Genetic aspects of replacement heifers in current and future production systems

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Abstract

Development or purchase of replacement heifers represents a significant cost in cow-calf production systems, and expression of genetic effects on maternal traits largely determines genetic effects on production efficiency. A dynamic simulation model was used to evaluate the effects of several maternal traits on production system efficiency (weight weaned per cow exposed, **WWCE**) and profit (ranch gross margin, **RGM**). The production system studied was a northern range, spring calving, cow-calf system. Traits studied were age at puberty, yearling conception rate, dystocia, postpartum interval to estrus, mature cow conception rate, milk yield, and soundness (modeled as involuntary culling rate). Increased age at puberty or decreased yearling conception rate decreased WWCE. Effects of both traits on RGM depended on culling practices for yearlings. When nonpregnant yearlings were sold in the fall, net effects on RGM were small, and income from yearlings replaced income from calves. When nonpregnant yearlings were saved and bred again, RGM declined. Increased incidence of dystocia, longer postpartum intervals, and lower mature cow conception rates also severely decreased efficiency and profit. Age at puberty and postpartum interval demonstrated thresholds of response. For the system simulated, effects of increased milk yield depended on whether increased nutrient demand was met by added supplementation. Without added supplementation, increased milk yield had negative effects on WWCE and RGM, because reproductive rate declined due to loss of body condition. When supplementation increased with milk yield, RGM declined but at a much slower rate. Increases in involuntary culling rate led to large decreases in WWCE and RGM. Compared to current practice, genetic evaluation of more maternal traits is needed to allow breeders to implement complete multiple-trait selection programs. Advances in genetic prediction are important to meeting this goal but will likely depend on whole-herd recording and reporting to be implemented. Management systems targeted to exploit market cycles and(or) consumer preferences may increase performance demands on cows. Understanding of the biological mechanisms controlling the expression of genetic differences will be critical to the successful management of these systems.

Key Words: Beef Cattle, Genetics, Selection, Systems

Introduction

Development or purchase of replacement heifers represents a significant cost in cow-calf production systems. Genetic effects on replacement heifer performance are not independent of genetic effects expressed in mature cows or progeny (birth to carcass). Because most resources used in cow-calf systems are allocated to reproductive females, expression of genetic effects on maternal traits largely determines genetic effects on production efficiency.

Bulls have a greater impact than cows on genetic change, primarily because sires leave many more calves per year than dams (especially with AI), and selection differentials for heifers are normally much smaller than those possible for bulls. This highlights the importance of sire evaluation in the genetic improvement of maternal traits. Although maternal traits are potentially very important to production efficiency and profit, they have received less emphasis than growth traits in genetic evaluation programs.

Advances in data management, computing, and genetics will permit the recording and genetic evaluation of a larger array of maternal traits, and breed associations are positioning to exploit these technologies (Snelling, 1998). Examples include multibreed genetic evaluation (Pollack and Quaas, 1998), marker-assisted selection (e.g., Green et al., 1998; Stone et al., 1999), whole-herd recording and computation of EPD for stayability (Snelling et al., 1995; Ducrocq and Solkner, 1998), and estimation of grandmaternal effects (Dodenhoff et al., 1999; Quintanilla et al., 1999). Potential responses of production systems to genetic changes in some maternal traits have not been well quantified.

The objectives of this study were to evaluate the effects of changes in several maternal traits on life-cycle production efficiency and profit and to identify areas of potential importance in current and future breeding programs.

Materials and Methods

Traits studied

Replacement heifers are saved or purchased with the intent that they will enter the breeding herd. Usually they are expected to conceive and then deliver live calves without assistance, during a prescribed calving season. To do this, heifers must be cycling and conceive during the breeding season. After they are in the breeding herd, cows are expected to wean desirable calves at a regular interval. To stay within a 365-d calving interval, cows must return to estrus and conceive again within approximately 85 d. Added demand for nutrients associated with lactation increases the likelihood of nutritional stress after calving.

