Influence of weaning date and late gestation supplementation on beef system productivity II: economic analysis

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ABSTRACT: Cow–calf production systems were analyzed using experimental data and historical economic information to model four separate production year using the 10-yr price period from 2005 to 2014. Treatments included two weaning dates, October (OCT) and December (DEC), and four winter nutritional treatments, grazing winter range with no supplement (WR0), low supplement (WR1), high supplement (WR2); or grazing corn residue with no supplement (CR) applied in a 2 × 4 factorial arrangement. Net returns at the December weaning date were greatest ($P < 0.05$) for DEC systems ($151.14$/cow) or CR ($140.17$/cow), intermediate for cows fed the WR1 ($110.44$/cow), and least for cows fed WR0 ($62.23$/cow). Average net returns across winter nutrition treatments at the December weaning date were greater ($P < 0.01$) for DEC systems ($115.99$/cow) compared with OCT systems ($110.28$/cow). Marketing October weaned calves in December increased net returns on average by $47.24$/cow compared with October marketing. Retained and owned (RO) slaughter steer net returns sold on a hot carcass weight (HCW) basis were greatest ($P < 0.05$) for CR systems ($190.62$/cow) or WR2 ($188.13$/cow), intermediate for WR1 ($132.67$/cow), and least for the WR0 ($68.08$/cow) treatment. In general, purchasing weaned calves (PC) and marketing them as finished steers either on a HCW basis or on a marketing grid were not profitable. The WR2 and the CR grazing regimes were more profitable than WR0 and WR1 regardless of market end point, primarily due to reduction in replacement and production loss costs.

Key words: beef cattle, economic analysis, supplementation, weaning

INTRODUCTION

Beef cattle management decisions affect biological performance, yet the economic implications ultimately determine the implementation and adoption of those decisions. Allowing cows to graze may be more profitable than mechanically
harvesting and feeding forages because it reduces labor and machinery costs (Stockton et al., 2007). However, cows in late gestation cannot meet their nutritional requirements with dormant forages, making it necessary to supplement (Stalker et al. 2006, 2007). If supplementation could be omitted without sacrificing productivity, costs could be reduced. In addition, feeding this supplement may possibly be eliminated by weaning earlier, providing enough time for cows to regain body condition (BC) before winter grazing and late gestation. Added condition provides a nutrient reservoir to buffer the effects of short periods of undernutrition. Weaning earlier not only alters the cows BC; it affects the calf and economics and requires careful evaluation. Incorporating corn residue grazing can further reduce costs (Griffin et al., 2012). It was hypothesized weaning date and winter nutritional plane affect net returns in spring-calving production systems. To test this hypothesis this study evaluated how altering late gestation nutrition and weaning date affected the production costs, revenue changes, and the resulting net returns at three common production end points, October weaning, December weaning, and Slaughter weight.

Evaluating the economic effects of a biological response to a set of experiments or treatments requires understanding the connection of physical activities and their costs and values. The profit function is the ideal method to evaluate these relationships. Net return, profit, as a measure of economic activity it potentially impacts revenue more than the expected value gained from the cost savings. If this is true the producer would have been more profitable adopting a more costly strategy with a higher net return. Identifying the economically superior system involves comparing net returns of those systems. However, once identified it is the factors that contribute to costs or revenues that provide insight into why one system is superior to another. This is how and why bio-economic systems models are so powerful in providing insight into the value of experimental results to both producers and animal scientists as they strive to either have business success or develop new hypothesis and pursue searchable questions.

MATERIALS AND METHODS

Data Source

Cow–calf production systems data collected during a 4-yr study of March-calving cows at the Gudmunsen Sandhills Laboratory, near Whitman, NE (lat 42.08°N, long 101.45°W, elevation 1,073 m) were used in this analysis. Cows calved annually from early March near and around the 10th and finished calving on or around May 1. A detailed description of the biological experiment and the animal particulars is available in the companion paper Luebbe et al. (2019). For your convenience and reference two summary tables from that paper have been included here, Supplementary Tables S1 and S2. Supplementary Table S1 lists cow and steer feedlot information, and Supplementary Table S2 includes calf information by gender. These tables have a limited amount of statistical detail and were lifted directly from the companion paper. Animals were stratified by body weight (BW) within age and treatments and were assigned randomly in a 2 × 4 factorial arrangement: weaning either October 1 (OCT) or December 1 (DEC); and one of four nutritional treatments from December 1 to February 28 where cows were fed the equivalent of 0.0, 0.41, or 0.82 kg dry matter (DM)/(cow • d) of a supplement delivered 3 d/wk on dormant winter range (WR0, WR1, and WR2, respectively) or grazed corn residue without supplement (CR). The rest of the year, cows were managed as a single herd. After December weaning all dams were relocated to dormant upland range pastures, or transported to corn residue fields. Supplement was delivered 3 d/wk on a pasture (35.6 ha) to WR1 and WR2 cows. From March 1 to June 15 cows and cow–calf pairs were fed hay harvested from sub-irrigated meadows in a common calving lot. Then cow–calf pairs grazed native upland range as a single herd from June 15 to October 1. On October 1 calves assigned to the OCT weaning treatment were weaned and grazed sub-irrigated meadow regrowth until December 1. Cows assigned to the OCT weaning treatment and pairs assigned to the DEC weaning treatment
grazed a common upland pasture from October 1 to December 1.

