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SYMPOSIUM

INVITED REVIEW: Choosing a calving date[1]

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ABSTRACT

Calving date affects cost and timing of production events. Because of the polyestrous nature of beef females, producers can choose a calving date that fits their production system and geographic region. Any time an entire production system is considered, decision making becomes complex. Any calving system, regardless of date, should address the relationship between nutritional requirements of beef females and the quality and quantity of available feed. Nutritional status of beef females is influenced by stage of production and the environment, including length of growing season, forage species, day length, topography, forage quality and availability, ambient temperature, annual rainfall, and weather extremes. These differences cause grazing and feeding strategies to vary across regions. Ideally, high nutrient demand at parturition and peak lactation overlaps with optimal weather conditions and seasonal peaks in forage quality, and lowest nutrient demand overlaps with lowest quality forage, to minimize supplemental feed cost. Calving systems that do not match nutritional demand with forage quality must address potential nutrient deficits faced by breeding females, likely occurring in late gestation and early lactation. Alternative calving systems with higher feed costs need to justify alternative dates through increased revenue generated from higher market value, increased calf performance, or improved reproductive performance. Heat stress, resulting from high temperature and humidity, can reduce calf performance and negatively affect reproductive performance in both the male and female. Hot and humid regions may favor a breeding season during seasonally lower temperatures to minimize poor reproductive performance. Additionally, regions prone to freezing temperatures, heavy snowstorms, or other severe weather events, must consider such risks when choosing a calving date. Many differences exist across regions in regard to environment, production systems, and marketing strategies that contribute to the complexity of choosing a calving date; therefore, beef producers must make site-based decisions according to conditions present on their operation.

Key words: calving date, calving season, reproduction

INTRODUCTION

One of the most important decisions a cow-calf producer must make is choosing a calving date. This decision must take into account the entire beef production system, environmental conditions, available resources, and production and lifestyle goals. Calving season influences when other production events occur, such as peak lactation, rebreeding, weaning, and marketing, all of which affect an operation's profitability and efficiency. Selecting a calving date results in long-term implications that do not allow for adjustments associated with yearly variations in weather, annual rainfall, and forage availability. Environmental conditions such as ambient temperature, annual rainfall, humidity, wind, elevation, and growing season are unpredictable, vary by location, and contribute to the complexity of choosing a calving date.

Calving date influences animal health, nutrition, range and resource management, labor management, lifestyle and workplace preferences, risk tolerance, marketing objectives, production costs, availability of supplemental feed, time-bound grazing

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permits, market trends, and land use. Because of many differences within and among regions and production systems, a universal calving date that will meet the goals and objectives of every producer is not possible. Thus, advantages and disadvantages of different calving periods will be based on environmental, biological, and economic conditions. Additionally, each beef production system, regardless of region, may have site-specific advantages favoring a particular calving period.

Traditionally, calving has occurred early in the year, to ensure an older, heavier calf at fall weaning. Increased input costs in the commercial and feedlot setting, variable market prices, and environmental and economic factors have producers considering the calving season and its effect on their beef production system. Many producers have adjusted calving dates to manage the physiological state of breeding females, range and forage resources, production costs, marketing strategies, and labor. In many environments, matching forage quality with cow requirements is a prudent approach to minimize production costs and increase profitability, but it is not exclusively the most profitable option for every region or operation.

REVIEW AND DISCUSSION

Environmental Considerations

Matching Cow Nutrient Requirements and Peak Forage Quality. Nutritional requirements of beef females vary with physiological state (NRC, 2000), which is determined by calving and weaning dates (Grings and Phillips, 2006). Periods of growth, gestation, and milk production each influence nutrient requirements for the growing and adult female. The relatively high nutritional requirements of cows in late gestation and early lactation can affect subsequent reproductive performance in limited nutritional environments (Houghton et al., 1990).