Imbalance between available feed nutrients and milk yield may lead to weight loss and reproductive failure (Short and Adams, 1988). In range production systems cows are commonly culled if they are not pregnant (or bred too late), unsound, too old, they wean undesirable calves, or exhibit unacceptable behavior.

Systems analysis techniques were used to evaluate the net effects of several traits on production efficiency and profit. A dynamic simulation model of range beef production was used. The model simulates animal and enterprise performance in response to inputs describing genotypes, management groups, feeds, grazed forage, and management decisions. Individual animals are simulated; however, genetic potentials for animals of the same genotype are equal. Reproductive traits are simulated stochastically, and growth and body composition traits are deterministic. Energy and protein metabolism, nutrient partitioning, and body composition changes are simulated as dynamic interactions of feed intake and physiological state. Description and evaluation of the model were presented by Tess and Kolstad (2000a,b).

Maternal traits studied were age at puberty, yearling conception rate, first-parity dystocia rate, postpartum interval to estrus, mature cow conception rate, potential milk yield, and involuntary culling rate. Simulated changes in each trait were evaluated for their effects on production efficiency, measured as kilograms weaned per cow exposed (**WWCE**), and profit, measured as ranch gross margin (**RGM**, gross income – variable expenses, $/yr). Amounts of change for each trait are presented in the Results section. Simulated means presented represent 10 replications of each scenario.

Production System Simulated

The northern range cow-calf production system simulated was similar to that described by Tess and Kolstad (2000b). Mature weights were assumed to be 560 kg, and peak milk yield for mature cows was 12 kg/d. The mating system was a two-breed rotational system at equilibrium using Angus and Hereford cattle. Breeding seasons were June 1 to July 31 for yearling heifers and June 15 to August 14 for older cows. Calves were weaned November 1. Cows were culled if they were nonpregnant, unsound, or were 13 yr of age. Cull yearlings were sold September 15 and all others November 1.

After weaning, replacement heifers were fed alfalfa hay (5.5 kg/d) until January 1, when a 12% CP supplement was added (2 kg/d) and hay offered was increased to 6.5 kg/d. Heifers were turned out on native range pastures May 1 through December 31, with a 20% CP supplement added beginning November 1 (1 kg/d). Prior to their first parturition heifers were fed alfalfa hay. After calving, a 12% CP supplement was added (1.5 kg/d) until turnout to grass on May 1. Older cows were fed similarly, except that grass-alfalfa hay (2.0 Mcal ME/kg DM, 55% NDF) was substituted for alfalfa hay (2.1 Mcal ME/kg DM, 46% NDF). All hay fed to cows was offered for ad libitum consumption. All supplements contained 3.1 Mcal ME/kg DM.

Steer calves and nonreplacement heifer calves were marketed through an order-buyer on November 1, and cull cows were shipped to an auction market the same day. Marketing expenses for calves included pencil shrink (2%), check-off and inspection fees ($1.15/calf); expenses for cull cows included shrink (3.5%), trucking ($.003/kg), check-off and inspection fees ($1.15/cow), and commissions (2.25%). Market prices, including weight slides for calves, were averaged prices reported for Montana and Wyoming from 1990 through 1998 (October 15 through November 15, Cattle Fax, 1990–1998).

Prices for inputs were based on local Montana prices for 1998. Prices for 12 and 20% CP supplements were 125 and $180/t, respectively. Annual costs based on inventory included expenses for growth implants, vaccines, parasite control, antibiotics, ear tags, pregnancy diagnosis, property taxes, overhead, and interest on investment and totaled 6.53, 41.59, 50.89, and $51.32/animal for calves, yearling heifers, 2-yr-old cows, and older cows, respectively. Annual bull costs (25 cows/bull) included similar costs plus breeding soundness exam and depreciation and totaled $539.61/bull. Annual labor costs were $20 per cow exposed. Added costs for dystocia were $16/case. Interest on purchased inputs was 10%, and operating loans were held 6 mo.

