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BEEF

Chapter 1

System Approach to Beef Cow Herd Management

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Chapter 1:

Systems Approach to Beef Cow Herd Management

Introduction

Beef cattle operations can benefit from evaluation of available inputs and potential outputs considered as a full system. Approaching management decisions in this manner may help to optimize the use of resource including: feed inputs, labor availability, and marketing impacts. Evaluation of these factors can lead to varied preferences for calving seasons, weaning dates, timing of feed resource use, and selection of animal genetics. Production systems are regionally dependent and are heavily influenced by the goals of individual producers.

Feed resources availability is often the major factor influencing beef production systems. In South Dakota, due to varied agro-ecologies associated with soil type and precipitation and temperature patterns, cow-calf systems are quite variable, ranging from extensive rangeland based systems in the west to integrated mixed crop-livestock systems in the east, although these systems are not geographically exclusive.

Calving Seasons

Systems can be designed by evaluating how feed resources match with the needs of beef cows throughout the year. Nutrient demand for beef cows is greatest at the time of peak milk production, generally considered to be about 50-60 days after calving followed by decreasing demands as milk yield declines. Nutrient requirements increase again in late pregnancy as the fetus begins to grow rapidly. Season of calving can be used to match cattle nutrient demands to varied forage qualities by shifting the timing of milk yield and fetal growth to periods when forage quality can supply high levels of nutrients.

Several studies on calving seasons for rangeland-based beef production systems have been conducted within the Great Plains (Pang, et al., 1998; Adams et al., 2001; Smith et al., 2001; Grings et al., 2005; Reisenauer Leesburg et al., 2007). A major consideration for selecting calving season is whether rangelands are dominated by warm- or cool-season forages.

Key Points

- Beef production systems can be designed to match cow nutrient demand to forage quality in both rangeland and mixed crop-livestock systems.
- Decisions about calving season are complex and must include a thorough analysis of feed resources, labor availability and marketing strategies.
- Weaning time can be used to help match cow nutrient demand to forage supply on a short term basis.
- Milk yield potential and cow size should be adjusted to the feed availability and environmental stressors found in a specific environment.

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Time of peak forage quality varies between these two vegetation types (Figure 1), resulting in varied benefits for each different system. Cool-season forages make most of their growth during cool spring temperatures and forage quality will be greatest during this time. Growth stops and quality declines during the heat of summer. In contrast, growth of warm-season forages is delayed and these species are of highest quality in the warm summer months. To select a calving season that will overlap the time of peak nutritional demand (peak milk production) to peak forage quality, count back 60 days from peak forage quality to calving. This may lead to an early spring calving time when cool-season forages are dominant or a late spring calving time where warm-season forages are more prevalent.

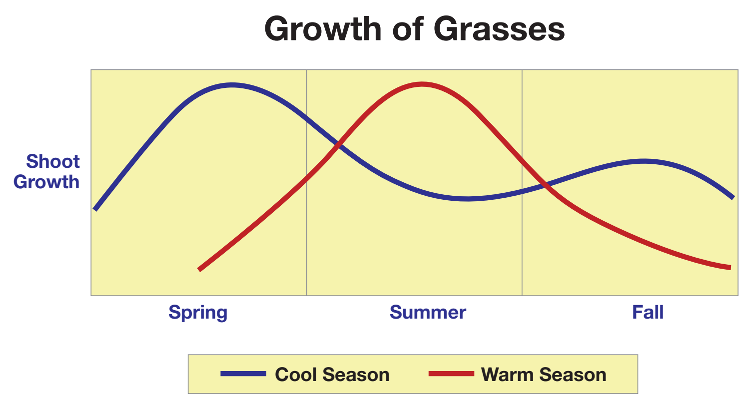

Figure 1: Periods of relative plant shoot growth of cool-season and warm-season grasses.

Another option for designing a beef production system is to try to match periods of low forage quality with the periods of lowest nutritional demand. This might be accomplished by using a late spring calving system in either a cool-season or warm-season forage environment. This option results in nonlactating cows being in midgestation (the period of lowest nutritional demand) during winter when forage quality is lowest. Even in situations where harvested feeds are used in winter, a lower quality (and presumably less expensive) feed source can be used to support a late spring-calving herd through winter.

Example:
If a 1400 lb cow needs 3.14 lbs of crude protein to support 20 lbs of milk at peak milk yield and she eats 30.5 lbs of dry matter per day, the needed concentration of protein is 10.31%. If that same cow eats only 25 lbs. of forage, the needed concentration of crude protein is 12.6%.