Beef females experience the greatest level of nutritional stress during lactation. Choosing a calving date that matches high forage quality with peak lactation has the potential to reduce costs (Adams et al., 1996; Stockton et al., 2007). The appropriate period to match calving with optimal range forage quality will vary by location based on environmental factors influencing forage quality. Managing the calving season to follow spring green-up provides opportunity for females to experience an increasing plane of nutrition that corresponds to the increases in nutritional requirements that occur from before calving throughout the postpartum period. In the central Great Plains, Adams et al. (1996) analyzed early summer calving (June), matching peak nutrient requirements of cattle with abundant availability of low-cost, high-quality nutrients through grazed forage. Breeding females experienced an excess in available nutrients just before parturition and the onset of lactation. During this time of high nutritional demand, requirements were met entirely through grazed forages at or near the time CP and TDN of range forages were at seasonal highs. Consequently, cows grazed dormant pasture longer as decreases in nutrient requirements decreased concomitant with decreasing forage quality.

Postweaning and pre- and postpartum management can influence the response to improving range quality occurring during the spring green-up because of the positive relationship between body condition and maintenance energy requirement. Cows managed at greater BCS will have greater maintenance energy requirements than cows at lower BCS (NRC, 2000). Small improvements in range quality associated with onset of green-up may be sufficient to meet or exceed maintenance energy requirements of lower BCS animals but insufficient for animals with greater body mass and maintenance energy requirements. A 3-yr study in the Nebraska Sandhills evaluated reproductive performance of cows grazing dormant range that were either supplemented or not supplemented during the prepartum period (December 1 to February 28) with 0.45 kg of supplement per cow per day (42% CP). During the calving season (March 1 to April 20), cows were managed in a common group and offered grass hay in a drylot setting at an average of 14 kg per cow per day (DM basis). During the postpartum period between calving and breeding (May 1 to May 31), half of the cows were assigned to graze subirrigated meadow while the other half were offered grass hay in a drylot. During the breeding season (beginning June 1), treatment groups were combined and managed as one group grazing upland range in common pastures. Cows fed supplemental protein during the prepartum period maintained BW, and unsupplemented cows experienced a 29-kg loss in BW. Cows supplemented during the prepartum period maintained a BCS of 5.1 from before calving through before breeding, whereas cows that had not received supplement exhibited an improvement in BCS from 4.7 to 4.9 from before calving through before breeding. Postpartum interval, percentage of cows conceiving within the first 21 d of the breeding season, final pregnancy rate, and calf birth weight were not affected by prepartum treatment. Cows maintained on dormant native range without supplement had a lower precalving BCS (4.7 vs. 5.1) and a slightly lower prebreeding BCS (4.9 vs. 5.1) than supplemented cows but experienced the same reproductive performance as supplemented cows, as well as experiencing a greater BCS improvement from before calving through before breeding. This study suggests a BCS as low as 4.7 is adequate for reproductive success. However, feeding supplement prepartum increased the percentage of live calves at weaning (98.5 vs. 93.6%) and resulted in greater weaning weights (218 vs. 211 kg). Prepartum treatment did not affect feedlot DMI, ADG, or carcass weight of offspring (Stalker et al., 2006).

Management of cows during calving and day of calving within the calving season can also affect efforts to match animal requirements to range quality. In production systems where cows are maintained on full feed in confined calving lots or pastures, nutritional quality provided through feeding may exceed that available in pasture forages. If cows are removed from confinement after calving and placed on pastures where they rely on grazed forage, a delay in timing or rate of quality improvement associated with variation in time of green-up may result in greater synchrony of nutrient demands with nutritional availability for late-calving cows than earlier-calving cows. Late-calving cows will have a nutritional advantage because ME requirements for late gestation are less than ME requirements for early lactation and calving later allows for more days for developing higher-quality range forage. This management scenario may put early-calving cows at a nutritional disadvantage to later-calving cows. This situation may benefit by shifting the calving season a few weeks later in the year.

