ABSTRACT: A bioeconomic computer model was used to evaluate alternate calving seasons in a cow-calf enterprise under range conditions representative of the Northern Great Plains. The simulated ranch utilized a rotational breeding system based on Hereford and Angus and had a fixed forage base (4,500 animal unit months of native range, 520 t of grass hay, and 183 t of alfalfa hay). Calving seasons studied were spring (SP, beginning March 15), summer (SU, beginning May 15), and fall (FA, beginning August 15). Weaning dates were October 31, December 15, and February 1, for SP, SU, and FA. The SP system was also simulated with a 5% increase in calf mortality (SP-IM), and SU with early weaning on October 31 (SU-EW). Herd size for the fixed resource was 509, 523, 519, 560, and 609 cows exposed per year for SP, SP-IM, SU, SU-EW, and FA, respectively. Corresponding values for weight weaned per cow exposed were 206, 186, 193, 153, and 145 kg. Steer calves, nonreplacement heifer calves, and cull cows were sold at the time of weaning. Quarterly cattle and feed prices used were representative of the peak, descending, valley, and ascending phases of the 1990s cattle cycle adjusted for inflation. Estimates of ranch gross margin (gross returns minus variable costs) were greatest for SP, followed by SP-IM, SU, SU-EW, and FA, and the ranks were consistent across phases of the cattle cycle. Differences between ranch gross margin for SP-IM and SU were small. In beef enterprises representative of the Northern Great Plains, with a restricted grazing season, limited access to low-cost, high-quality grazeable forage, and with calves sold at weaning, switching from early spring to a summer or fall calving date is not expected to improve profitability. If delaying calving improves calf survival, then calving in early summer may be a competitive choice.

Key words: beef cattle, calving season, marketing, system

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INTRODUCTION

Efficiency of livestock production might improve if nutrient demand associated with animal physiological state was optimally coordinated with seasonal changes in forage quality (Vavra and Raleigh, 1976; Adams et al., 1996). Some producers have switched to a summer calving season to better match cow nutrient requirements and forage nutrient availability (May et al., 1999a). Late winter or early spring calving can be effective in increasing sale weights and revenue from weaned calves in the fall (Julien and Tess, 2002). Alternatively, fall calving provides a mechanism to exploit seasonal price cycles and allows producers to run more cows to utilize range resources (Kreft et al., 1998).

At weaning, cow-calf producers have several marketing options. Retaining ownership of weaned calves to heavier BW or slaughter may increase profits. Variation in cattle prices within years (seasonal cycles; Peel and Meyer, 2002) and across years (cattle cycle; Anderson et al., 1996) may affect rankings of management systems. Few studies related to calving season have systematically evaluated effects of calving season in combination with marketing methods for calves.

The objectives of this project were to evaluate alternate calving seasons and different calf marketing strategies for their effects on profitability. This paper describes methods and results associated with range beef enterprises marketing calves at weaning. The companion paper presents results and methods for retained ownership scenarios (Reisenauer Leesburg et al., 2007).

MATERIALS AND METHODS

We used a systems approach, employing computer simulation. A dynamic simulation model of beef produc-
Cattle Management

Calving seasons simulated included spring (SP), summer (SU), and fall (FA, Table 1). Spring and SU calves were weaned at 7 to 7.5 mo of age, and FA calves were weaned at 5.5 mo to represent regional practice. Grimes and Turner (1991a,b) and Azzam and Azzam (1991) concluded that early weaning of fall calves was not detrimental to subsequent performance and may be beneficial to dams as more time is allowed to regain body condition for winter. Short et al. (1996) demonstrated the effects of time of weaning and supplementation in cow and calf performance. Because SU cows face nutritional challenges of lactation that coincide with declining forage quality, an early weaning system (SU-EW) was also simulated to assess the tradeoffs between spared nutrient requirements for cows and reduced calf performance. One disincentive for spring calving is that great calf mortality might be expected due to severe weather at that time of year. Grings et al. (2005) reported mortality rates of 3.5 and 1.5% for April and June calves, respectively. Therefore, we also simulated a spring calving herd with an increased mortality rate (SP-IM; 8 vs. 3% for all others).

Cattle performance parameters utilized were the same used by Tess (1999). A Hereford-Angus rotational breeding system was utilized. Mature BW were assumed to be 560 kg, and peak milk yield for mature cows was 11 kg/d. Average breeding season length was 60 d, with heifers exposed 10 d earlier than mature cows. Cows were culled if they failed to conceive, became unsound, or exceeded 12 yr of age. Cull cows were sold at weaning. The cow:bull ratio was 25:1, with bulls used for an average of 4 yr.