Figure 2 shows an example of how dietary crude protein is shifted relative to calving for cows in late winter (Feb), early spring (Apr), or late spring (Jun) calving systems in the mixed grass prairie of the Northern Great Plains. The crude protein requirement for a cow at peak lactation is from 8.6 to 12.9% depending on cow size and milk yield. Figure 2 indicates that cows calving in late winter see greatest dietary crude protein concentrations from range forage after peak lactation and breeding. However, dietary crude protein was over 14% at two months postcalving, which is greater than the suggested crude protein concentration for most cows. Of greater concern might be whether these cows can consume adequate dry matter while eating new growth of early spring forage with its high moisture content and relatively low biomass. Planning to have standing forage carried over from the previous year may be an important

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consideration for a late winter calving herd. The suggested crude protein concentration for cattle diets comes from combining the expected dry matter intake with the needed crude protein intake. If dry matter intake is less than expected, the required concentration (percentage) of crude protein will increase (see example in side bar).

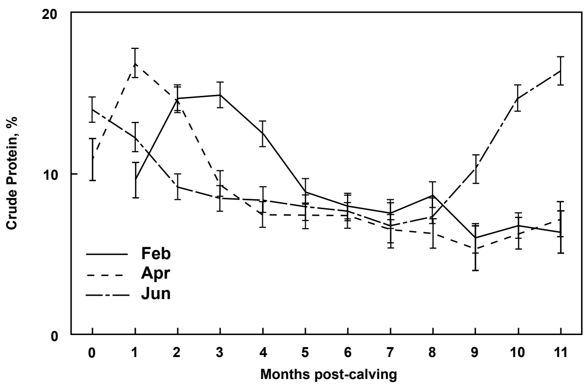

Figure 2: Dietary crude protein relative to physiological state (months after calving) for beef cows grazing northern Great Plains rangelands. Average calving date was February 8 (Feb), April 5 (Apr), and May 31 (Jun) for the three calving seasons. Grings et al., 2005

Late spring calving cows experience an increase in dietary crude protein late in gestation when they are grazing spring forage before calving, a situation not observed for the other two calving seasons. The high quality forage eaten by late spring calving cows before calving may help them to add body condition between winter and calving. This may allow decreased winter supplemention in a late spring calving system compared to late winter or early spring calving, resulting in decreased feed costs.

Cows may increase milk yield during the time of highest nutrient availibility, which may shift their nutrient use profile to something slightly different from that described in the NRC requirement tables. In a study conducted in eastern Montana at the USDA-ARS Fort Keogh Livestock and Range Research Laboratory (LARRL), first-calf heifers in a late winter calving system delayed peak lactation to 88 days post-calving, which occurred at an average calendar date of May 4 (Table 1). A late spring or summer calving system could result in cows reaching peak milk production earlier in the lactation period.

Cows grazing in areas with a greater reliance on warmseason forages will be expected to consume forage that results in different nutrient quality curves than those shown in Figure 2. Expected dietary crude protein would be greater during the summer months such that diet quality would not fall as rapidly as for the cool-season rangeland shown in Figure 2 (i.e. post-calving months 3-5 for Feb, months 2-4 for Apr and months 1-3 for Jun). Fall calving operations again rely on regrowth of cool-season forages during cooler months of the year and cows may see a sharply different forage nutrient profile than spring or summer calving herds.

A variety of factors in addition to forage quality needs to be considered when selecting a calving season. Labor needs and marketing will also be dramatically affected by choice of calving season and, therefore, the resources and goals of the entire operation must be considered in the calving season decision. Table 2 provides a summary of resource needs, marketing impacts and general advantages and disadvantages associated with varied calving seasons.

Current recommendations for managing the nutrition of a cow herd throughout the year often center around having the cow at a moderate body condition score of about 5 (on a 1-9 scale) at calving to ensure adequate reproductive performance (Pruitt and Momont, 1988). In cold climates it is generally recommended to have late winter and early spring

Table 1: Day of peak milk production for first-calf heifers calving in late winter, early spring or late spring in a Northern Great Plains rangeland-based cow-calf production system. *Grings et al., 2008*

	Calving System		
	Late Winter	**Early Spring**	**Late Spring**
	Day of Peak milk production		
Days Postcaving	88[a]	61[b]	51[b]
Calendar Day	May 4	May 31	Jul 19

[ab] Means with differing superscrips differ, P<0.01

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Table 2: Resource needs, marketing impacts and advantages and disadvantages for cow-calf systems based on varied calving seasons.