Differences in range quality associated with different calving periods can also have large effects on calf performance. Late-winter calving systems allow rumen development to take place in the calf within a timeframe that allows them to use forage when quality is high. In contrast, calves born to a late-spring calving system may not reach full rumen function until forage quality has begun to decrease. Consequently, calves born to late-spring calving systems will commonly be lighter at the time of weaning than early season calves of the same age (Adams et al., 1996; Grings et al., 2005). This slower rate of gain is also a function of decreased milk yield in the cow, in response to lower forage quality during lactation. Data from Grings and Phillips (2006; Table 1) demonstrate calves born in late spring gained at similar rates to other calving seasons until after 140 d of age, at which time ADG decreased compared with calves born earlier. The lower ADG was associated with decreases in forage quality, and colder temperatures (October–December) may have also contributed to increased calf maintenance requirements during this period.

Systems designed to rely heavily on grazed forage with minimal purchased feed inputs may result in fewer animals maintained in the herd compared with systems where cows are provided supplemental feed as a large portion of their requirements. Kruse et al. (2008) reported for an eastern Montana operation, herd size should be 11% smaller for a late spring than early spring system using the same forage base and weaning calves at similar age but with greater amounts of harvested feed input provided to the early spring system. In a simulation of calving seasons in the northern Great Plains conducted by Reisenauer Leesburg et al. (2007), herd size was 2% greater in the summer-calving versus spring-calving herd because summer-calving cows were fed greater amounts of harvested feed in winter to maintain body condition, rather than allowing body condition to drop slightly during winter. A key consideration from these studies is that optimal herd size will be influenced by the level of supplemental feeding incorporated into the management strategy, further complicating economical comparison of different calving date scenarios.

Heifer Development. Calving period also influences management strategies for postweaning development of replacement heifers. Key development periods in the replacement female are affected by calving season and influence the nutritional

Table 1. Least squares means of weight, performance, preweaning ADG, and weaning weight of steers born in late-winter (LW), early-spring (ES), or late-spring (LS) calving systems in Montana and weaned at 1 of 2 ages (adapted from Grings and Phillips, 2006)

Item	Calving system						SE
	LW		ES		LS		
Birth weight[1] (kg)	37		37		40		1.0
ADG from birth to 69 d[2] (kg/d)	0.85		0.99		0.97		(2.2)
ADG from 69 d to first weaning (kg/d)	1.06		0.92		1.01		0.07
	Age at weaning (d)						
	190	240	190	240	140	190	
ADG from birth to weaning (kg/d)	1.00	0.93	0.95	0.86	1.01	0.86	0.06
Weaning weight[3] (kg)	227	271	217	255	180	205	12.4
ADG from first to second weaning[4] (kg/d)	0.87	0.78	0.64	0.50	0.53	0.59	0.11

[1]LS differs from the average of the LW and ES calving systems, $P = 0.03$.

[2]LW differs from ES calving system, $P = 0.02$.

[3]LS differs from the average of LW and ES for 190-d weaning age, $P = 0.08$; 190-d differs from 240-d weaning age for LW and ES, $P = 0.01$; 140-d differs from 190-d weaning age for LS, $P = 0.04$.

[4]Several treatments were assigned to the steers weaned early, but treatments were consistent across calving systems.

Table 2. Nutrient composition of forages used in Nebraska heifer development trial evaluating development system and calving date[1]

Item	2011	2012	2013
Development period diet			
Winter range CP[2] (% DM)	5.6	5.4	7.8
Winter range TDN[2] (% DM)	51.7	52.5	54.4
Winter meadow CP[2] (% DM)	7.7	10.7	9.9
Winter meadow TDN[2] (% DM)	55.8	60.7	61.2
Hay CP[3] (% DM)	7.3	7.3	6.8
Hay TDN[3] (% DM)	54.4	55.9	48.2
March-calving breeding season diet			
June range CP (% DM)	14.0	10.1	19.3
June range TDN (% DM)	64.3	61.5	79.7
May-calving breeding season diet			
July range CP (% DM)	11.1	10.6	14.7
July range TDN (% DM)	61.2	59.6	71.0
September range CP (% DM)	6.9	8.2	9.8
September range TDN (% DM)	61.4	58.5	65.0

[1]Collected from esophageally fistulated cattle.

[2]Values for the developmental period are obtained from the previous December.