A series of bio-economic models of the production systems were created by combining partial budget techniques, the profit equation, and experimental artifacts in a Microsoft Excel spreadsheet. These models included eight combinations of weaning date and winter nutritional treatments, with three sale end points, with the last end point being repeated under two different calf ownership options each marketed using two different pricing systems, resulting in a total of 48 model variations (Fig. 1). The sale end points analyzed included steer and heifer progeny sold shortly after October weaning (including hypothetical sales of DEC herd progeny), steer and heifer progeny sold shortly after December weaning (including progeny from the OCT herd) and slaughter steers. Fed steers were treated as either being retained weaned calves fed to slaughter, retained ownership (RO) or

Figure 1. Forty-eight production scenarios shown were analyzed using production data from Luebbe et al. (2019). Treatments applied to the March-calving cows in that study included weaning their progeny in October or December and one of four winter nutritional treatments applied during late gestation (December 1 to February 28). Treatments included range without supplement (WR0), winter range with 0.45 kg DM/d 32% CP supplement (WR1), winter range with 0.91 kg DM/d 32% CP supplement (WR2), or corn residue without supplement (CR). In Table 1, results from 2 sale end points using both steer and heifer progeny were evaluated: sell calves in October (Oct sell), or sell calves in December (Dec sell). In Table 2, results from sale end points that used only the steer progeny and feeding until slaughter. Steers were marketed either on a HCW basis or a grid-priced (GP) basis. In addition, the HCW and GP marketing was analyzed for both a retained ownership (RO) scenario and a purchased at December weaning (PC) scenario.
as purchased weaned calves (PC) fed to slaughter. Fed calves were marketed in two ways, on a hot carcass weight (HCW) basis, or on a grid-priced (GP) basis. Net returns were used instead of a complete profit specification. In the standard profit relationship all costs and revenues would be included. For this analysis, only relevant costs unique among production system were subtracted from the relevant incomes, this is the implementation of the partial budgeting (Tigner, 2018) technique. Partial budgeting captures the potential profit differences among the systems (treatments) being considered. Net returns were represented as dollars returned per cow ($/cow). This analysis accounted for seasonal trends in both costs (seasonal variation in input values) and revenues (seasonal cattle prices), which potentially affect profitability of each system. Feedstuffs costs and cattle prices were calculated using historically comparable monthly values from 2005 to 2014, at the appropriate time during their annual occurrence within each system. As the objective was to compare long-term profitability differences among systems; prices for each of the 10 yr were used to make those comparisons, similar to other studies (Phillips et al., 2003; Stalker et al., 2006; Stockton et al., 2017). This is not an aggregation of costs and revenues into a single 10-yr average prior to initiating the model, but rather each of the 48 models were solved using each of the 10 yr, for each of the 4 observed years of data, by individual cow and calf. However, reported values are the 10-yr averaged values of these results. This method, as opposed to the single 10-yr average, maintains subtle correlations, provides added information with regards to the annual stability of net returns, allows the use of analysis of variance techniques to define the significance of the results, and reflects the natural relationship between profit and time.