Calving Season	Feed & Facility Needs	Labor & Management Needs	Marketing Impacts	Advatages	Disadvantages
Winter	Very high, both in amount of harvested feeds and quality required. Highest level of facilities investment needed.	High amount of labor required due to cold weather conditions	Should have heaviest weight calves at set date in fall. Excellent fit for seedstock or for cattle moving directly to feedlot.	Labor demands occur during time when other enterprises are less demanding. Highest production if using a fixed date as the endpoint	Highest level of feed and facility costs. Highest level of skilled labor required.
Early Spring	Relatively high feed needs required in late gestation and early lactation.	Depending on spring weather conditions, labor requirements cold be as high as winter calving.	Advantage in flexibility, spring born calves can fit either accelerated or forage-based growing program depending on genetics.	Avoids the worst of cold weather. Peak grass production occurs during time when calves are best able to take advantage of additional nutrients. Labor needs occur when at low labor times of year.	Spring storms can be disastrous. Mud can pose significant health and management challenges in wetter climates. Investing in sufficient facilities to eliminate weather risk will greatly increase fixed overhead costs.
Late Spring/ Early Summer	Lowest level of harvest feeds required to meet needs of the cowherd. Calves may need supplemental nutrients to meet growth needs pre-weaning. Minimal facility requirements.	Favorable weather conditions during calving greatly reduce the amount of supervision required.	Later calving sacrifices output particularly if calves are marketed at a fixed time. Difficult to implement in seedstock markets. Some kind of retained ownership maybe required to recoup some of the lost performance.	Calves are born on pasture, should result in less disease pressure, lower facility expense, and lower labor requirements.	Workload occurs at same time as other farm/ranch enterprise. Breeding season occurs on poorer quality forage. Increased chance of heat stress during breeding season.
Fall	High quality feeds needed during fall and winter period, difficult to supply without using harvested feeds.	Much less supervision required during calving compared to spring.	Calves are produced when markets are at seasonal highs (feeder cattle and cull livestock). Seedstock producers would need to hold animals for extended time frame to market to spring herds.	Lower labor requirements. Allows producers to take advantage of seasonal marketing opportunities.	Calving (and nutrient demand) occurs when forage quality is declining. Breeding season can be disrupted by winter storms and cold weather resulting in increased numbers of open cows.
Combinations of two or more of the above	Depends upon calving season chosen.	Could mean speding twice as long calving, two groups of calves to wean, etc.	Multiple marketing windows available.	Maximize use of herd bulls. Allows open females to be bred for the next group.	More management groups in the herd resulting in increased complexity. Greater proportion of the year spent calving.

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calving herds in moderate condition by early winter to avoid needing to add body condition when forage quality is low and cold weather can increase energy needs. Late spring and early summer calving cows, however, are in mid-gestation through part of the winter and therefore have relatively low nutrient requirements in winter. These cows will graze spring forage for a period before calving and may be able to add condition in the last month or so before calving. In this situation it may be possible to carry late spring and early summer calving cows through the winter in slightly lower body condition than late winter or early spring calving cows to help lower winter feed costs. However, there is risk associated with the need for adequate spring precipitation to provide the high quality forage needed to add body condition before calving.

Reisenauer Leesburg et al. (2007) used a simulation model to compare expected biological and economical differences among three calving season in the Northern Great Plains. Model results indicated that when working with a fixed forage base, late-spring calving would result in higher feed costs when the late spring calving herd was fed at a level to maintain body condition throughout the winter. These results differed from those observed in the LARRL study where feed costs where less for the late spring calving herd and where body condition was allowed to fall slightly during winter. Assumptions used in the simulation led to ranch gross margins being less in the summer than spring calving herds (Table 3), which again differs from the LARRL study. This illustrates the importance of understanding the resources and marketing strategies of each individual operation when selecting a calving season.

It is important to consider that systems designed to rely heavily on a fixed grazed forage base with minimal purchased feed inputs result in fewer animals that can be maintained in the herd. Using the LARRL example, herd size was approximately 11% smaller for a late spring than early spring system using the same fixed forage base and weaning calves at 190 days of age. In the simulation of calving seasons conducted by Reisenauer Leesburg et al. (2007) herd size was 2% greater in the summer calving than the spring calving herd. If early weaning (October 31 instead of December 15) was used with summer calving, herd size was increased by 10% over the spring calving herd. This difference in expected herd size was again a consequence of winter feed management decisions.