As described by Tess and Kolstad (2000b), the simulation model predicts RGM for a ranch of fixed size. For this study, fixed ranch resources were 4,450 animal unit months (AUM) of range forage, plus 184 t of alfalfa and 486 t of grass-alfalfa hay with market values of 82.67 and $77.16/t, respectively. If all hay was not used within a year, the value of that left over was credited to income at market value. If extra hay was needed it was purchased at market value.

Results and Discussion

For the base scenario the simulated ranch supported over 530 cows. This is the number of cows exposed to breeding including 75 replacements. Responses for WWCE and RGM to changes in individual traits are presented in Figures 1 through 7. To help explain information presented in the figures, several measures of system performance for selected scenarios are presented in Table 1.

Heifer Reproduction

Age at Puberty. As age at puberty increased an increasing number of heifers experienced their first estrus during the breeding season or missed the season entirely. Conception rates are lower during puberal estrus (Byerley et al., 1987). These facts are reflected in the drop in WWCE (Figure 1a). When all nonpregnant cows were culled in the fall, RGM did not change as age at puberty increased (Figure 1b). This surprising result was due to two factors: 1) enough replacement heifers were saved to maintain herd size within forage constraints and 2) heifer prices generally made weight gains for yearlings competitive with calf weight. Hence, because fewer heifers were bred, more were sold as yearlings and more heifer calves were saved, essentially shifting enterprise income from calves to yearlings. Increasing age at puberty from 357 to 417 d had little effect on WWCE and RGM. As age at puberty increased from 417 to 477 d the number of heifers saved increased from 75 to 128, and the percentage of ranch income from yearlings shifted from 2 to 23%. When age at puberty exceeded 477 d, the ranch was not sustainable (i.e., it could not produce enough replacement heifers to maintain herd size).

For comparison, the same changes were evaluated in a system in which nonpregnant yearlings were kept and allowed to breed the following season. Responses for WWCE were similar for both management systems, but RGM declined precipitously as age at puberty exceeded approximately 430 d. Under this system the number of heifers saved and income from yearlings remained essentially unchanged from the base scenario.

Currently, it is generally impractical to measure age at puberty in either males or females. Scrotal size has a favorable genetic correlation with age at puberty (e.g., Kress et al., 1994), and this has partially motivated the measurement of scrotal size and computation of EPD by some breed associations. These results demonstrate the importance of age at puberty within cow-calf systems, showing the threshold nature of the response (~420 d) and the trade-offs that exist among income centers within a beef enterprise. For the system simulated mean age at puberty for most breeds seems to be within acceptable limits (Schafer, 1998), and crossbreeding should add a further measure of safety (Gregory et al., 1991). However, certain combinations of genetic types and nutrition may result in unacceptable ages at puberty.

Yearling Conception Rate. As simulated, yearling conception rate is the probability of conception per estrous cycle. Conception probabilities for older cows were held constant (.70). Conception rates shown in Figure 2 correspond to post-puberal estrous cycles. Weight weaned per cow exposed declined with yearling conception rate (Figure 2a), and RGM behaved in a manner similar to age at puberty (Figure 2b). When nonpregnant yearlings were sold, reduced calf income was offset by added income from yearlings, and RGM was relatively stable. At the lowest conception rate (.20), the number of heifers saved increased to 154 and yearlings accounted for 31% of revenues. When nonpregnant yearlings were saved and exposed again as 2-yr-olds, RGM declined with decreasing yearling conception rate, reflecting the added expense and lower efficiency when nonpregnant cows were wintered. Unlike age at puberty, yearling conception rate did not show a threshold response.

Scrotal size also has a desirable genetic correlation with yearling pregnancy rate (Toelle and Robison, 1985; Morris and Cullen, 1994). Because age at puberty is also favorably correlated with yearling pregnancy rate (Morris and Cullen, 1994), it seems likely that the association between scrotal size and yearling pregnancy rate is partially mediated through age at puberty.

Dystocia. For most applications of our simulation model, dystocia (calving difficulty) is simulated from the ratio of birth weight to cow size (Tess and Kolstad, 2000a). However, for this study, simulated changes in dystocia (Figure 3) were accomplished by increasing the probability of dystocia, without changing calf or cow size. Only dystocia rates for first-parity cows were changed.