**Cow–Calf Costs and Returns**

Sources of information used to calculate costs and returns are listed in Table 3. The actual dollar values used in the models varied by year, the values listed here are simple averages and are used illustratively and to provide a rough outline. Range costs were calculated using land rent costs reported by Jansen and Wilson (2015) combined with the recommended stocking rate of 1.5 animal unit months (AUM)/ha (Stubbendieck and Reece, 1992). Cows, calves, or cow–calf pairs were normalized to an animal unit (AU) by dividing their BW or combined BW by 454 kg to determine their average AU equivalent. The resulting total AUM’s were then multiplied by the average 2005 to 2014 AUM costs (Jansen and Wilson, 2015). Grazing costs during the growing season (May 1 to September 30) averaged $26.18 per AUM. Range costs during the winter period (October 1 to April 30) were estimated as half the value of summer range ($13.09/AUM). Each cow on range was charged an additional cost of $0.125/d for labor, management, and equipment cost. On days when WR1 and WR2 cows were supplemented, an additional $0.055/cow was charged. This charge covered equipment and labor costs associated with supplementation and the supplement purchase price ($0.37/kg of DM). Cows wintered on CR were charged $7.03/AUM, calculated by dividing the average corn residue rental rate of $26.01/ha (Dawson County Nebraska survey) by a stocking rate of 3.7 AUM/ha. This rental cost included fence maintenance and animal care and management; therefore, additional daily charges were not assessed. Transportation costs for CR cows were charged at $2.16/loaded km to and from corn fields (146 km). Individual cow total transportation cost is the product of per kilometer rate and total distance divided by 22,700 kg (legal load limit for a semitruck) times the average cow BW (this assumes no partial truckloads). The annual differences in the cost to transport animals were estimated based on the historical share of fuel prices (U.S. Energy Information Administration) of transportation costs on a loaded kilometer basis. Costs associated with winter range grazing for approximately 10 d per yr were included for cows assigned to the CR treatment as corn residue grazing did not span the entire winter grazing period. Hay was fed to cows during the calving season and averaged $0.13/kg (National Agricultural Statistics Survey) with an additional charge of $0.28/d for equipment, labor and other costs. Fall grazing was charged at the same rate as the summer rate, but varied by individual animal depending on the size of the cow and calf.

Commercial cow slaughter and national pregnant cow prices were based on monthly 2005 to 2014 prices reported by CattleFax (Centennial, CO). Cull cows were valued by multiplying cow weaning BW by commercial cow slaughter price in October ($1.35/kg). Replacement pregnant cows were priced at $1,214.70/hd. Cull cow income and replacement cow cost were adjusted for replacement rate of cows, which was calculated by dividing the number of cows replaced by the original number of cows in the treatment. Thus, treatments that had higher replacement rates also had increased income from the sale of cull cows and higher cow replacement
costs. Productivity loss is the added cost per cow for feeding cows that never produce a calf and varies by systems feed costs and pregnancy rates.

October feeder steers and heifers were $3.60 and $3.37/kg (Livestock Marketing Information Service), respectively; and December feeder steers and heifers were $3.61 and $3.39/kg, respectively. A price slide adjusted feeder calf price was used for BW differences within dam treatment combinations. Weaning, pregnancy, and calving rates were assigned according to the experimental outcomes. The weaned calf crop was adjusted for a 2% annual death loss. Two profit partial budget models, 16 total, were used to evaluate the economic effects, net returns, of maternal treatments on weaned calves: 1) October weaning and calf sales (8 models) and 2) December weaning and calf sales (8 models). This was done to compare the net returns of selling OCT weaned calves at weaning or backgrounds OCT weaned calves for 2 mo until DEC weaning. Cows assigned to the DEC weaning treatment were charged additional forage consumed as a lactating cow (NRC, 2016). Supplement offered to weaned calves was charged for a 60-d period in the OCT weaning treatment at the same price as described earlier.

Opportunity costs, interest on the capital invested in the cow–calf enterprise, were included in the analysis and were based on the time relevant prime rates reported by the Federal Reserve.