Calving season decisions need to include marketing strategies for calves as some calving seasons allow easier marketing of calves during periods of the year when prices tend to be higher. Marketing plans can be altered and adapted to fit changing conditions much more easily than can decisions regarding calving seasons. Figure 3 shows a 20- year trend (1997 – 2007) in calf prices at Torrington, WY. Prices for lighter weight calves have tended to be greater in spring than fall over this period. As

Table 3: Economic model of herd size, cattle performance, and feed costs as affected by calving season.
Reisenauer Leesburg, 2007

	Spring[1]	Summer	Sumber + EW[2]	Fall
Herd size, cows	509	519	560	609
WWCE[3], lbs	453	425	337	319
Calves sold				
Steers	212	216	232	252
Heifers	114	142	155	167
Weaning weight, lbs				
Steers	543	510	403	381
Heifers	499	469	365	352
Ranch gross margin, $/year	$182,341	$164,789	$143,230	$123,686

[1] Date calving begins and weaning date, respectively: Spring = Mar 15, Oct 31; Summer = May 15, December 15; Summer + EW = May 15, October 31; Fall = August 15, February 1.
[2] EW = early weaning
[3] WWCE = Weaning calves per cow exposed

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calving season and weaning date have shown some interaction, a careful study of the variation of price among differing weight classes of calves is needed to evaluate the profitability of different calving seasons.

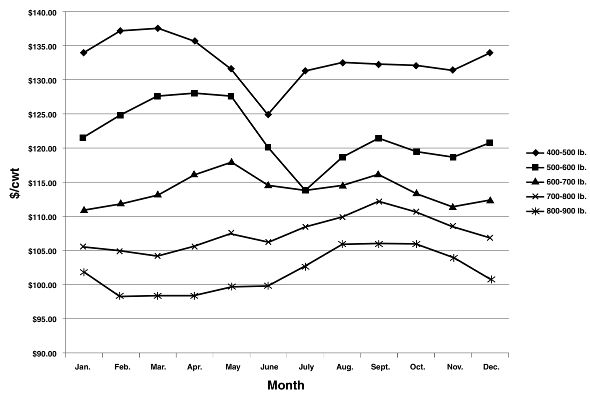

Figure 3: Twenty-one year average steer prices by month and weight class (1987-2007) for Torrington, Wyoming.
USDA, Agricultural Marketing Service and Strauch et al., 2010

Weaning Date

The amount of milk produced by the cow is a major factor affecting both her dry matter intake and nutrient requirements. Weaning a calf creates a substantial decrease in nutrient needs of the cow and therefore, adjusting weaning time is a means to match nutritional needs and supply. Decisions regarding time of weaning should be based upon a combination of forage supply and quality and cow body condition. If forage supply is limited, weaning can be used as a strategy to extend available forage. A non-lactating cow eats as much as 25% less than a lactating cow (depending on stage and level of milk production). Protein and energy requirements are also decreased (Table 4). Additionally, weaning and moving the calf to an alternate feed resource will also help to extend the forage supply by removing the consumption of forage by the calf.

Table 4: Example comparison of expected dry matter intake (DMI) and nutrient requirements a mature beef cows (1350 lbs) when lactating at 4 or 6 months post-calving or when calves are weaned.

	Dry cow	Lactating cow, months post-calving	
		4	6
Mature cows	lbs/d		
Predicted DMI	26.4	29.6	27.1
CP	1.6	2.7	2.1
TDN	11.9	16.5	14.4

Weaning can be timed so that cows in lower body condition can regain condition before calving. Figure 4 shows an example of how weaning a calf at 6 or 8 months after calving might affect body condition change to next calving for cows on different quality forages. When high quality forage is available for cows, early weaning will increase the rate at which body condition score changes. This might be useful if cows will be shifted to very low quality forage in early winter. Early weaning when forage quality is low may help prevent further losses of cow body condition before winter.

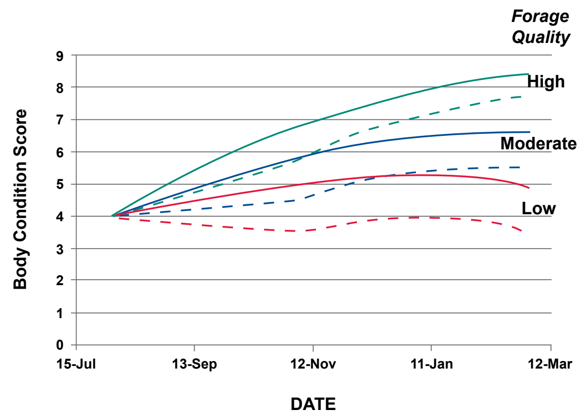

Figure 4: The impact of weaning date on expected cow body condition score using NRC (1996) requirement tables. This graph assumes a 1350 lb cow at BCS 4 on August 1 with calf weaned on either August 1 (solid lines) or October 25 (dashed lines) and grazing forage of high (green lines; 61% TDN, 13% CP), medium (blue lines; 55% TDN, 10% CP), or low (red lines; 51% TDN, 7% CP) forage until calving on March 1.