In the short term, it can be argued that western ranches have little opportunity to expand their ranch size. In this case, average supplies of pasture and home-raised hay are essentially fixed. Hence, ranch size was defined as a fixed forage resource. Grazed forage was measured in animal unit months (AUM, 304 kg of DM/mo; SRM, 1989). The annual fixed forage base was 4,300 AUM of range forage, plus 520 t of grass hay, and 183 t of alfalfa hay. For each replication of each management system, the model predicted the number of cows that could be managed on the ranch, as constrained by the amount of grazeable forage. Hence, herd size was a response variable for each simulation (Tess and Kolstad, 2000b; Torstenson et al., 2002). Contingent on the amount required, hay was purchased or sold at market value to maintain a constant inventory.

Supplemental Feeding

All cattle grazed native range from May 1 to January 1 and were supplemented as needed thereafter. Management groups were assigned by age (<1, 1, 2, and 3+ yr) with feeding and management decisions specified for each group. Quality parameters for hays fed and domestic pastures grazed for the experiment were assumed to be representative of the Northern Great Plains region (Julien and Tess, 2002). Simulated diet amounts were based on reasonable practice and were calibrated for the performance of the Hereford-Angus dams in each system. Feeding regimes developed for cows in each calving season were chosen to maintain cow body condition at breeding and weaning.

Heifers and 2-yr-old dams were fed alfalfa (2.1 Mcal of ME/kg of DM, 46% NDF, DM basis), whereas older cows were fed alfalfa/grass hay (2.0 Mcal of ME/kg of DM, 55% NDF). Pregnant and lactating cows were given ad libitum access to hay during the winter feeding period. Range cubes (12 or 20% CP, DM basis, 3.1 Mcal of ME/kg of DM) were used as supplements. High protein cubes were used only in the fall to maintain intake of dormant range forage (Tess and Kolstad, 2000a,b). Supplement amounts ranged from 0.0 to 2.0 kg/d. Compared with cows in SP and SP-IM, cows in SU required more supplement in the fall (0.9 to 1.3 kg/d more for 2-yr-old and mature dams, respectively), but were supplemented for a shorter time during the spring (2.0 kg/d for 30 d vs. 1.0 kg/d for 120 d). Compared with SU, early weaning (SU-EW) reduced fall supplement requirements by 0.8 to 0.9 kg/d. Compared with cows in SP and SP-IM, cows in FA required supplement earlier.
Table 2. Input prices and assumptions used for all systems

<table>
<thead>
<tr>
<th>Feed</th>
<th>Price ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay, $/t</td>
<td>82.67</td>
</tr>
<tr>
<td>Alfalfa/grass hay, $/t</td>
<td>71.65</td>
</tr>
<tr>
<td>Range cubes (12% CP), $/t</td>
<td>125.00</td>
</tr>
<tr>
<td>Range cubes (20% CP), $/t</td>
<td>177.00</td>
</tr>
<tr>
<td>Dystocia, $/case</td>
<td>16.00</td>
</tr>
<tr>
<td>Hired labor, $/cow exposed</td>
<td>23.00</td>
</tr>
<tr>
<td>Annual expenses, $/animal</td>
<td></td>
</tr>
<tr>
<td>Steer calves¹</td>
<td>6.53</td>
</tr>
<tr>
<td>Heifer calves¹</td>
<td>6.53</td>
</tr>
<tr>
<td>Yearling heifers²</td>
<td>49.46</td>
</tr>
<tr>
<td>Two-year old cows³</td>
<td>50.89</td>
</tr>
<tr>
<td>Mature cows³</td>
<td>51.32</td>
</tr>
<tr>
<td>Bulls⁴</td>
<td>539.61</td>
</tr>
<tr>
<td>Interest on purchased inputs, %</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Marketing

- Pencil shrink (weaned calves), %: 2.0
- Actual shrink (yearling heifers and cull cows), %: 3.5
- Commission (yearling heifers and cull cows), %: 2.5
- Brand inspection and check-off, $/animal: 1.30
- Trucking (161-km trip), $/100 kg: 0.77

¹Clostridial, infectious bovine rhinotracheitis/bovine viral diarrhea (IBR/BVD), pasturella, vitamin A, implants, pinkeye, scours, and pneumonia treatment, and ID tags

²Pregnancy test, clostridial, IBR/BVD, campylobacteriosis/leptospirosis (C/L), wormer, bangs, fly treatment, pinkeye treatment, ID tags, taxes, and interest.