**Steer Costs and Returns**

Net returns during the finishing phase were determined for steer progeny. The finishing diet was 48% dry-rolled corn, 40% corn gluten feed, 7% prairie hay, and 5% dry supplement and priced at $0.171/kg (Livestock Marketing Information Center). In addition to feed, costs associated with transportation, veterinary expense, yardage, death loss, and interest were included. All of the steer calves from this study were retained and marketed as fed cattle. Steers were priced on a per unit weight ($/kg) HCW and as carcasses valued based on premiums and discounts added to a base price, GP. Fed cattle were priced at ($3.59/kg, HCW), as well as on a marketing grid ($3.56/kg, base price) using prices reported by the Livestock Marketing Information Center. Historical average discounts and premiums were used for yield grade, quality grade and carcass weights. The grid price was based on United States Department of Agriculture information relative to premiums and discounts reported and does not represent any one specific pricing scheme but rather is a combination of many different prices reported nationally. Net return for each of the eight systems was calculated four different ways. The first (RO) represents a simulation of retained ownership or accrued costs using inputs and resources as they might occur for each system. The second is entrepreneurial in nature where production systems costs for calving labor, breeding costs, and management were replaced by the relevant market values of purchased calves (PC). This method represents the way a feedlot would acquire calves and prepare them for the fat cattle market. Each of these two calf ownership options was studied using HCW and GP methods of marketing. The HCW method makes all animals within the relevant group valued at the same price regardless of any quality differences. The GP method differentiates among animals and pays discounts or premiums for specific carcass characteristics by animal, i.e., quality grade, yield grade, and carcass weight limits. The eight different systems feedlot entry costs for the RO and PC regimes are listed in the first two rows of Table 2. In RO scenarios, costs were a total of previous expenses. In the case of PC scenarios, costs were assigned as though steers had been purchased at the current DEC weaning market value and then placed in the feedlot where all of the remaining costs for finishing were identical to ROs.

**Statistical Analysis**

Cattle with the same weaning date within winter pasture served as the experimental unit. Replicated treatment means within year were used for analyses of cow, calf, and steer response variables. Model fixed effects included weaning date, winter nutritional treatment, and their interaction. Year and residual error were considered random effects. Data were analyzed with the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, NC). Effects of treatment or the interaction were considered significant when $P < 0.05$ as detected by Fischer’s test. When the $F$-test was significant, least square means of treatments were separated using a $t$-test when $P < 0.05$. Owing to interaction between weaning date and winter nutritional treatments for many of the dependent variables, data are reported as simple effects.

**RESULTS AND DISCUSSION**

**Marketing Progeny at Weaning**

**Feed costs.** Feed costs are listed by type and summed in the first section of Table 1. The cost
of grazing corn residue, including transportation, averaged $43.32/cow. Supplement cost for WR1 and WR2 averaged $14.85 and $29.90/cow, respectively for both OCT and DEC weaning dates. Calving lot cost included all feed and expense while confined during the calving period and varied by cow size with a low for DEC-WR0 system with a cost of $156.45/cow to the high for OCT-CR with a cost of $182.18/cow. Winter range varied with a low costs for the DEC-WR0 system of $4.64/cow to the high for the OCT-WR1 system of $56.50/cow. Summer range varied with a low for the DEC-WR0 system of $171.44/cow to the OCT-CR high of $184.08/cow. Fall range varied in costs with a low for the DEC-WR2 system with a cost of $35.91/cow to a high for OCT-CR of $37.96/cow. each of the four supplement treatments compared to the OCT weaning cows. Each of the feed costs was different ($P < 0.05) from other feed costs within their weaning groups. This difference relates directly to cow size. Regardless of weaning date, WR2 cow feed costs were the most expensive due to the amount of winter feed supplement added to those systems. Feed expenses for the OCT-WR2 system were $474.19/cow and those of DEC-WR2 were $448.47/cow. For all eight treatment combinations, DEC-WR0 had the lowest, $416.55/cow.
followed closely by OCT-WR0 with $426.34/cow, total cow feed costs. The middle two feed costs switched ranks within their respective weaning groups. For the DEC cow feeding systems CR was ranked as being more expensive than WR1, whereas the OCT group ranked WR1 as more expensive than CR. This switch is also a result of cow size differences which led directly to costs changes among the four treatments. The DEC-WR1 cows were on average 39 kg/h lighter than the DEC-CR cows, the OCT-WR1 cows were less than 19 kg/h lighter. The added increased feed consumption of the DEC-CR cows increased costs more than the lower per unit feed costs savings associated with corn residue grazing, when compared to DEC-WR1. Total feed costs between weaning dates and winter feed treatments were unique ($P < 0.05$) except between OCT-CR and DEC-CR which were not different from each other. Total cow feed costs for OCT and DEC weaned groups, winter nutritional treatment, and the interaction were significant ($P < 0.01$) (Table 1).