Cows that experience dystocia have longer postpartum intervals and lower subsequent conception rates (Laster et al., 1973). Calves born with difficulty are much more likely to die (Azzam et al., 1993). Added labor and veterinary expenses are also associated with dystocia (simulated as $16 per occurrence). Means for WWCE and RGM declined as dystocia rates increased, but not as steeply as shown for yearling conception rate. Doubling added costs for dystocia did not change results noticeably, demonstrating that the most important consequence of dystocia is on subsequent reproduction and calf crop. It should be noted that these results do not account for the emotional strain experienced by managers and employees associated with managing herds with high dystocia rates.

Many breeders have successfully reduced calving difficulty by using bulls with low birth weights or low birth weight EPD. Pelvic area also plays a role in dystocia; however, selecting heifers for large prebreeding pelvic area is largely unsuccessful in reducing dystocia rates a year later (Basarab et al., 1993; Cook et al., 1993; Bellows et al., 1996; Colburn et al., 1997). Several reasons contribute to this result. First, measurement of pelvic area at 1 yr of age is not completely accurate in predicting pelvic area at first calving. Second, the genetic correlation between pelvic area and birth weight is positive; hence, cows with larger pelvic openings tend to give birth to heavier calves. Third, selection intensity in replacement heifers is limited, restricting the opportunity to increase mean pelvic area through selection in heifers. Finally, natural variation in birth weight within families makes it impossible to control or predict birth weight precisely. In short, producers do not have absolute control over, nor can they predict, the ratio of cow pelvic area to calf birth weight (Cook et al., 1993). Pelvic measurements can be used to identify extremely small or abnormal pelvic shapes that could be associated with extreme dystocia (Bellows and Staigmiller, 1994). Index selection for increased pelvic area and lower (or constant) birth weight may be effective in improving the maternal components of dystocia (Brinks, 1994).

Genetic trends reported for birth weight have been relatively flat in several breeds, suggesting that breeders have focused seriously on avoidance of calving difficulty (AGA, 1998; AHA, 1998; AICA, 1998; ARAA, 1998; AAA, 1999; ASA, 1999; NALF, 1999). Dystocia incidence and scores are recorded, and EPD for calving ease is computed by a few breed associations (AGA, 1998; ASA, 1999). Although birth weight and dystocia have a strong positive genetic correlation, genetic trends reported for Simmental suggest that calving ease (the opposite of dystocia) can improve without a decrease in birth weight. Basing selection directly on calving ease, rather than on birth weight, should be preferred.

Calving ease as a trait of the dam is not the same trait as expressed by the calf. Genetic correlations between maternal and direct calving ease are small but may be negative (ASA, 1999) or positive (AGA, 1998). Negative correlations suggest that heifers sired by bulls with extremely low birth weight or high calving ease EPD would be at greater risk of experiencing dystocia if selected as replacements. Selection for improved maternal calving ease may be partially mediated through pelvic size (Brinks, 1994).

Postpartum Reproduction

Postpartum Interval to Estrus. Postpartum interval to estrus is controlled by genetic, nutritional, and environmental factors (Short and Adams, 1988). For this study, simulated changes in postpartum interval were accomplished by simply changing the minimum genetic interval. Hence, observed responses were not due to changes in nutritional management or environment.

As postpartum interval increased beyond 70 d WWCE and RGM declined rapidly. Responses for WWCE reflect the fact that number of calves weaned per cow exposed declined, and that because age at weaning decreased, calf weaning weights also declined. When breeding seasons are of fixed length, long postpartum intervals lead to increased numbers of nonpregnant cows, and eventually to systems that are not sustainable. Specific responses for breeding seasons of different length may be different in magnitude from those simulated but are expected to yield similar conclusions.