There is an interaction of calving season with weaning date that reflects how changing forage quality and environmental conditions affect both the nutrient needs of a lactating cow and the growth demands her calf. Data from the LARRL study showed that calves born in late spring and weaned at 190 days of age were lighter at weaning than those born in early spring and weaned at the same age (Table 5). This was due to the lower quality forage between October and December, which provides fewer nutrients for both milk production and directly to the calf through forage intake. Colder temperatures and limited forage availability due to snow cover may have also affected calf gains in the October to December time frame.

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Table 5: Body weight of beef cows and their calves in an early versus late spring calving season as affected by weaning age. *Grings et al., 2005*

Calving Season:	**Early Spring**		**Late Spring**	
Weaning date:	**October**	**December**	**October**	**December**
Weaning age, days	190	240	140	190
Calf weaning weight, lbs	477	561	396	451
Cow weight in October, lbs	1122	1120	1137	1131
Cow weight in December, lbs	1126	1091	1131	1065
Cow BCS in October	5.1	4.9	5.4	5.0
Cow BCS in December	4.9	4.4	5.0	4.4

Timing of Feed Resource Use

The availability of pasture or range forage is dictated in large part by the type of dominant forage present as well as weather factors such as precipitation and temperature. As shown in Figure 1, there are distinct differences in growth patterns between cool-season and warm-season grasses. One of the challenges in cow-calf management is matching the peak demand for nutrients from the cow with the nutrient supply provided by the grazing resource.

Integrating a cow-calf enterprise with a cropping system provides a method to compensate for mis-matches between forage supply and demand. Feed resource options could include annual forages (winter, cool, or warm-season), various cover crop mixtures, or crop residues. A guideline for when these various alternatives are available is shown in Table 6.

Table 6: Seasonal patterns of non-pasture feed resources.

Season	**Possible Resources**
Very Early Spring	Winter Annuals
Spring	Cool-season annuals
Summer	Warm-season annuals
Fall & Winter	Cover crops, crop residues, stockpiled forage

Strategic use of these types of forage resources can serve to reduce the amount of harvested feeds required and potentially lower costs of production. Utilizing cover crops or crop residue in the fall and winter is a time-tested cost reduction strategy employed by a large number of cow-calf operations in the plains. This approach could also be employed to provide high quality feed resources to fall calving cows at a time in the year when those nutrients would otherwise need to be supplied by harvested feed.

Another example of using annual forages to supplement an existing forage base and meet a herd's nutrient requirements would be utilizing summer annuals. For instance, one of the challenges of an early summer calving system is that breeding occurs when grass resources, particularly cool-season grasses, are declining in quality. In this case, a planned animal rotation to a summer annual crop such as sudangrass or pearl millet could be managed so that a source of higher quality forage was available right at the start of the breeding season.

Selection of Animal Genetics (Matching the Cow to the Environment)

A major consideration in evaluating a beef system is how well the cow matches the resources available. Many factors such as cow size, milk yield, heat and cold tolerance, and grazing behavior are influenced by breed choice and genetic selection.

The effect of the combination of cow size and milk production on dry matter intake and dietary crude protein requirement is shown in Table 7. The appropriate size of cow and level of milk yield will depend upon the quality and quantity of feeds available to support production. In looking at Table 7, it is important to understand that although the concentration of crude protein (expressed as % CP in the table) required declines as cow size increases, the total pounds of crude protein needed increases. The lowered concentration is related to the fact that dry matter intake is expected to increase at a faster rate than crude protein needs. As milk yield increases, both concentration and amount of crude protein required increases, showing that high levels of milk production place very high nutritional demands on the cow.

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Table 7: Required dry matter intake, percentage crude protein and pounds of crude protein for beef cows of 3 mature weights and 3 level of milk production at 2 months postcalving. *NRC, 1996*

Cow mature weight, lbs	Peak milk yield		
	10	20	30
	lbs dry matter intake		
1,000	22.1	25.0	27.8
1,200	24.9	27.8	30.6
1,400	27.6	30.5	33.3
	% Crude protein		
1,000	9.1	11.2	12.9
1,200	8.8	10.7	12.3
1,400	8.6	10.3	11.8
	lbs Crude protein		
1,000	2.01	2.80	3.58
1,200	2.19	2.97	3.75
1,400	2.36	3.14	3.92

The Beef Improvement Federation has provided a table (Table 8) of production traits to consider when attempting to match the cow herd to the environment (feed availability and environmental stressors). Traits considered include milk production potential, mature cow size, ability to store energy for use during periods of energy deficit, susceptibility to stresses such as heat, cold, parasites, calving ease, and lean yield.