**Other costs.** Costs associated with cow replacement and productivity loss measured system differences as they relate to sustained production and are summed along with opportunity costs and labeled as total other costs (Table 1). It is these first two costs along with death loss that capture the effect of unproductive cows and transfer it to those cows that wean a calf. This transfer changes the simple cost per cow into a measure of cost per productive cow. These three costs are significant for the main effects of weaning, the four winter feeding regimes, and their interaction ($P < 0.01$). Within winter nutrition treatments, the OCT systems generally had higher total other costs than the DEC groups, except for WR2, which were similar ($P > 0.05$) between weaning treatments. Total other costs for each winter feed treatment is inversely related to cow feed costs. The cost savings in feed was much less than the combined increased replacement and production loss costs for each treatment. From a cost perspective the Total Costs October (Table 1, row 14) found WR0 to be the most costly followed in descending order by WR1, CR and WR2 for both OCT and DEC cows. The OCT-WR0 and DEC-WR0 cow feed costs were $426.34/cow and $416.55/cow the two lowest feed costs. But the cows in the same two treatments had the highest total costs in their weaning groups, ($P < 0.05$, $721.02/cow) and ($P < 0.05$, $693.08/cow), respectively. Overall, DEC cows had lower total costs compared with OCT cows. This stems from both lower feed costs and generally lower other costs. This in part relates to the size differences among cows in the treatments.

**October revenues.** Revenues are estimated as the product of calf weight and appropriate market values on a per calf basis. The table reports this value as average revenue per cow by scenario. Calves from DEC-WR0 cows had the lowest market returns received in October ($P < 0.05$) with an average revenue of $704.02/calf which was different ($P < 0.05$) from the other seven systems average revenues. The OCT-WR0 and DEC-WR1 had average revenues of $722.05/calf and $723.87/calf which were similar ($P > 0.05$) to each other, but different ($P < 0.05$) from all other systems. The DEC-CR and OCT-WR2 systems were also similar ($P > 0.05$) with average revenues of $751.35/calf and $748.91/calf, respectively. The four systems with the greatest revenue were OCT-WR1 ($756.51/calf), OCT-CR ($757.12/calf), DEC-WR2 ($756.91/calf), and DEC-CR ($751.35/calf) and were not different ($P < 0.05$) from each other. The similarity in revenues among these last four systems is a good indication that each of them are producing a similar-sized weaned calf, when measured in October. The real difference will come when revenues and costs are combined to derive net returns.

**October returns.** When sold in October average net returns for the OCT treatments ranged from a low of $1.02/cow in the OCT-WR0 system to a high of $102.32/cow for the OCT-WR2 system. The DEC cows for the same corresponding winter treatments net return averages ranged from a low of $11.74/cow to a high of $115.82/cow. Within each weaning group net returns were unique ($P < 0.05$) from each other and as a whole were significant ($P < 0.01$) for the main effects of wean date and winter feed treatment but not for their interaction ($P = 0.11$).

Generally among the eight different systems costs were lower for the DEC weaning systems when compared with the OCT weaning systems. When comparing like winter treatment groups between weaning systems the OCT cows cost more to feed, had higher replacement and production losses than the DEC cows, except for the OCT-WR2, which had lower replacement and production losses then DEC-WR2. These costs are associated with slightly larger cows in the OCT groups. Calf revenue for calves sold in October was higher than DEC groups for all the OCT groups except WR2. However the greater revenues for the OCT cows were not enough to overcome their higher costs giving the DEC cows the profit advantage. The WR2 systems had the highest level of supplementation and feed cost up to the OCT weaning event, but still resulted in the highest net returns per cow for their respective
groups. Again extra feed costs were more than compensated for by the added value created by lower replacement rates and increased calf productivity when compared to the other winter feed treatments within their weaning groups.

**Feed costs October to December.** Feed costs for meadow grazing and feed supplementation (used only by the OCT weaned calves), lactation and calf range costs (used only by the DEC systems), and preconditioning costs (both OCT and DEC systems) were all based on calf and cow BW’s. The OCT systems calf feed costs were more than double those of the DEC systems. This was expected because these calves were fed to match the expected weight gain of their DEC counter parts. For the OCT systems, calf feed costs were lowest for the WR0 calves, due to calf size. The other three OCT groups WR1, WR2, and CR were not found to be different from each other with costs of $52.02, $51.38, and $52.18/calf respectively. The DEC systems WR0 and WR1 treatments were similar with costs of $19.35 and $19.99/calf) but less than (P < 0.05) than WR2 and CR which were similar in feed costs (P > 0.05, $21.07 and $21.01/calf).

**December revenues.** When OCT weaned calves were backgrounded until December, the estimated average increase in revenue per calf for the OCT weaned calves was $98.62, whereas estimated revenue for the DEC calves increased an average of $61.71/calf from October 1, a $36.91/calf difference. Revenues increased in December due to market value increases, the result of market forces i.e., seasonal demand, and calf growth. The increase in calf weights due to growth was the major contributing factor in changing calf values.