Conception Rate. Changes in probability of conception for cows $\geq$ 2 yr of age were simulated, leaving conception probabilities for yearlings constant (.70). As cow conception rate decreased WWCE and RGM declined severely, number of heifers saved increased, cow costs per kilogram sold increased, and calf revenues decreased and were replaced by smaller revenues from cull cows. Average cow age declined with conception rate, decreasing calf weaning weight and further reducing profit due to age of dam effects.

Unlike age at puberty, conception rate (i.e., per breeding season) is easy to measure and record, yet data on nonpregnant cows are seldom reported to breed associations (i.e., data for genetic evaluation). Scrotal size has a favorable genetic correlation with lifetime pregnancy rate (Morris and Cullen, 1994), which is influenced by age at puberty, postpartum interval to estrus, and conception rate. Whole-herd reporting offers an opportunity to compute EPD for conception rate directly, which may allow for more rapid genetic improvement than selection based on scrotal size (Evans et al., 1999).

Milk Production. Because postpartum reproduction involves the interaction of genetic potentials for productivity and reproduction with nutrition, changes in milk potential were simulated to demonstrate some of these effects. Nutritionally, milk production places great demands on cows; cows seem to maintain milk yield at the expense of body stores, especially during early lactation when nutrient requirements are greatest (Short and Adams, 1988). Under prolonged negative energy balance actual milk yields fall below genetic potential as body stores are exploited. In the model, postpartum interval to estrus is determined by genotype, calving body condition score, and postpartum weight change (Tess and Kolstad, 2000a).

When nutritional management was left constant, increased milk potential led to reductions in cow body condition, longer postpartum intervals, more nonpregnant cows, and more heifers saved for replacements. Average calf weights increased only slightly with increased milk potential due to declines in average age of dams and calf age at weaning. With no change in management, WWCE and RGM declined severely as milk potential increased (Figure 6).

For comparison, changes in milk potential while simultaneously increasing nutrition (i.e., supplements) were simulated in order to maintain body condition similar to that of cows under the base scenario. Certainly a wide array of choices and costs might be explored as means to supplement highly productive cows; these simulations merely illustrate one such choice. Increased supplementation allowed reproductive rate to remain stable and calf weights to increase. When supplementation was increased WWCE increased with milk potential. However, RGM still declined, though not as steeply, because supplementation increased costs more than revenues.

These results illustrate the delicate balance between productivity and resource cost. Other studies have also shown that increasing genetic milk level in range beef cows is likely to reduce efficiency and profit (e.g., Holloway et al., 1975; Kress et al., 1990; Davis et al., 1994). Genetic trends for maternal milk are positive for most breeds (AGA, 1998; AHA, 1998;AICA, 1998; ARAA, 1998; AAA, 1999; ASA, 1999; NALF, 1999). The range of milk EPD within Angus, for example (95% of population = 10 kg), corresponds to approximately an 8 to 10% increase in milk potential in these simulations (based on simulated changes in weaning weight). Diaz et al. (1992) reported that a single measure of milk production in Polled Hereford × Angus cows increased by approximately 1%/kg sire EPD (Polled Hereford), which would be 2%/kg cow milk EPD, or 1%/kg cow breeding value (i.e., a relationship very similar to that simulated). The degree to which cow nutrition has improved with milk EPD in U.S. beef herds is unknown. However, these results suggest that selecting for increased milk yield in range environments may not be profitable. Current research (M. D. MacNeil, personal communication) offers promise for making a more direct link between maternal milk EPD and nutrient requirements.

As beef production becomes more integrated, systematic, and more closely linked to consumers either through alliances or ownership, producers may be motivated to implement strategies that supply slaughter cattle during all months of the year. Alternatives include multiple calving seasons and slotting weaned cattle on different growth tracks. In range environments, such management systems could accentuate the nutritional stresses associated with postpartum interval to estrus, challenging managers to match forage resources and nutrient requirements.