On operations with relatively high feed availability and reduced environmental stress, moderate to high milk production and cow size are viable options to improve economic returns. Under conditions of low feed availability both cow size and milk yield should be limited. The ability to store energy for use in periods of nutrient deficiencies is also critical. The ability to store energy as fat and high lean yield are somewhat antagonistic and selection of these traits represent a trade off in matching cattle to the feed resource. Feed resources should be considered in terms of both amount and quality. Milk production requires both high nutrient quality and quantity. Some environments may have adequate amounts of feed available, but if quality is low, high genetic potential for milk can still put a nutritional stress on the cow that results in poor reproductive performance. The increase in needed feed availability for greater cow size may be more a need for greater dry matter intake, with less need for greater concentrations of specific nutrients. Inappropriate matching of genetics to the environment increases production risk and the degree and skill of management needed.

Over the last few decades there has been an emphasis on increasing milk yield as indicated by increasing breed average EPDs for maternal milk. While milk yield is correlated to increased weaning weight, this affect is greater at lower levels of milk yield and there is a decreasing response in weaning weight to

Table 8: Matching Genetic Potential for Different Traits to Production Environments[1]. *BIF, 2010*

Production Environment	Traits						
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
Breed role in terminal crossbreeding systems							
Maternal		M to H	L to H	M to H	M to H	H	L to M
Paternal		L to M	H	L	M to H	M	H

[1] L = Low; M = Medium; H = High.
[2] Heat, cold, parasites, disease, mud, altitude, etc.
[3] Ability to store fat and regulate energy requirements with changing (seasonal) availablity to feed.
[4] Physiological tolerance to heat, cold, internal and external parasites, disease, mud and other factors.

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increased milk yield at high levels of milk production (Lewis et al., 1990). The cost of increased feed needed to support high levels of milk needs to be considered along with this declining rate of response in expected weaning weight. Also, post-weaning gain may be more rapid in calves from dams with lower milk production (Lewis et al., 1990). This matching of cow size and milk production to feed resources is also a critical factor in calving season selection with the varied synchronization of nutrient supplies and cow needs as discussed previously.

One of the criticisms of reducing cow size has been that the feedlot performance and carcass weight output of the calves produced will not be acceptable if those trends were taken too far. Terminal crossbreeding systems provide an effective option for overcoming the dilemma of matching the environment and end-product goals. Use of maternal lines to produce a cow herd that matches the environment can be combined with sire breeds or lines with attention paid to growth rates (high mature size) and the necessary carcass traits to meet the intended end-product target. The suggested range in traits for maternal and paternal lines is shown in the last two lines of Table 8 and can be combined with the matching of feed availability to production traits in the upper portion of the table.

In addition to considerations of cow size, milking ability and response to stresses, differences in grazing behavior may be an important component of matching cows to the environment. Different breeds of cattle have been shown to vary in their grazing behavior with differences observed in the distance cattle graze from water (Winder et al., 1996), number of hours spent grazing (Aharoni et al., 2013) and the amount of time spent in upland versus lowland sites (Bailey et al., 2001). These differences can be used to alter vegetation and riparian area management. Within herds, individual cows have been observed to vary in their use of vegetation types and topographies (Bailey et al., 2004). Cow age has also been shown to affect grazing behavior (Walburger et al., 2009), young cattle have been shown to learn from their mothers about grazing areas (Howery, et al., 1998) and heifers raised on rangeland to have different grazing behaviors in the following summer (Hojer et al., 2012). All of these behavioral patterns can be important to matching the cow to forage resources.

Exploitation of these behavioral traits can be used to optimize use of vegetation and topography on a particular ranch. For example, a different breed type might be considered for a mixed crop-livestock system in relatively flat terrain than for a rangeland-based operation with rough topography or sparse water development. In purchasing new cattle for an operation, consideration of pervious grazing experience may improve the transition to a new environment.

Summary

Developing a production system to fit a particular beef operation is a challenging exercise. A thorough evaluation of the operation’s resources and management goals is needed to develop a well-fitting plan. Interactions among responses to management activities are complex and difficult to predict. Evaluation of feed inputs, labor availability, and marketing impacts will lead to varied preferences for calving seasons, weaning dates, timing of feed resource use, and selection of animal genetics for each operation.