**December returns.** December sales of calves regardless of the feeding or weaning regime were more profitable. Overall average net returns for December sales of the OCT cows was $110.28/cow, whereas DEC cows averaged $115.99/cow. Both weaning and winter feeding treatments were significant (P < 0.01), the interaction of the two however was not (P = 0.51). The net return rankings were unchanged from the October weaning results for both weaned treatments. The net returns for the December sales point for OCT and DEC cows ranged from the low of $54.74/cow and $62.23/cow for the two WR0 systems, to a high for the WR2 systems of $144.36/cow and $151.14/cow. The CR systems were ranked second with $132.29/cow for OCT group and $140.17/cow for DEC group. The WR1 winter feed treatments were ranked third with $109.73/cow and $110.44/cow for OCT and DEC groups. The WR2 and CR winter feeding treatments for both weaning groups were similar (P > 0.05), with the exception that the lower net return (OCT-CR) system did differ (P < 0.05) from the highest net return (DEC-WR2) system.

Backgrounding calves from October to December in the OCT system ameliorates some of the lost net returns due to the effects of the early weaning and early sales of those calves. The average difference per cow in net returns between the corresponding pairs of winter grazing treatments for OCT and DEC (Table 1) assuming calves were sold in October (selling DEC weaned calves in October is hypothetical), averaged $11.60/cow in favor of the DEC calves. However if the same OCT calves were kept and sold in DEC the average difference between weaning groups would have fallen to $5.72/cow, a $5.88/cow gain for OCT weaned calves but still in favor of DEC weaning. Backgrounding increases calf weight more than it adds costs relative to not weaning calves and reduces the gap between the two weaning systems. The WR2 and CR systems were more profitable within their weaning groups than the other two winter nutrition treatments, suggesting that grazing corn residue is superior in profitability to no or low levels of supplementation. The net returns within group rankings were the same as those of the October end point for the same reasons as just discussed. The higher levels of nutrition in both weaning regimes resulted in lower replacement costs (higher pregnancy rates) less productivity loss and increased revenue (calf productivity). The exception to this is the OCT-WR2 treatment where calf revenue is smaller than either OCT-WR1 or OCT-CR treatments. But the added benefits to cow retention and productivity reduce costs enough to still make it more profitable than the other three OCT winter feeding treatments.

**Marketing Steer Progeny at Slaughter**

**Feedlot costs.** As already indicated rather than steer calves being sent to market as weaned calves they were retained and finished as market animals. The weaning and winter treatments were fed identically so that feedlot differences in costs relate directly to the individual calf weight. As calves entered the feedlot their entry costs were estimated using two methods. Method one, RO, estimated as the current cumulative costs of production upon feedlot entry. This method reflects how producers might account for costs transfer among enterprises, such as moving weaned calves to a feed area to be finished as fat cattle. The second method, PC,
associates the costs of the steers with their market values. This method reflects what a typical cattle feeder does when they purchase younger calves and develop them into fat cattle. Both these costs are listed in the first two lines of Table 2. These costs varied slightly from calf costs and market value listed in Table 1 because only steers were transferred and the entry weights had some minor variations. These weight variations are likely due to weights recorded twice, once at the ranch and then again upon entering the feedlot. Differences in market values with systems with similar average weights are accounted for as the effect of the price slide in combination with different variances. Total Feedlot Costs in Table 2 were estimated using feed ingredient values, daily yardage fees, the quantity of feed consumed, and death rate. The DEC-WR1 system incurred the lowest ($P < 0.05$) DEC feedlot

### Table 2. Effects of an October or December weaning date and winter nutritional treatment$^1$ on steer progeny value through slaughter ($$/steer$$)

| Item ($$/steer$$) | October | December | SE$^3$ | P-value$^2$ |
|------------------|---------|----------|--------|------------|
| Costs            |         |          |        |            |
| RO, Total Costs  | 765.83$^a$ | 748.59$^b$ | 699.70$^c$ | 9.48 | <0.01 | <0.01 | <0.01 |
| PC, Market value | 868.53$^a$ | 910.30$^b$ | 877.75$^c$ | 11.78 | <0.01 | <0.01 | <0.01 |
| Feedlot cost     | 528.71$^a$ | 525.19$^b$ | 518.44$^c$ | 7.59 | <0.01 | <0.01 | <0.01 |
| Revenue          |         |          |        |            |
| HCW value        | 1,348.87$^a$ | 1,365.15$^a$ | 1,357.86$^a$ | 31.75 | <0.01 | <0.01 | <0.01 |
| GP value         | 1,343.40$^a$ | 1,353.87$^a$ | 1,359.31$^a$ | 25.37 | <0.01 | <0.01 | <0.01 |
| Revenue rankings |         |          |        |            |
| HCW rank         | 6       | 4        | 5      | 8         | 7       | 7       | 2       | 3       |
| PC rank          | 6       | 5        | 3      | 1         | 7       | 8       | 2       | 4       |