Soundness. In the simulation model, involuntary culling is a random function, with the probability of culling controlled by model inputs. Hence, involuntary culling rate was changed without changing other performance characteristics. Means for WWCE and RGM declined rapidly with increased culling rates. Higher culling rates increased the number of replacements needed (145 at cull rate = .21) and decreased the number of calves weaned per cow exposed (.86 vs .72 at involuntary cull rates of .01 and .21, respectively). Weaning weights declined as average cow age declined. In the simulations, cows culled for unsoundness were sold at the same prices as other types of cull cows. If defects in soundness were severe enough to reduce salvage values, declines in RGM would have been steeper.

These results illustrate the importance of stayability to enterprise efficiency and profit. Longer productive life spreads cow replacement costs over more output. The fact that genetic trends for stayability are positive for the two breeds associations that compute them (ARAA, 1998; NALF, 1999) suggests that culling decisions of breeders are keyed upon some heritable combination of factors related to length of productive life. Genetic evaluation methods for stayability are becoming more feasible (e.g., Ducrocq and Solkner, 1998). However, stayability is a crude index at best and is surely composed of many traits that may be poorly documented and subjectively measured with nonstandardized scores. In addition to reproductive traits, potential components of stayability include docility, feet and leg conformation, udder conformation, dentition, and fleshing ability. Some breeders are currently scoring cows for some of these traits. Because cows with shorter productive lives leave fewer offspring, there is always some selection for stayability. However, better understanding of the components of stayability (i.e., their genetic control and association with other traits) will improve the effectiveness of selection as a tool to improve productive life.

Additional Considerations

The results reported here demonstrate that several maternal traits, some of which are not routinely considered in selection programs, can have important effects on efficiency and profit. Interactions among traits were not studied here but merit further investigation. For example, it is possible that system responses to increased age at puberty may be larger if yearling conception rate is lower. Similarly, postpartum interval to estrus or dystocia rate may interact with mature cow conception rate. Notter and Johnson (1988), using a model of reproduction, showed that effects of postpartum interval and conception rate on herd calving rate were dependent on previous calving date.

In this study a limited set of maternal traits were evaluated. Other traits may be considered "maternal" because of their association with cow overhead costs or feed use. Cow weight (i.e., maintenance) represents an overhead cost to beef production systems. Dickerson (1970) argued that mature weight, by itself, was of minor consequence. However, Kolstad (1993) found that increases in mature weight (independent of other growth traits) had negative effects on profit. Because size is related to intake capacity, severe reductions in mature weight might also have negative effects. Market targets for carcass weight and yield may play a role in determining mature weight. A balance of mature size with productivity may be implied.

Carcass traits are receiving more attention in breeding programs. Contributing factors include retained ownership and value-based or grid marketing. Several breed associations now compute EPD for carcass traits. One measure of carcass merit is lean yield (percentage of retail product, cutability, and yield grade). In pigs, selection for increased lean yield or reduced fatness has produced correlated negative responses in feed intake in some systems (Webb, 1986). If selection for lean yield in beef cattle decreased intake capacity or appetite in range cows, this could have severe negative effects on efficiency. Correlated responses to selection for carcass yield or quality have not been documented for range production systems. However, estimated genetic correlations between carcass and reproductive traits suggest that selection for lean yield may increase age at puberty (MacNeil et al., 1984), increase dystocia, and decrease calving rate (MacNeil et al., 1984; Splan et al., 1998), whereas selection for increased fatness may improve calving rate.

Emphasis on carcass traits may provide incentives for more producers, especially those with larger herds, to implement terminal crossbreeding systems. Terminal systems allow sires and sire breeds to be selected based solely on growth and carcass traits, ignoring maternal performance (Tess and Lamb, 1992).

Registration statistics indicate that Angus and Angus-derivative breeds represent an increasing proportion of the U.S. herd (Taylor and Field, 1999). Subjective observations in Montana confirm this trend. Presumably, this change is driven by premiums for highly marbled carcasses and breed specifications in alliance programs. Such dominance by one breed may decrease the use of crossbreeding and heterosis. Heterosis is a valuable tool for efficient cow-calf systems and should not be discarded (Davis et al., 1994).