³Pregnancy test, IBR/BVD, C/L, wormer, lice and grubs, Escherichia coli, pinkeye, fly treatment, ID tags, horse charge, taxes, and interest.

⁴Depreciation (4 yr), trichinosis test, breeding soundness exam, IBR/BVD, C/L, wormer, lice and grubs, fly treatment, pinkeye treatment, taxes, and interest.

in the fall due to lactation and greater amounts generally (0.4 to 0.7 kg/d) throughout the feeding period.

Expenses and Prices

Non-feed input costs determined by regional practice and local prices in 1996 are presented in Table 2. Non-feed costs for calves included vaccinations, vitamins, identification tags, implants, and treatment costs for pinkeye and pneumonia, with an assumed incidence of 5%. For yearlings, these costs included vaccinations, dewormer, fly repellent, identification tags, pregnancy diagnoses, property taxes, and treatment costs for pinkeye (incidence of 5%). For reproductive-age animals, nonfeed costs included vaccinations, parasite treatment and repellent, replacement identification tags (2%), pinkeye treatment (5%), and property taxes. Added costs for bulls included annual depreciation, trichomoniasis tests, and breeding soundness exams. Annual expenses to own and maintain ranch horses were computed on a per cow basis. Opportunity costs (interest) were computed as 5% of market value. Small differences in annual costs among females of different ages were associated with differences in property taxes. Weaned calves were assumed to be sold at the ranch, with all other animals sold at auction. Marketing expenses included shrink, auction market commissions, brand inspection fees, and trucking.

In setting cattle prices, our goal was to fairly represent the pattern of seasonal price fluctuations that occur within years (seasonal) and across years (cattle cycle) due to changes in beef supply and demand. We attempted to remove variation associated with inflation or very short-term price fluctuations. Weekly cattle price data for cattle of all BW classes were obtained via the Livestock Marketing Information Center (Lakewood, CO), as reported by the USDA Livestock Reporting Commission in Billings, MT. The years 1989 through 2000 were chosen to represent a complete cattle cycle. Prices were averaged to monthly and then quarterly prices and adjusted for inflation using the Gross Domestic Product Implicit Price Deflator (base = 1996) as published by the Bureau of Economic Analysis (Economagic, 2006). Quarterly prices used for the simulations were taken from the peak (1989–1990), valley (1995–1996), and midpoint years of the descending (1993–1994) and ascending (1998–1999) phases within the 1989 to 2000 cattle cycle. Price slides for steers and heifers were determined from prices associated with representative BW increments and were used to determine the final sale price. Figures 1 and 2 present representative prices adjusted for inflation during each phase of the cycle for weaned steer calves, cull yearling heifers, and cull mature cows. Note that prices for SU-EW and FA steers were based on lighter weight calves (204 kg of BW) than for SP and SP-IM (249 kg of BW).

Feed costs represent the most expensive input in most cow-calf production units. Feed grains exhibit seasonal variation in price and are important components of beef cattle supplements. It is well known that feeder cattle prices are influenced by feed grain prices (Dhuyvetter et al., 2002). Hence, purchased feed costs were indexed to historical prices for barley, soybean meal, and hay. Prices for barley and soybean meal (the primary components of range cubes) were based on weekly
Figure 2. Cull female prices for each system at different stages of the cattle cycle (1989 through 2000) adjusted for inflation. $/100 kg. SP = spring; SU = summer; and FA = fall.

prices reported by USDA for Billings, MT, and Kansas City, MO, respectively. Quarterly prices were computed and then adjusted for inflation using the gross domestic product implicit price deflator (Economagic, 2006). Hay and supplements were assumed to be purchased in the fall of the year in which the calves were born (i.e., 1989, 1993, 1995, and 1998 for peak, descending, valley, and ascending stages of the cattle cycle, respectively). The feed prices shown in Table 2 represent the local prices used from 1996 (the base inflation year) from which feed prices were indexed.