[3]Hay used during the development year was harvested the previous summer.

status of growing females and costs associated with development. Heifer development costs are significant, the majority being feed cost, leading producers to seek cost-effective strategies to manage replacement females. Additionally, calving date influences when cull animals are marketed and will be affected by seasonal changes in market price. The beef producer must consider how a calving season interacts with the heifer development strategy from a nutritional, physiological, and economic standpoint.

An ongoing University of Nebraska study is comparing 2 calving periods (March vs. May) and 2 heifer development systems (hay vs. meadow) and their subsequent effects on growth and reproductive performance. Heifers from both calving periods (March and May) are either provided hay ad libitum with 1.81 kg/d supplement (29% CP) or allowed to graze stockpiled forage (meadow) with 0.45 kg/d supplement during the winter development period from mid-January to mid-April. Prior to and following treatment, heifers are managed as a single herd until the respective breeding seasons. Heifers that graze stockpiled forage for both March and May calving periods have a lower ADG than those fed hay during the winter development period. But because of compensatory gain, BW has not been different in June, July, or at pregnancy diagnosis. There has also been no difference observed in pubertal status or conception rate among groups (hay vs. meadow) within calving period. However, there has been a difference ($P < 0.01$) in pregnancy rates between heifers in March and May calving systems, with 87 and 63% pregnancy rates, respectively. These decreased pregnancy rates in the May-calving heifers are attributed to decreasing forage quality and availability on Sandhills range during the breeding season (July and August) for a May-calving herd. Table 2 (Nielson, 2015) illustrates the decrease in range quality from June to September. Currently, breeding season supplementation strategies for the May-calving herd are being investigated to determine effect on pregnancy rates. The later breeding season would also be coupled with greater ambient temperature and could also be a contributing factor to lower pregnancy rates; however, Griffin et al. (2012a) found no difference in pregnancy rates in 3 different calving periods with mature cows on the same ranch. Unless younger and older beef females are differentially affected by ambient temperature to suppress pregnancy rates, it seems more likely this is a function of declining nutritional quality whereby the younger females cannot physically eat enough of this lower quality forage to meet requirements. This work suggests low input heifer development systems can reduce input costs for both March and May calving systems; however, pregnancy rates are lower in the later-calving system, which is important to recognize when determining replacement rates (Table 3; Nielson, 2015).

Lactation and Calf Weaning. Lactation affects both feed intake and nutrient requirements and may also influence reproduction via a short-term effect where neuronal stimuli from suckling may lengthen postpartum interval and delay or reduce pregnancy early in the breeding period, and through a long-term inhibitory effect due to negative nutritional status when feed resources are insufficient to meet nutrient demands. Operations with available high-quality feed resources and minimal environmental stress can sustain larger cow size and greater levels of milk production for increased economic returns. But under conditions of low feed availability and greater environmental stress, cow size and milk production should be limited (Table 4; BIF, 2010). This consequence is often most noticeable in young females that conceived as yearlings but did not regain sufficient body condition after first calving to become pregnant the following year (Whittier, 1995). Meeting the nutrient demands of lactation is critical for the subsequent reproductive success of beef females. Producers should consider cow size and milk production potential when selecting bulls and replacements to fit their environment. Figure 1 illustrates how reproductive risk, management intensity, and cost increase due to large mature cow size, increased milk production potential, and challenging range environments as a result of low annual rainfall. The

Table 3. Cost analysis of winter heifer development system in the Nebraska Sandhills

Item	Hay[1]	Meadow[2]
Hay[3] ($/head per day)	0.66	—
Meadow pasture ($/head per day)	—	0.50
Supplement (1.8 kg/d)[4] ($/head per day)	0.77	0.19
Yardage ($/head per day)	0.20	0.20
Total ($/head per day)	1.63	0.89
Treatment total[5] ($/head)	146.70	80.10

[1]Heifers received ad libitum hay and 1.81 kg/d supplement from January 15 to April 15.

[2]Heifers grazed meadow and received 0.45 kg/d supplement from January 15 to April 15.

[3]Hay cost assumed as $132/t (5 kg/d).