National cattle evaluation is a powerful genetic tool, allowing more accurate estimation of breeding value on thousands of animals. This seems especially important for sires because sires can leave many more offspring than dams. Genetic improvement of maternal traits like those studied here will be largely dependent on the use of superior sires. Currently, EPD for these traits are largely unavailable.

Genetic prediction methods remain highly dependent on performance testing and reporting by breeders. It is probably fair to state that the data reported largely represent traits that can be easily measured and that breeders have some incentive to report. Advances in data management and technology are making data recording and reporting more practical. Procedures to disentangle direct, maternal, and grandmaternal genetic effects are being developed (Dodenhoff et al., 1999; Quintanilla et al., 1999), as well as improved procedures to evaluate traits such as stayability (Ducrocq and Solkner, 1998). Whole-herd reporting offers the possibility of computing genetic evaluations for an increasing array of maternal traits that may be economically very important to commercial producers. Some maternal traits are expressed late in life (e.g., stayability and its components), making genetic evaluation at early ages more difficult. If molecular markers associated with these traits can be identified, inclusion of marker information could permit the genetic evaluation of young animals.

Beef producers manage complex and dynamic production systems. Management decisions often involve compromises between theory and practice, or between competing goals. Management of replacement heifers is one such area of compromise. Kinghorn (1998) has referred to some of these choices as "tactical" vs "strategic" decisions. For example, in some management systems, selecting replacements based on breeding value for weight might lead to lower conception rate simply because genetically superior females might be too young or light to breed as yearlings without excessive expense (BIF, 1996). Management decisions regarding animal performance do not always have genetic consequences. For example, culling of females based on some component of soundness may phenotypically improve the current herd but has little effect on breeding value in the next generation because heritability may be low and selection intensity very weak. In most commercial systems genetic progress is largely accomplished through purchased bulls or semen. Hence, aside from breed composition (due to its implications regarding heterosis), selection and management of heifers based on phenotype may be more profitable than selection based on breeding value.

Implications

In cow-calf production systems, maternal performance traits can have large effects on efficiency and profit. Genetic evaluation of these traits is needed to permit breeders to implement multiple-trait selection. Advances in genetic prediction are important to meeting this goal but will likely depend on whole-herd recording and reporting to be implemented. Management systems targeted to exploit market cycles and(or) consumer preferences may increase performance demands on cows. Understanding the biological mechanisms controlling the expression of genetic differences will be critical to the successful management of these systems.

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Notes

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Table 1. Measures of system performance for selected scenarios[a]

Scenario[b]	MGT[c]	RGM, $/yr	WWCE, kg	CWCE	WWT, kg	NCE	NREP	%YI
Base	A	130,738	201.7	.857	235.3	537.3	74.6	1.7
	B	129,916	201.5	.857	235.1	537.5	69.7	.4
Puberty = 477 d	A	131,281	177.2	.767	231.1	578.4	128.2	22.5
	B	119,607	188.5	.811	232.5	547.0	68.3	.4
Yrlg CR = .20	A	132,586	169.4	.725	233.7	594.5	154.9	30.8
	B	118,640	186.9	.800	233.8	547.7	69.0	.3
Dystocia = .65	A	125,214	194.7	.827	235.1	547.7	88.8	1.7
PPI = 90 d	A	106,092	158.9	.717	221.5	587.6	143.5	3.7
Mat CR = .40	A	109,337	164.9	.717	229.9	580.6	143.8	3.3
Milk = +10%	A	110,665	177.7	.747	238.9	563.4	123.2	2.3
	C	125,800	209.8	.856	245.0	553.6	77.0	1.9
Cull rate = .21	A	112,301	168.0	.719	233.7	575.0	145.4	3.0

[a] Means of 10 replications. RGM = ranch gross margin, WWCE = weight weaned per cow exposed, CWCE = calves weaned per cow exposed, WWT = average calf weaning weight, NCE = number of cows exposed, NREP = number of replacement heifers saved, %YI = percentage of income from yearling heifers.

