase in BCS. Calves in the drylot had a greater ending BW compared to calves grazing cornstalks. Similarly, DL calves had greater ADG and BW per d of age compared to CS calves (Table 13). The breeding season was nearly complete before the experimental treatments were applied. Therefore, the effect of treatment on reproduction could not be measured until the following breeding season. Overall, pregnancies was 90%, but the number of cows is too small to make a treatment comparison.

The cost of each wintering system was also evaluated. Winter production inputs (Table 14) for grazing cornstalks

Table 12. Performance of cows by wintering system.[1]

Item	CS[2]	DL[3]	SEM	*P*-value
Cow BW, lb (kg)				
Initial	1183 (537)	1187 (538)	62 (28)	0.93
Ending	1121 (508)	1322 (600)	57 (26)	<0.01
Cow BW Change, lb (kg)	-64 (-29)	132 (60)	16 (7)	<0.01
Cow BCS[4]				
Initial	5.3	5.3	0.3	0.92
Ending	4.6	5.9	0.2	<0.01
Cow BCS change[4]	-0.7	0.5	0.2	<0.01

[1]Two years of data from EAST and 1 year of data from WEST.
[2]CS= pairs wintered on cornstalks.
[3]DL= pairs wintered in drylot.
[4]BCS on a 1 (emaciated) to 9 (obese) scale.

Table 13. Performance of calves by wintering system.[1]

Item	CS[2]	DL[3]	SEM	*P*-value
Initial age, d[4]	125	129	5	0.49
Ending age, d[5]	282	284	3	0.51
Calf BW, lb (kg)				
Initial	331(150)	326 (148)	9 (4)	0.68
Ending	541 (245)	642 (291)	13 (6)	<0.01
Calf ADG, lb (kg)	1.33 (0.60)	2.04 (0.93)	0.1 (0.05)	<0.01
BW•d•age, lb[6] (kg)	1.96 (0.89)	2.32 (1.05)	0.1 (0.05)	<0.01

[1]Two years of data from EAST and 1 year of data from WEST.
[2]CS= pairs wintered on cornstalks.
[3]DL= pairs wintered in drylot.
[4]Initial age= age at initiation of cornstalk grazing period.
[5]Ending age= age at collecting weights following weaning.
[6]Weight per d of age at collecting weights following weaning.

Table 14. Winter production inputs by wintering system.

Inputs, $/pair/day	CS[1]	DL[2]
Cornstalk rent[3]	0.20	–
Yardage	0.30	0.50
Ration[4]	–	1.66
Supplement[4]	0.37	–
Net cost, $/pair/day	0.87	2.16
Net cost, $/pair/wintering season	144.55	356.40
Net cost difference, $/pair	212.85	

[1]CS= pairs wintered on cornstalks.
[2]DL= pairs wintered in drylot.
[3]Cornstalk rent = $12 per acre (0.404 hectares).
[4]Distillers priced at 100% of corn assuming $3.50 per bu of corn.

were estimated to be approximately $0.87 per pair per day, resulting in a total of $144 per pair for a 165 day winter grazing season. In contrast, the DL wintering system was estimated at $2.16 per pair day or $356 per pair per grazing season.

A partial budget (Table 15) was utilized to economically compare the reduced performance, as well as decreased winter production cost of the CS wintering system. The reduced winter production input is observed under reduced cost. In the CS wintering system, additional feed would be required for the cow to compensate for BW and body condition reductions observed throughout the winter. Consequently, additional post-weaning feed for the CS cow would cost approximately $16. The lighter weaning weight of CS calves would result in a reduced return of $60 per calf when a $20/cwt price slide is used between the calf weaning weights of the CS and DL wintering systems. A net change of $137 per pair was observed when winter cornstalk grazing was incorporated into an intensive production system. Lower winter production inputs may be significant enough to compensate for the reduced performance of calves when cow-calf pairs are wintered on cornstalks.

Conclusions

Weaning calves at 90 day of age appears to have marginal effect on cow BW and BCS change and pregnancy rates when cows are limit-fed high energy diets to meet requirements, provided BCS is acceptable (≥ 5.0) prior to the beginning of the breeding season. Because calf ADG per unit of feed energy intake for the cow and calf combined were relatively

Table 15. Partial budget of winter cornstalk grazing.

Additional costs		**Additional returns**	
Post weaning feed[1]	$16		
Reduced returns		**Reduced costs**	
Lighter weaning wt[2]	60	Winter production inputs	$213
Total	$76	Total	$213
Net change	$137		

[1]Cost to feed an additional 3.6 lb (1.6 kg). (DM) of ration at $0.06 per lb. ($0.03 per kg). for 165 days to compensate for body condition reduction of cow.
[2]The difference in calf value at weaning between treatments; calf price, April 30; $20/cwt ($20/45 kg) price slide.

similar, the total energy requirements for weaned cows and calves or nursing pairs do not appear to be markedly different. Thus, decisions regarding early-weaning should be made on the discretion of management as opposed to feed efficiency. Cow-calf systems are complex, but the economic feasibility of a cow-calf production system is ultimately a function of the costs of replacement females, the value of calves, feed prices, and reproductive rates. These same fundamentals also determine profitability of alternative systems centered around feeding cows in intensive management. Incorporating corn residue grazing into the cow-calf production system that doesn't include grass pasture as a grazing component makes this system economical to conventional cow-calf production systems.