[4]Supplement containing 29% CP, DM priced at $424/t, composed of processed grain byproducts, plant protein products, roughage products, calcium carbonate, molasses products, urea, vitamin A supplement, copper sulfate, zinc oxide, magnesium sulfate, and monensin.

[5]Treatment total for 90-d treatment period.

amount of range forage availability is predominantly influenced by annual rainfall. In areas of low precipitation, where limited range forage availability exists and winter feed may be limited and costly, mature cow size and milk production potential should be limited to match breeding females biological type with their production environment (Figure 1; BIF, 2010).

Grings et al. (2008) demonstrated the timing of peak milk production can be influenced by quality and quantity of available grazed forage. Peak milk production in cows calving in late winter (February 1) occurred later (88 d after calving) than in cows calving in early spring (April 1; 61 d after calving) and late spring (June 1; 51 d after calving). Cows calving in late winter were provided greater quantities of supplemental feed than cows calving in early spring, which were provided access to only native range during lactation. Total estimated milk yield for late-spring-calving cows varied in response to yearly variation in forage quality, but milk yields in earlier calving seasons were not affected by variations in forage quality between years, likely due to the provision of supplemental feed. These results provide an example of how environmental conditions and quality and quantity of forage affect timing of peak and total milk production.

When calves are weaned and lactation ends, the nutrient requirements of dams decrease substantially. Weaning dates may be used as a strategy to manage nutrient requirements and influence body condition. Weaning dates may be varied to shorten or prolong the lactation period based on current market prices, market outlook, environmental conditions, and available resources.

Weather and the Environment. In regions where drought occurs regularly, range condition is contingent upon amount of springtime rainfall (Kruse et al., 2007; Smart et al., 2007). April and May precipitation patterns and rainfall amounts in the Great Plains can be used as an indicator of subsequent range condition. Production decisions such as stocking capacity and grazing strategy are influenced by the expected range condition. In a drought situation, producers managing late-spring (April to June) calving seasons have less time

Table 4. Matching genetic potential for different traits to production environments (adapted from BIF, 2010)

Production environment		Trait[1]					
Feed availability	Stress[2]	Milk production	Mature size	Ability to store energy[3]	Resistance to stress[4]	Calving ease	Lean yield
High	Low	M to H	M to H	L to M	M	M to H	H
	High	M	L to H	L to H	H	H	M to H
Medium	Low	M to H	M	M to H	M	M to H	M to H
	High	L to M	M	M	H	H	H
Low	Low	L to M	L to M	H	M	M to H	M
	High	L	L	H	H	H	L to M

[1]L = low; M = medium; H = high.

[2]Heat, cold, parasites, disease, mud, altitude, and so on.

[3]Ability to store fat and regulate energy requirements with changing (seasonal) availability of feed.

[4]Physiological tolerance to heat, cold, internal and external parasites, disease, mud, and other factors.

and flexibility in regard to managing drought. Because calving commences during May and June when many drought management decisions are made, having very young calves and late-term cows at this time may limit a producer's drought flexibility. Thus, calving season can influence drought management strategies such as modified stocking rate, early weaning, and culling.

Important production events such as calving, nurturing young calves, and breeding can be significantly influenced by extreme weather. In regions where winter blizzards, freezing rain, or flooding occur regularly, producers may choose calving seasons to avoid such risks to protect against potential losses. In the northern Great Plains, Kruse et al. (2008) reported a 4% increase in calf morbidity and 2% increase in calf mortality for a late-winter (January) compared with early- (March) or late-spring (May) calving seasons, demonstrating the risk associated with calving in the coldest part of the year.