Model Outputs

Simulated measures of system performance reported here include number of cows exposed (a measure of herd size), weight weaned per cow exposed, feed cost, number of calves sold, average weaning weights of steers and heifers sold, and ranch gross margin (RGM). Ranch gross margin was defined as gross income less variable costs. Variable costs included purchased feed, marketing expenses, hired labor, dystocia expenses, annual expenses per animal, and interest (Table 2). Grazed forage and home-raised hay were considered fixed expenses in the computation of RGM. To separate the effects of price variation (i.e., seasonal and cattle cycle) from production costs associated with calving seasons, each system was also simulated with constant cattle prices (i.e., prices used for SP at the peak of the cattle cycle).

Due to the stochastic nature of the MSU Beef Model (Tess and Kolstad, 2000a), it is possible to statistically compare simulated systems (Julien and Tess, 2002; Torstenson et al., 2002). However, the model used to simulate postweaning performance in the companion paper (Reisenauer Leesburg et al., 2007) was deterministic, which did not permit any statistical analyses of the data. Hence, to make the results from the cow-calf portion of the study compatible with results from the postweaning portions, we simulated 30 replications for each combination of the calving season and cattle cycle phase and computed simple means for each variable reported. By using a large number of replications, the SEM becomes small, making the means of the model outputs essentially deterministic.

RESULTS

Herd Size, Cattle Performance, and Feed Costs

As described above, AUM of grazeable forage was considered fixed. Hence, herd size varied across management scenarios as each system used the available forage (Table 3). Differences reflect differences in forage intake associated with lactation (lactating cows require more nutrients and consume more forage per day, NRC, 1996), age of calves (older and larger calves consume more forage per day; Julien and Tess, 2002), and forage quality changes associated with advancing forage maturity (increasing fiber content reduces intake, Tess and Kolstad, 2000a,b). Compared with SP, increasing calf mortality by 5% (SP-IM) permitted herd size to increase by 2.8% reflecting the forage intake of nursing calves and the lower intake of dry cows. Herd sizes for SU, SU-EW, and FA were 2.0, 10.0, and 19.6% greater than SP. Increased herd size allows for greater outputs from the system (calves and culls), but also increases all expenses incurred on a per head basis.

Weight weaned per cow exposed is a frequently used measure of system performance that combines herd reproduction, calf mortality, and calf growth. The feeding strategy employed in this study was designed to maintain cow body condition; hence, no differences in pregnancy rate were detected across systems. Deutscher et al. (1991) reported that spring calving herds had overall higher fertility than fall calving herds, but Azzam et al. (1989) reported fall calving resulted in higher conception rates than spring calving. Bellido et al. (1981), Bagley et al. (1987), and Grings et al. (2005) reported no effect on conception rate as affected by calving season. Compared with SP, weight weaned per cow exposed was decreased by 9.7, 6.3, 25.7, and 29.6% for SP-IM, SU, SU-EW, and FA, respectively (Table 3). These decreases were due to increased calf mortality for SP-IM,
and decreased calf weight at weaning for SU, SU-EW, and FA.

Calf weaning weight was heaviest for SP and SP-IM, followed by SU, SU-EW, and FA (Table 3). Compared with SP, calf age at weaning was younger for SU, SU-EW, and FA (Table 1). Cows calving and calves born later in the calendar year grazed forage of increasing maturity and lower forage quality, which compared with SP decreased forage intake, milk production, and calf gains. These results are consistent with those reported by Julien and Tess (2002) who found that weaning weights declined as calving and weaning dates were moved later in the year. Kreft et al. (1998) reported that fall-born calves had lighter weaning weights than spring-born calves.

As reported here, purchased feed represents the balance of hay purchased, sales of excess home-raised hay, and expenses for purchased supplements (Figure 3). Very little hay was purchased in the SP system. The pattern over time reflects changes in barley and hay prices over time. Barley prices in 1989, 1993, 1995, and 1998 were 102, 90, 84, and 87% respectively, of those reported for 1996 (the base year with regard to inflation). Corresponding prices for range cubes (20% CP) were 84, 75, 99, and 87%, respectively, of those reported for 1996 (the base year with regard to inflation). The small differences seen are due to the random elements within the simulation model. The 13% increase in RGM for FA (peak minus constant in Table 4) reflects the effects of higher seasonal cattle prices for calves marketed under this system.