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Calving season case study: USDA-ARS, Fort Keogh LARRL, Miles City, MT

During 1998-2001, a study was conducted to test how calving season would influence a number of production characteristics of a rangeland-based cow-calf operation on the Northern Great Plains (Grings et al, 2005). Three herds were developed to calve in late winter (LW), early spring (ES) or late spring (LS). For each calving season, calves were weaned on one of two dates. Average breeding, calving and weaning dates are shown in Table A1.

Replacement heifers stayed within their calving season so that heifer development options could be evaluated. Steer calves were placed into several backgrounding/finishing programs that included backgrounding and finishing in the Northern Great Plains on corn silage-based diets, backgrounding in the Northern Great Plains until May when steers were shipped to Oklahoma for grazing on wheat pasture before finishing, and shipping after weaning to Oklahoma for forage-based backgrounding before finishing.

Cow BW change and BCS dynamics were affected by calving system, but fall pregnancy rate was not. Estimated harvested feed inputs were less for the LS compared to LW or ES systems. Birth weight and overall rate of gain from birth to weaning did not differ for steers from the three calving systems (Table A2). Calf weaning weight differed by weaning age within calving system, and steers from the LS calving system and weaned at 190-days of age tended to be lighter than the same age steers from the LW or ES calving systems.

Feed inputs included differing amounts of hays (sudan, oat, grass and alfalfa), alfalfa pellets, protein and grain supplements, corn silage and rolled barley. Table A3 shows average feed costs for the

Table A1: Breeding and weaning dates for calving systems evaluated at ARS-USDA Miles City, MT 1998-2001.

	Late Winter	Early Spring	Late Spring
Breeding dates			
Average calving date	Feb 8	Apr 5	May 31
Weaning dates			
Weaning 1	Aug 15 (190-d-of-age)	Oct 19 (190-d-of-age)	Oct 19 (140-d-of-age)
Weaning 2	Oct 19 (240-d-of-age)	Dec 9 (240-d-of-age)	Dec 9 (190-d-of-age)

Table A2: Least squares means of birth weight, pre-weaning 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 one of two ages.
Grings et al., 2006

Item	Calving System						
	LW		ES		LS		S.E.
Birth weight, lbs[a]	81		81		88		2.2
ADG from birth to 69 d, lbs/d[b]	1.87		2.18		2.13		0.04
ADG from birth to 69 d, lbs/d[b]	2.33		2.02		2.22		0.15
Age at weaning, d	190	240	190	240	140	190	---
ADG from birth to weaning, lbs/d	2.20	2.05	2.09	1.89	2.22	1.89	0.13
Weaning weight, lbs[c]	499	596	477	561	396	451	27.3
ADG from first to second weaning, lbs/d[d]	1.91	1.72	1.41	1.10	1.17	1.30	0.24

[a] LS differs from the average of the LW and ES calving systems, P = 0.03.
[b] LW differs from ES calving system, P = 0.02.
[c] LS differs from the average of LW and ES for 190-d weaning age, P = 0.08; 190- differs from 240-d weaning age for LW and ES, P = 0.01; 140- differs from 190-d weaning age for LS, P = 0.04
[d] Several treatments were assigned to the steers weaned early for treatments were consistent across calving systems.

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3 calving seasons over the three year period of 1998 to 2001 (Kruse et al., 2008). The decreased feed inputs associated with the late spring calving contributed to numerically greater ranch gross margins for this system, but variability was high due to yearly differences in feed needs based on weather conditions.

The impacts of calving systems and weaning age on steer performance during the growing phase depended on the system used and the endpoint for a given calf crop as shown in Table A4 and A5. Steers from various pre-weaning systems that were backgrounded to a common weight endpoint in Montana did not differ in grower or finisher average daily gains (ADG). Stocker cattle in Oklahoma exhibited no difference in ADG during winter but ADG did differ in spring with overall ADG not differing for calving system or weaning age. Steers from the LS calving system were leaner whether they were younger (Oklahoma finishing) or of similar age (Montana finishing) at harvest than steers from LW or ES systems. In a vertically integrated beef production system, calving later in the calendar year shifted more of the body weight gain for steers to the stocker and finishing phases.

Table A3: Purchased feed costs and herd reproductive performance in of cows calving in late winter or early or late spring.

Feed cost per cow $	**Late Winter**	**Early Spring**	**Late Spring**
1998 to 1999	149	98	88
1999 to 2000	76	107	0
2000 to 2001	216	279	122
Average	147	161	70
Calf morbidity, %	6	2	2
Calf mortality, %	3.5	1.5	1.5
Calves weaned per cow calving, %	96	98	98

Table A4: Least-square means for carcass characteristics of steers born in Montana in late winter (LW), early spring (ES), or late spring (LS) and weaned at 140, 190, or 240-d of age and developed through finishing in Montana (MT Growing-Finishing).