Heat Stress. Heat stress results from a combination of high temperature and humidity causing an extreme heat index. These conditions can negatively affect male and female reproductive performance. Much research has been conducted in the dairy and beef industries to determine the effects of heat stress on reproductive performance. Responses in beef cattle may differ slightly due to environmental, dietary, and genetic differences in the dairy industry, but similar physiologic responses and negative effects on reproduction are experienced by beef females. Endocrine changes observed during times of heat stress reduce the degree of dominance of the selected follicle. Reduced follicular activity alters the ovulatory mechanism resulting in reduced oocyte quality at the onset of estrus (Dunlap and Vincent, 1971). The uterine environment is compromised during heat stress because blood flow to the uterus is reduced and uterine temperatures increase. These changes inhibit embryonic development and increase embryonic loss (Gwazdauskas et al., 1975; Roman-Ponce et al., 1978). Increased incidence of anovulatory estrus and shortened estrus was observed in heat stressed females (Younas et al., 1993), as well as longer postpartum interval and an increased number of services required for conception (Ray et al., 1992). The reproductive performance of herd bulls may also be compromised by extreme heat because spermatogenesis is sensitive to heat and exposure to a hot, humid environment may compromise the development of spermatozoa (Skinner and Louw, 1966).

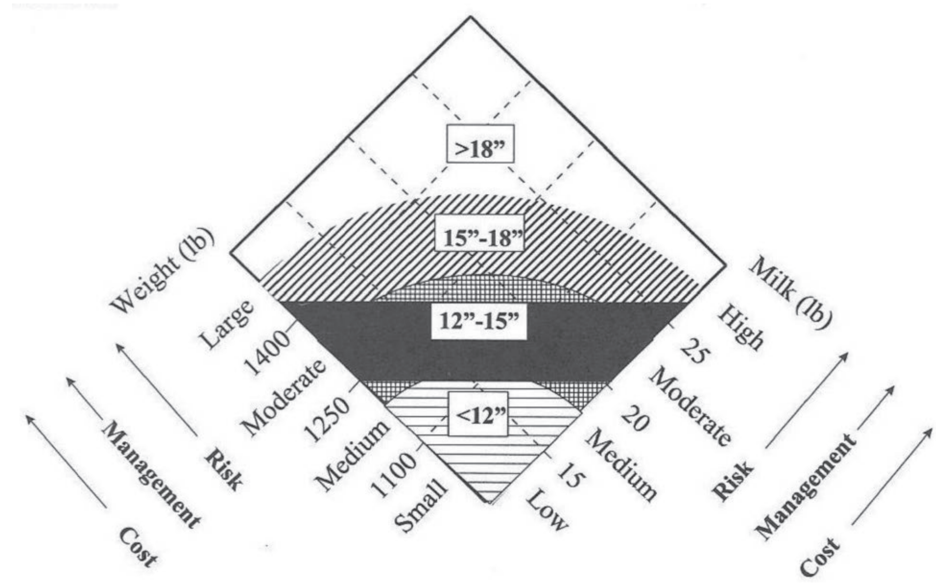

Figure 1. Matching cow biological type (weight and milk, 1 lb ≈ 0.454 kg) to range environment, with associated risk, management, and cost. Ranges in inches (12”–15”, 1 inch = 2.54 cm) are annual precipitation or represent availability of winter feed resource (adapted from Kress and MacNeil, 1999).

Producers should make efforts to avoid the negative effects that heat stress can have on reproductive performance and, ultimately, ranch profitability. Wright et al. (2014) evaluated the effect of ambient temperature on gestation length of Angus cows calving in either August or October while grazing native prairie in Oklahoma. August-calving cows tended to have a shorter gestation length compared with October-calving females. This difference was proposed to be in response to greater cortisol concentrations in August-calving cows during the last 4 d of gestation.

Bos indicus–influenced genetics has introduced a more heat tolerant animal suited to perform in the hot, humid environment of the southeastern United States. Additionally, some beef producers in the Southeast choose a calving and breeding season when ambient temperatures are lower and extreme weather is less likely to disrupt breeding or create environmental stress during calving. Precipitation patterns may also need to be considered in the selection of optimal calving season. High annual rainfall and poorly drained pastures can cause standing water, which may result in decreased performance of the growing animal as well as contribute to an increased parasite load.

Federal Grazing Allotments. Many cattle producers in western states use federal grazing allotments. Some of these are shared allotments where multiple producers may graze together for 4 to 6 mo out of the year. Producers may choose to breed cows earlier in the year before cows are moved to the shared grazing allotments, resulting in an early calving season and older and more developed calves at the time of spring turn-out. Additionally, cattle are regularly trailed to allotment locations, and it may be challenging for very young calves to travel long distances. An older calf is preferred in these conditions because many of these allotments are located in remote mountainous terrain where predation is a concern. Because of environmental factors and herd management, calving date selection may be limited in these production systems.