The SP had the greatest RGM at all points in the cattle cycle (Figure 4). Compared with SP, RGM averaged 7 to 12% lower for SP-IM, 9 to 18% lower for SU, 18 to 30% lower for SU-EW, and 23 to 57% lower for FA. Across management systems, compared with RGM under peak prices, RGM at the descending phase of the cattle cycle averaged 9 to 11% lower, 52 to 73% lower at the valley phase, and 36 to 44% lower at the ascending phase. Effects of the cattle cycle tended to be greater for the FA system than for all others. Systems ranked similarly across the cattle cycle. The only switch in ranks was between SP-IM and SU (ascending phase vs. all others).

**DISCUSSION**

Simulation models facilitate the integration of scientific concepts, experimental results, management alternatives, and market characteristics into tools that can be used to address enterprise-level questions that are beyond the practical scope of live-animal experimentation (experimentation that would be too costly in terms...
of time, animals, ranches, or money). Models attempt to mimic important aspects of real systems; yet, models are always abstractions of reality. Assumptions made and the model’s boundaries determine what inferences can be made from research based on simulation. Improved understanding of the dynamics of simulated responses may be as valuable as the results themselves. Computer models encourage researchers (and readers) to ask many what-if questions. The number of possible alternative scenarios can easily multiply; at some point researchers have to limit the number of alternatives evaluated in a single study.

Key assumptions made in this study should be emphasized. First, we assumed that ranch size was fixed and based on available grazeable forage. In the near term, this is a reasonable constraint for most existing ranch enterprises. We assumed that the ranch produced a base level of hay and that hay could be purchased or sold at market value as needed to meet the herd’s requirements and maintain inventory. Annual profit was computed on a ranch basis under these assumptions. Hence, our results for RGM cannot be easily compared with simulation studies where profit was calculated on a per-head basis.

Late spring or summer calving has been proposed as an effective way to lower cow feed costs, by better matching nutrient requirements to available nutrients from grazed forage, and by extending the grazing season (Adams et al., 1996). In the Nebraska Sandhills, Adams et al. (1994) found that management systems that utilized more grazed forage during the winter and during the breeding season, and especially superior quality subirrigated meadows, had lower annual cow feed costs ($/cow) than systems that utilized more hay or lower quality pasture. Julien and Tess (2002) also demonstrated an economic benefit to lengthening the grazing season, although over a relatively restricted range of days. May et al. (1999b), utilizing mixed integer programming models, concluded that calving in June vs. February reduced cow feed costs by allowing cows to graze native range or domestic forages for a longer period and reducing the amount of hay fed per cow. In the current study, purchased feed expenses were greater for SU than SP because cows were supplemented with protein in the fall to maintain forage intake and body condition (Short et al., 1996; Lardy et al., 1999) and because body condition was not allowed to drop to low levels. May et al. (1999b) found that if body condition was not allowed to drop, annual feed costs per cow for June and February calving systems were $218 and $193, respectively, compared with $216 and $173 when body condition was allowed to drop. Studies that have shown an advantage for late spring/summer calving over late winter/early spring calving have generally assumed that grazeable forage was available year round, including good quality forage such as subirrigated meadows (Adams et al., 1996) or improved domestic grasses (May et al., 1999a,b). In this study we assumed that good quality forage was not available in the late fall. Hence, calf growth rates were slower for SU than for SP, and lactating SU cows required more supplement in the fall than SP cows. In southeastern Montana when supplementation was based on forage availability and management constraints (during calving), Grings et al. (2005) reported that April and June calving systems had lower feed costs than a February calving system, though 1 of the 3 winters of the study was very open with little snow cover, which greatly reduced feed costs for the June

### Table 4. Ranch gross margin as affected by calving season and stage of the cattle cycle

<table>
<thead>
<tr>
<th>Item</th>
<th>SP</th>
<th>SP-IM</th>
<th>SU</th>
<th>SU-EW</th>
<th>FA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>$182,341</td>
<td>$169,335</td>
<td>$164,789</td>
<td>$143,230</td>
<td>$123,686</td>
</tr>
<tr>
<td>Stage of the cattle cycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>$181,720</td>
<td>$168,912</td>
<td>$164,628</td>
<td>$142,752</td>
<td>$139,768</td>
</tr>
<tr>
<td>Descending</td>
<td>$164,553</td>
<td>$150,274</td>
<td>$148,570</td>
<td>$131,157</td>
<td>$127,091</td>
</tr>
<tr>
<td>Valley</td>
<td>$87,751</td>
<td>$77,898</td>
<td>$71,925</td>
<td>$61,093</td>
<td>$37,891</td>
</tr>
<tr>
<td>Ascending</td>
<td>$111,063</td>
<td>$97,586</td>
<td>$100,684</td>
<td>$91,014</td>
<td>$78,887</td>
</tr>
</tbody>
</table>

1$/yr, SP = spring; SP-IM = spring, increased calf mortality; SU = summer; SU-EW = summer, early weaning; and FA = fall.