$^1$Winter nutritional treatments: range without supplement (WR0), winter range with 0.45 kg DM/d 32% CP supplement (WR1), winter range with 0.91 kg DM/d 32% CP supplement (WR2), corn residue without supplement (CR).

$^2$P-values: weaning date treatment main effect (Wean), winter nutrition treatment main effect (Winter), weaning date by winter grazing treatment interaction (W × W).

$^3$Standard error of the least squares mean ($n = 12$ observations per treatment replication [3/yr]).

$^a$$^b$$^c$$^d$$^e$$^f$Within a row, indicate that the values that lack a common superscript letter differ ($P < 0.05$).

### Table 3. Cost or return data and source of information used to calculate net return

| Cost/return                      | Source                                                                 |
|----------------------------------|------------------------------------------------------------------------|
| Grazing prices                   | 2005–2014 Nebraska Farm Real Estate Market Highlights (http://agecon.unl.edu/) |
| Supplement                       | Actual purchase price                                                  |
| Corn residue grazing prices      | Dawson County Nebraska survey data (http://extension.unl.edu/statewide/dawson/2015%20landrent.rsl.pdf) |
| Fuel prices                      | U.S. Energy Information Administration (www.eia.gov)                   |
| Hay prices                       | National Agricultural Statistics Survey data (www.nass.usda.gov)        |
| Cull cow prices                  | CattleFax (www.cattlefax.com)                                          |
| Pregnant cow prices              | CattleFax (www.cattlefax.com)                                          |
| Calf prices                      | Livestock Information Marketing Service spread sheets (www.lmic.info)    |
| Prime rates                      | Federal Reserve (www.federalreserve.gov)                               |
| Feedlot feed cost                | Livestock Information Marketing Service spread sheets (www.lmic.info)    |
| Live slaughter prices            | Livestock Information Marketing Service spread sheets (www.lmic.info)    |
| Carcass premiums and discounts   | Livestock Information Marketing Service spread sheets (www.lmic.info)    |
costs of $513.79/steer, whereas the OCT-WR2 had the lowest ($P < 0.05$) OCT feedlot cost of $518.44/steer. Ironically, the DEC-WR2 system incurred the highest ($P < 0.05$) feedlot costs for the DEC weaning treatment with a cost of $529.24/steer whereas CR was the OCT weaning treatment highest ($P < 0.05$) feedlot costs with $536.77/steer. Feeding costs varied a total of $22.98/steer across all eight production systems. Total feedlot costs for OCT and DEC weaned groups, winter nutritional treatment, and the interaction were significant ($P < 0.01$).

**Carcass value.** The following information is based on a per steer basis. Not surprisingly the ranking of the eight systems’ revenues differed slightly depending on how they were marketed. The HCW pricing method resulted in the following ranking, in order from lowest to highest revenue: DEC-WR0 (eighth), DEC-WR1 (seventh), OCT-WR0 (sixth), OCT-WR1 (fifth), DEC-CR (fourth), OCT-WR2 (third), DEC-WR2 (second), and OCT-CR (first). The GP-marketed steers differed in rank from those marketed on a HCW basis; DEC-WR0 switched with DEC-WR1 going from (eighth to seventh), and OCT-WR2, went from fifth to third, which moved DEC-CR from third to fourth and OCT-WR1 from fourth to fifth (Table 2). The loss in revenue from GP pricing was greatest for the CR treatments which received more discounts than the other treatments. The HCW priced group generally had higher net returns than the GP group, this may be or at least in part an artifact of the GP specification which used a USDA composite average reported GP regime. Overall the HCW marketed calves averaged $12.78/steer more than the GP steers. In two instances GP resulted in a higher revenue than HCW (DEC-WR0 and OCT-WR2). These improvements were small $1.05/steer or less. Steers from dams with the higher levels of nutrition, WR2 and CR, had higher revenues due mostly to growth and size. The difference in weaning weights persisted through the feeding period giving the OCT system a slight advantage in revenue with the exception of WR2. The DEC-WR2 revenue exceeded the OCT-WR2 revenue. Calves from these two systems on average were nearly equal in size, but the DEC-WR2 calves had a higher rate of gain in the feedlot of 0.08 kg/d, making them end up being heavier and more valuable than their OCT contemporaries by $29.98/steer for the HCW sales and $20.07/steer for the GP priced animals.