Economic Considerations

Marketing. Cattle markets typically have seasonal variation within a given year, creating opportunities to match a production system with seasonally higher market prices (Griffin et al., 2012b). Many factors influence feeder calf prices, but supply and demand account for much of the variation between seasonal calf prices. Most spring-calving production systems have historically marketed cattle in November, resulting in a high calf supply. An increased supply at this time results in a lower price when compared with calf prices in winter or spring. The market trend for low calf prices in the fall provides impetus for producers to consider alternative calving dates. By altering the calving date, production and marketing timing also shift to a different time of the year, which may be economically advantageous (Stockton et al., 2007). Calves sold at an alternative time to November generally receive a higher price because of decreased supply at weaning and marketing. A higher price received must offset the potential added cost of harvested feeds needed to support an alternative calving system.

Management strategies should be aimed at maintaining production levels while finding ways to minimize production costs and or maximize production revenue. Value of any productivity increase must exceed any cost increase incurred by achieving greater productivity (Sprott et al., 2001).

Reports from Adams et al. (2001b) in the central Great Plains and Grings et al. (2005) in the northern Great Plains demonstrated late-spring (May to June) calving reduces feed inputs and minimizes production costs compared with winter or early-spring calving. In Nebraska, late-spring (May to June) calving was most profitable, whereas Reisenauer Leesburg et al. (2007) projected March calving to be most profitable. Optimal calving date will vary across and among different regions and production systems; therefore, it is important for beef producers to consider their operation, and how it may be influenced by environment, region, and marketing conditions, before making a calving date decision.

A study evaluated late-winter (February), early-spring (April), and late-spring (June) calving periods on northern Great Plains rangeland to determine how calving system and weaning age may influence cow and calf performance (Grings and Phillips, 2006; Table 1). Weaning dates were 190 and 240 d for the February- and April-calving groups and 140 and 190 d for the June-calving group. From birth to weaning, rate of gain was greater for earlier- compared with later-weaned calves for all calving systems. June-born calves weaned at 190 d tended to weigh less than calves of the same age from the February- or April-calving groups. This difference is likely due to decreasing forage quality later in the lactation period and greater amount of environmental stress (cold temperatures) later in the year. Gross margin per cow was similar for systems with calves born in June and weaned at 190 d of age and those born in late winter and weaned at the same age, but it was greater than that for a system with an early-spring calving season with calves weaned at 190 d of age. Differences were related primarily to decreased feed costs for the June-calving herd. Pregnancy rate (86% for a 32-d breeding season) was not different among calving treatments (Grings et al., 2005).

In an effort to reduce the need for harvested feed, Adams and coworkers (2001a) targeted a late-spring (May to June) calving period compared with March calving. This adjustment extended the grazing period by allowing cattle to graze dormant winter forage longer with decreased amounts of supplemental hay. Calving in late spring reduced harvested forage by 1.35 t/yr compared with March calving. Calf weaning BW at a similar age were 32 kg less for June-born calves compared with March-born calves, but the savings in hay cost for the late-spring calving system more than compensated for the decrease in weaned BW. Clark et al. (1997) analyzed March versus June calving in the Nebraska Sandhills. When comparing production costs for calves born in each calving system, March-born steers averaged \$31.76/45.36 kg, whereas June-born steers averaged \$24.11/45.36 kg. The largest factor contributing to the difference in cost between calving systems was harvested feed. Feed cost for a March-calving cow was \$125.65 versus \$4.40 for a June-calving cow. Purchased feed (supplement), salt, and mineral was \$15.78 per cow for the March-calving system and \$21.23 per cow for the June-calving system. Kruse et al. (2008) also found feed cost per cow to be approximately 45% less for a late-spring (May to June) compared with either a late-winter (January to February) or early-spring (March to April) calving system in eastern Montana when averaged over 3 yr, but year-to-year variability was large due to winter weather conditions.