2Cattle and feed prices used were the same for all systems (no seasonal variation).

3Historical cattle and feed prices were used and deflated to a 1996 base.
system. In the system simulated here, we assumed that hay-feeding was required from January 1 to May 1. When May et al. (1999b) restricted the availability of range grazing the advantage of June over February calving was reduced by $16/cow. Hence, in their study when body condition changes and the grazing season were restricted, the feed cost advantage of June over February calving was only $7/cow. Taken together, these studies suggest that the advantage of late spring/summer calving over late winter calving in annual cow feed costs is quite sensitive to the availability of better quality grazeable forage (higher CP and ME, and lower NDF) over the winter.

Compared with calving later, late winter calving runs the risk of greater calf mortality associated with weather extremes (May et al., 1999a). Grings et al. (2005) reported that calves born in February had a mortality rate of 3.5% compared with 1.5% for April- and June-born calves. In this study when calf mortality was simulated to be 5% greater, profit was similar between spring and summer calving (SP-IM vs. SU). It is probably safe to assume that the relationship between RGM and calf mortality is nearly linear over the range explored in this study.

Pang et al. (1999) simulated spring vs. fall calving with several weaning ages and found that for weaning ages of less than 200 d, spring calving was more efficient than fall calving (net returns per cow per year), but fall calving was more efficient at older weaning ages. Their model assumed that all nutrient requirements would be met throughout the production year for all systems. The model used here simulated forage intake as the dynamic interaction of animal physiological state, forage availability, and forage quality (Tess and Kolstad, 2000a,b). Hence, in our model calf growth was restricted by forage quality, which had a negative effect on calves born later in the year, similar to that reported by Grings et al. (2005). Due to the cost of maintaining lactating cows during the late fall or winter, FA calves were weaned and sold earlier in this study.

Few studies of calving seasons have evaluated the entire enterprise, but instead have focused on feed costs (Adams et al., 1996; May et al., 1999b) or amounts of feed used (Grings et al., 2005). Pang et al. (1999) studied a complete enterprise but assumed no constraints on feed resources and calculated profit on a per cow basis. These approaches cannot account for differences in herd size required by switching calving seasons (profit per cow and profit per ranch do not necessarily rank systems the same when herd size is different) and ignore some very real constraints faced by ranchers. In this study, ranch size was constrained in an attempt to better represent the net effect of changing calving dates on a ranch enterprise.

In anecdotal reports about changing calving seasons, most ranches studied have also implemented several management and marketing changes when calving seasons were changed (May et al., 1999a). Hence, the effects of changing calving dates were confounded with changes in grazing management and marketing of calves. This study looked specifically at changing calving date without changes in grazing strategy or calf marketing. In a companion paper we evaluate retained ownership strategies for calves in combination with calving season changes (Reisenauer Leesburg et al., 2007).

In a beef enterprise the timing of breeding and calving may impact several components of the production system and may also impact other associated enterprises (May et al., 1999a). For example, labor and equipment may be shared between a farming enterprise and the beef enterprise, and the timing of calving is important to the allocation of these resources between enterprises. In beef enterprises utilizing federal grazing permits, the timing of calving may be important to the practical management of this resource. Constraints such as these were not directly considered in this study.

The large changes in RGM within systems across the cattle cycle reflect the large and important effects the cattle cycle has on profitability of beef cow/calf enterprises. However, rankings of different calving systems in this study were not affected by the stage of the cycle. Interactions among marketing strategies for calves and stages of the cattle cycle will be addressed in a companion paper (Reisenauer Leesburg et al., 2007).

Changes in breeding, calving, and weaning dates have large and important effects on many components of beef cattle production systems. Amounts and quality of available forage resources, grazing season constraints, and marketing strategies are critical driving variables affecting efficiency and profit. In beef enterprises representative of the Northern Great Plains, with a restricted grazing season, limited access to low-cost, high-quality grazeable winter forage, and with calves sold at weaning, switching from early spring to summer or fall calving date is not expected to improve profitability. If delaying calving improves calf survival, calving in early summer may be a competitive choice.

**LITERATURE CITED**