Endnotes

[a]ScourGuard® 4KC, Zoetis, Florham Park, NJ
[b]Vision® 7 Somnus, Merck Animal Health, Summit, NJ
[c]Bovi-Shield Gold® 5, Zoetis, Florham Park, NJ
[d]Bovi-Shield Gold® FP® 5 VL5 HB, Zoetis, Florham Park, NJ
[e]SAS Inst. Inc., Cary, NC
[f]Microsoft®, Redmond, WA

References

1. Anderson RV, Rasby RJ, Klopfenstein TJ, Clark RT. An evaluation of production and economic efficiency of two beef systems from calving to slaughter. *J Anim Sci* 2005; 83:694-704.
2. Anderson VL, Ilse BR, Engel CL. Drylot vs pasture beef cow-calf production: three-year progress report. *NDSU Beef Report*. 2013; 13-16.
3. Arthington JD, Kalmbacher RS. Effect of early weaning on the performance of three-year-old, first-calf beef heifers and calves reared in the subtropics. *J Anim Sci* 2003; 81:1136-1141.
4. Arthington JD, Minton JE. The effect of early calf weaning on feed intake, growth, and postpartum interval in thin, Brahman-crossbred primiparous cows. *Prof Anim Sci* 2004; 20:34-38.
5. Barker-Neef JM, Buskirk DD, Black JR, Doumit ME, Rust SR. Biological and economic performance of early-weaned Angus steers. *J Anim Sci* 2001; 79:2762-2769.
6. CattleFax. http://www.cattlefax.com/news.aspx. Accessed September 15, 2015. *CattleFax*, Centennial, CO.
7. Close DL. *Outside in – confined cow-calf production is a viable model for rebuilding the U.S. cow herd numbers*. Dr. Kenneth & Caroline McDonald Eng Foundation Symposium. Innovations in intensive beef cow production, care and management. 2015; 17-24.
8. Fluharty FL, Loerch SC, Turner TB, Moeller SJ, Lowe GD. Effects of weaning age and diet on growth and carcass characteristics in steers. *J Anim Sci* 2000; 78:1759-1767.
9. Freetly HC, Nienaber JA, Brown-Brandl T. Partitioning of energy during lactation of primiparous beef cows. *J Anim Sci* 2006; 84:2157-2162.
10. Griffin WA, Stalker LA, Stockton MC, Adams DC, Funston RN, Klopfenstein TJ. Calving date and wintering system effects on cow and calf performance II: economic analysis. *Prof Anim Sci* 2012; 28:260-271.
11. Houghton PL, Lemenager RP, Horstman LA, Hendrix KS, Moss GE. Effects of body composition, pre- and postpartum energy level and early weaning on reproductive performance of beef cows and preweaning calf gain. *J Anim Sci* 1990; 68:1438-1446.
12. Jensen R, Mark DR. *2010 Nebraska feedyard labor cost benchmarks and historical trends.* University of Nebraska-Lincoln Extension, 2010.
13. Kansas City Federal Reserve Bank. 2015. http://www.federalreserve.gov/releases/h15/data.htm. Accessed September 15, 2015. Kansas City Federal Reserve Bank, Kansas City, MO.
14. Loerch SC. Limit-feeding corn as an alternative to hay for gestating beef cows. *J Anim Sci* 1996; 74:1211-1216.
15. Lusby KS, Wettemann RP, Turman EJ. 1981. Effects of early weaning calves from first-calf heifers on calf and heifer performance. *J Anim Sci* 1981; 53:1193-1197.
16. May GJ, Van Tassell LW, Waggoner JW, Smith MA. Relative costs and feeding strategies associated with winter/spring calving. *J Range Manage* 1999; 52:560-568.
17. Meek MS, Whittier JC, Dalsted NL. Estimation of net present value of beef females of various ages and the economic sensitivity of net present value to changes in production. *Prof Anim Sci* 1999; 15:46-52.
18. Merrill ML, Bohnert DW, Ganskopp DC, Johnson DD, Falck SJ. Effects of early weaning on cow performance, grazing behavior, and winter feed costs in the intermountain west. *Prof Anim Sci* 2008; 24:29-34.
19. Meyer TL, Stalker LA, Volesky JD, Adams DC, Funston RN, Klopfenstein TJ, Schacht WH. Technical note: estimating beef-cattle forage demand: evaluating the animal unit concept. *Prof Anim Sci* 2012; 28:664-669.
20. Moe PW, Tyrrell HF, Flatt WP. Energetics of body tissue mobilization. *J Dairy Sci* 1971; 54:548-553.
21. Myers SE, Faulkner DB, Ireland FA, Berger LL, Parrett DF. Production systems comparing early weaning to normal weaning with or without creep feeding for beef steers. *J Anim Sci* 1999; 77:300-310.
22. Myers SE, Faulkner DB, Ireland FA, Parrett DF. Comparison of three weaning ages on cow-calf performance and steer carcass traits. *J Anim Sci* 1999; 77:323-329.
23. Myers SE, Faulkner DB, Nash TG, Berger LL, Parrett DF, McKeith FK. Performance and carcass traits of early-weaned steers receiving either a pasture growing period or a finishing diet at weaning. *J Anim Sci* 1999; 77:311-322.
24. NRC. *Nutrient requirements of beef cattle*. 7th rev ed. Washington DC: National Academy Press, 1996.
25. Pate FM, Crockett JR, Phillips JD. Effect of calf weaning age and cow supplementation on cow productivity. *J Anim Sci* 1985; 61:343-348.
26. Payne CA, Dunn BH, McCuistion KC, Lukefahr SD, Delaney D. Predicted financial performance of three beef cow calving seasons in south Texas. *Prof Anim Sci* 2009; 25:74-77.