Adams et al. (2001a) also observed June-born calves weaned in December weighed less than March-born calves weaned at the same age but received a higher price per hundredweight because of marketing at a time of decreased supply. June-born calves from either a range or meadow grazing treatment sold in January after weaning returned \$65 to \$75 more per calf than March-born calves sold in October after weaning. This difference in return was due mainly to lower production cost for a June-born calf and greater price received for June-born calves. These calves were marketed in January and received \$10/45.36 kg more than March-born calves (Adams et al., 2001b). Contrasting results come from a report using 2 bioeconomic computer models

Table 5. Production implications for varying calving seasons (adapted from Grings and Rusche, 2015)

	Season of calving		
Risk	Winter	Spring	Summer
Harvested feed	High	Moderate	Low
Bad weather	High	Moderate	Low
Weaning weight	High	Moderate	Low
Labor conflicts	Low	Moderate	High

to compare calving dates of March 15, May 15, and August 15 and various weaning strategies (Reisenauer Leesburg et al., 2007). Researchers concluded spring calving is expected to be more profitable than summer or early-fall calving scenarios in the northern Great Plains. Both studies show how calving date is confounded by region, and decisions should be based on site-specific conditions (Table 4; BIF, 2010).

A 4-yr study conducted in the Nebraska Sandhills compared net returns for 5 cow-calf production systems: (1) March-calving cows wintered on native range, (2) March-calving cows wintered on corn residue, (3) June-calving cows wintered on native range, (4) June-calving cows wintered on corn residue, and (5) August-calving cows wintered on corn residue. Multiple postweaning strategies were compared in the study. March-born steers entered the feedlot at weaning (November, calf fed). Steers and heifers born in June and August were divided into 2 postweaning management strategies: half entered the feedlot after weaning (May, calf fed) and the other half grazed subirrigated meadow and entered the feedlot as yearlings (September/October). Net returns were greatest for June-calving cows and least for March-calving cows (Griffin et al., 2012a). Net returns were further increased by retaining ownership of calf-fed steers through slaughter compared with selling at weaning (Griffin et al., 2012b). These data demonstrated potential effects of calving period and timing of marketing on production system profitability.

Labor Management. Labor costs contribute significantly to the beef production system and may influence the decision on when to calve. Finding and retaining skilled labor and managing labor efficiently can be challenging for many beef producers. Some producers may choose to avoid labor intensive calving systems to keep from hiring additional personnel or to more efficiently manage labor needs of the operation. Others may be more willing to explore less traditional calving dates because a particular calving period fits into other production enterprises. In some regions it may be reasonable to split the cowherd and manage 2 calving seasons, decreasing the number of bulls needed and spreading labor intensive periods such as calving over 2 different times of the year. In consideration of a combination farming and beef production enterprise, calving may be timed to alternate with labor intensive farming operations such as planting and harvest. Producers may decide to calve when farm labor is more readily available. Producers must also consider how calving date will influence other aspects of the production system such as branding, weaning, and the heifer enterprise, which may all require additional labor.

In conclusion, calving during periods of seasonally high forage quality can reduce the amount of harvested forage and supplements, reducing annual feed costs. Additionally, calving during periods of decreased environmental stress has the potential to decrease labor costs and increase calf survival. Annual rainfall, forage species, weather extremes, and other environmental factors vary by location and across regions, precluding a universal recommendation of particular calving and breeding dates. Careful consideration should be given to the entire beef production system, including cow nutrition, heifer development, production costs, the physical and economic environment, and the operation's marketing objectives when selecting or changing a calving date.

IMPLICATIONS

Selecting a calving date that fits a given production system is an extensive and challenging task because it will affect almost all factors of the cow-calf production system. Understanding how calving date affects the physiological state of breeding females and interacts with the environment and marketing conditions to affect overall ranch profitability will help determine an optimum calving period. Calving date decisions should be based on allocating ranch resources to ensure sustained profit or meet overall ranch objectives. This decision will vary across and among different production regions (Table 5; adapted from Grings and Rusche, 2015).

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