**Net returns.** The slaughter end point had a total of four types of outcomes, RO calves sold on a HCW or GP basis and PC calves sold using the same two methods. (Table 2).

RO slaughter net returns were greater ($P < 0.05$) for the DEC winter grazing treatments when compared with the OCT group for both the HCW and GP marketing scenarios. Overall the RO systems were on average $160.77/hd more profitable than the PC systems since the purchase costs far exceeded the costs of raising the same steers. The greatest HCW returns were RO-DEC-CR ($190.62/steer) and RO-DEC-WR2 ($188.13/steer) and not different form each other ($P > 0.05$). The RO-OCT-CR and RO-OCT-WR2 were also found not to be different ($P > 0.05$) from each other. The RO-CR treatments were ranked first in net returns for both weaning groups with RO-WR2 treatments as second. The CR calves performed best in each RO weaning group with relatively higher productivity with the highest average daily gain (Supplementary Table S1). The cost of the weight gain was less than the added revenue from that gain giving the CR treatments calculated higher returns vs. the relevant WR2 treatments when priced on the HCW basis.

Net returns for all PC treatments were negative except HCW-DEC-CR, which averaged $3.83/steer. Similar to RO in ranking, and as expected the PC steers were less profitable since calf entry costs were higher and revenues unchanged.

However the WR2 systems performed best when the marketing method was changed to GP displacing CR systems in both weaning groups. The reason for the switch relates two effects. First there was drop in the CR values when priced on the grid. The CR systems when priced on the grid were the most penalized winter treatment group. Second, the WR2s were rewarded for the OCT group and penalized less for the DEC group. To illustrate the point 2014 GP values were compared. The discounts for CR on average vs. the combined average for the other three winter feed groups were 4.0 times more than the other groups average quality grade discounts, 3.2 times more for the weight discounts and 5.4 times for discounts for yield grade.

The two treatments where the GP marketing scenarios net returns exceeded those of the HCW were OCT-WR2 with $1.45/steer more and DEC-WR0 with $6.60/steer more. These were the only two treatments to accrue enough average premiums to warrant revenues higher than their HCW values. Again using same 2014 pricing results, positive effects for the DEC-WR0 treatment were shown to be generated from yield grade premiums. The 2014 GP pricing for WR2-OCT also showed positive yield grade premiums and a small number of quality grade premiums.
Impacts. Winter range with the greatest level of supplement and grazing corn residue were similar and more profitable than no supplementation and low supplementation regardless of market end point, due primarily to a reduction in replacement and production loss costs. However when GP was applied to the CR slaughter calves, their net return performance was diminished. While the GP method showed some potential to elevate WR2 treatments to higher net returns. These particular outcomes warrant further investigation to both verify and investigate any possible physical and market opportunities that may be latent in these treatments. No supplementation WR0 resulted in smaller and fewer calves with higher per cow costs related to cow longevity and calf productivity. WR1 increased calf productivity and reduced cow replacement costs, making it a worthwhile investment compared to WR0. The escalation of supplementation found in the WR2 or nutritional change of the CR proved to increase profits even more. On average the benefits of the added nutrition outweighed the costs associated with their implementation. Weaning calves in December generated greater net returns than systems weaning calves in October and backgrounding them at a similar level of nutrition. Since costs were assigned by cow and calf size, it appears that cow size was one of the main drivers of higher costs which led to some of the profit disparity among the OCT and DEC treatments. Further attention and study to cow size and it relationship to calf productivity and longevity may provide some better answers. Differences among the systems in some cases were quite small and could benefit from applying a stochastic modeling process. The December end point was more profitable than the October end point which can be attributed to economics (seasonal market increases), and biological performance (calf growth and size). Changes in any one of the systems costs related to replacement costs or productivity loss is likely to change the rankings of the systems depending on its effect on other costs and revenues which leaves lots of room for creating and modify current systems to make them more efficient and profitable.

SUPPLEMENTARY DATA

Supplementary data are available at Animal Frontiers online.

Conflict of interest statement. None declared.

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