27. Peterson GA, Turner TB, Irvin KM, Davis ME, Newland HW, Harvey WR. Cow and calf performance and economic considerations of early weaning of fall-born beef calves. *J Anim Sci* 1987; 64:15-22.
28. Rasby R, Frazier M, Deutscher G, Rush I, Mader T, Gosey J, Hudson D. Integrated resource management. *Proceedings.* Low Input Sustain Agric Beef and Forage Conf, Omaha NE 1990; 23-30.
29. Schoonmaker JP, Loerch SC, Rossi JE, Borger ML. Stockpiled forage or limit-fed corn as alternatives to hay for gestating and lactating beef cows. *J Anim Sci* 2003; 81:1099-1105.
30. Schultz CL, Ely DG, Aaron DK, Burden BT, Wyles J. Comparison of an early and normal weaning management system on cow and calf performance while grazing endophyte-infected tall fescue pastures. *J Anim Sci* 2005; 83:478-485.
31. Shike DW, Faulkner DB, Parrett DF, Sexten WJ. Influences of corn co-products in limit-fed rations on cow performance, lactation, nutrient output, and subsequent reproduction. *Prof Anim Sci* 2009; 25:132-138.
32. Stock R, Klopfenstein TJ, Brink D, Lowry S, Rock D, Abrams S. Impact of weighing procedures and variation in protein degradation rate on measured performance of growing lambs and cattle. *J Anim Sci* 1983; 57:1276-1285.
33. Stockton MC, Adams DC, Wilson RK, Klopfenstein TJ, Clark RT, Carriker GL. Production and economic comparisons of two calving dates for beef cows in the Nebraska Sandhills. *Prof Anim Sci* 2007; 23:500-508.
34. Story CE, Rasby RJ, Clark RT, Milton CT. Age of calf at weaning of spring-calving beef cows and the effect on cow and calf performance and production economics. *J Anim Sci* 2000; 78:1403-1413.
35. Thrift FA, Thrift TA. Review: Ramifications of weaning spring- and fall-born calves early or late relative to weaning at conventional ages. *Prof Anim Sci* 2004; 20:490-502.
36. Tjardes KE, Faulkner DB, Buskirk DD, Parrett DF, Berger LL, Merchen NR, Ireland FA. The influence of processed corn and supplemental fat on digestion of limit-fed diets and performance of beef cows. *J Anim Sci* 1998; 76:8-17.
37. USDA. National agricultural statistics service, 2015. http://www.nass.usda.gov/. Accessed September 28, 2015.
38. Vermorel M, Geay Y, Robelin J. Energy utilization by growing bulls, variations with genotype, liveweight, feeding level and between animals. *Energy Metab Proc Symp* 1982; 29:88-91.
39. Wagner JJ, Lusby KS, Oltjen JW, Rakestraw J, Wettemann RP, Walters LE. Carcass composition in mature Hereford cows: estimation and effect on daily metabolizable energy requirement during winter. *J Anim Sci* 1998; 66:603-612.
40. Watson AK, Nuttelman BL, Klopfenstein TJ, Lomas LW, Erickson GE. Impacts of a limit-feeding procedure on variation and accuracy of cattle weights. *J Anim Sci* 2013; 91:5507-5517.
41. Wright CK, Wimberly MC. Recent land use change in the Western Corn Belt threatens grasslands and wetlands. *Proc Natl Acad Sci* 2013; 110:4134-4139.