Item	**LW**		**ES**		**LS**		**SEM**
	190[a]	**240**	**190**	**240**	**140**	**190**	
No. of steers	37	37	36	38	35	37	---
Harvest weight, lbs	1239	1188	1148	1170	1157	1168	22.2
Hot carcass weight, lbs[bdf]	726	702	664	682	662	678	8.6
Fat thickness, in	0.45	0.39	0.40	0.37	0.33	0.36	0.03
Longissimus area, in^2	12.3	12.6	12.0	12.3	12.0	12.3	0.2
Marbling score[cefh]	509	498	458	425	407	451	23.0
Quality grade[cgi]	12.7	12.6	12.4	11.9	11.8	12.2	0.21
Yield grade[jkl]	3.08	2.66	2.80	2.65	2.54	2.56	0.12

[a] e.g. LW190 = late winter calving season and weaned as 190 d of age.
[b, c] Steers from a LW calving system differ from steers from an ES calving system, $P < 0.01$ and $P < 0.05$, respectively.
[d, e] Steers from a LW calving system and weaned at 190 d of age differ from steers for an ES calving system and weaned at 190 d of age, $P < 0.01$ and $P < 0.10$, respectively.
[f, g] Linear effect of age at weaning in October (240, 190, and 140 d of age), $P < 0.01$ and $P < 0.05$, respectively.
[h] Slight = 300 to 399, small = 400 to 499, modest = 500 to 599
[i] Prime = 16, Prime - = 15, Choice + =14, Choice = 13, Choice - = 12, select = 11, standard = 10.
[j] Yield grade = 2.5 + (2.5 × adjusted fat thickness, inches) + (0.2 × % kidney, pelvic, and heart fat)+ (0.0038 × hot carcass weight, lbs) - (0.32 × longissimus area, in^2).
[k] Steers from a LS calving system and weaned at 190 d of age differ from steers the average of steers from LW and ES calving systems and weaned at 190 d of age, $P < 0.05$.
[l] Steers from LW and ES calving systems and weaned at 190 d of age differe from steers from LW and ES calving systems and weaned at 240 d of age, $P < 0.05$.

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Table A5: Least squares mean of weight, performance, and carcass traits for calves born in Montana in late winter (LW), early spring (ES) or late spring (LS), weaned at 140, 190 or 240 d of age, backgrounded in Montana and Oklahoma, then finished in conventional confinement feedlots or on pasture plus feed in Oklahoma (MT Growing-OK Finishing and OK Growing-Finishing).

Item	LW		ES		LS		SEM
	190[a]	240	190	240	140	190	
No. of steers	77	93	100	87	99	101	---
Feedlot performance:							
On-test BW, lbs[cefh]	950	944	849	827	744	744	14.1
Harvest BW, lbs[cefh]	1243	1241	1190	1186	1144	1151	20.0
Total gain, lbs/calf[cefh]	295	297	341	359	400	407	16.9
Finisher ADG, lbs	2.49	2.49	2.64	2.75	2.77	2.79	0.09
Days on finishing diet,[defh]	120	122	132	134	146	149	8.4
Age at harvest,[dcefh]	602	606	562	560	517	519	5.0
Carcass traits:							
Hot carcass weight, lbs[cefh]	763	763	728	719	697	702	14.1
Fat thickness, in[e]	0.47	0.44	0.48	0.46	0.42	0.41	0.03
Longissmus area, in^2	12.8	12.8	12.7	12.4	12.6	12.5	0.17
Marbling score[bdeg]	437	435	412	427	403	394	14
Quality grade[eg]	12.0	11.9	11.8	11.9	11.6	11.3	0.13
Yield grade	2.88	2.75	2.81	2.82	2.56	2.54	0.10

[a] e.g. LW190 = late winter calving season and weaned as 190 d of age.
[b] Slight = 300 to 399, small = 400 to 499, modest = 500 to 599.
[c, d] Steers from a LW calving system and weaned at 190 d of age differ from steers from an ES calving system and weaned at 190 d of age, P < 0.01 and P < 0.10, respectively.
[e] Steers from a LS calving system and weaned at 190 d of age differ from steers the average of steers from LW and ES calving systems and weaned at 190 d of age, P < 0.01.
[f, g] Linear effect of age at weaning in October (240, 190, and 140 d of age), P < 0.01 and P<0.05, respectively.
[h] Steers from a LW calving system differ from those in a ES calving system, P < 0.01.

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