[b] Base = reference scenario, where age at puberty (PUBERTY) = 357 d, yearling conception rate per cycle (Yrlg CR) = .70, dystocia rate = .15, postpartum interval to estrus (PPI) = 50 d, mature cow conception rate per cycle (Mat CR) = .70, milk potential = 12 kg/d at peak lactation, and involuntary culling rate = .01.

[c] Management systems (MGT): A = open yearlings culled, B = open yearlings saved, C = supplement increased with milk level to maintain cow body condition.

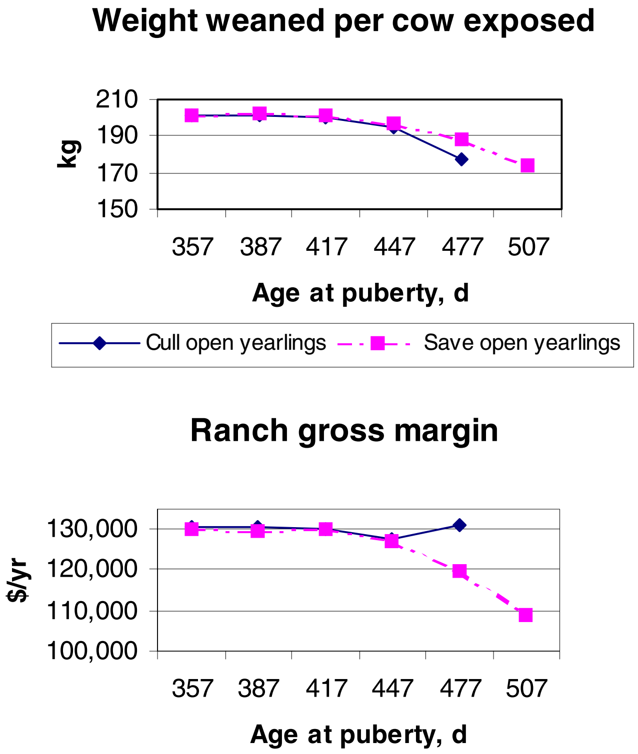

Figure 1. Effects of age at puberty on weight weaned per cow exposed and ranch gross margin under two management scenarios.

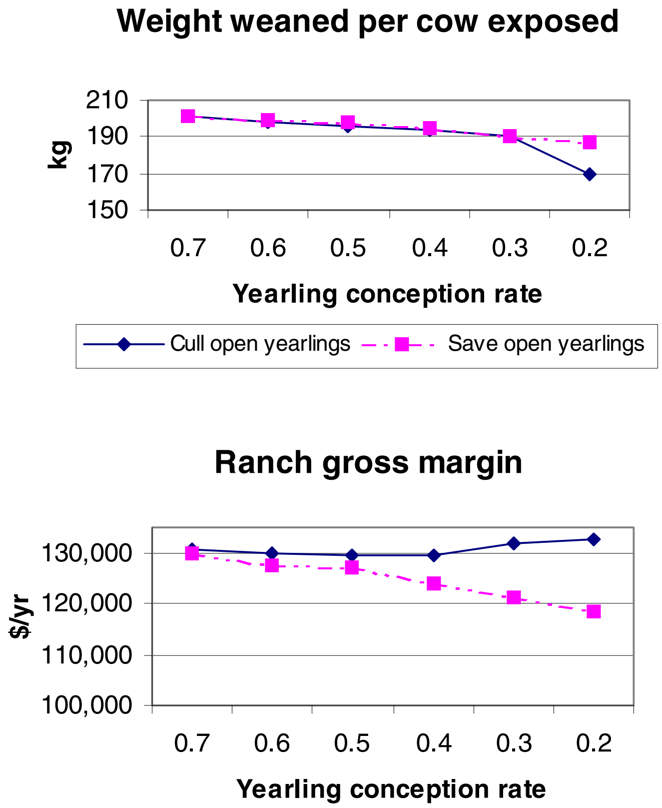

Figure 2. Effects of yearling conception rate per cycle on weight weaned per cow exposed and ranch gross margin under two management scenarios.

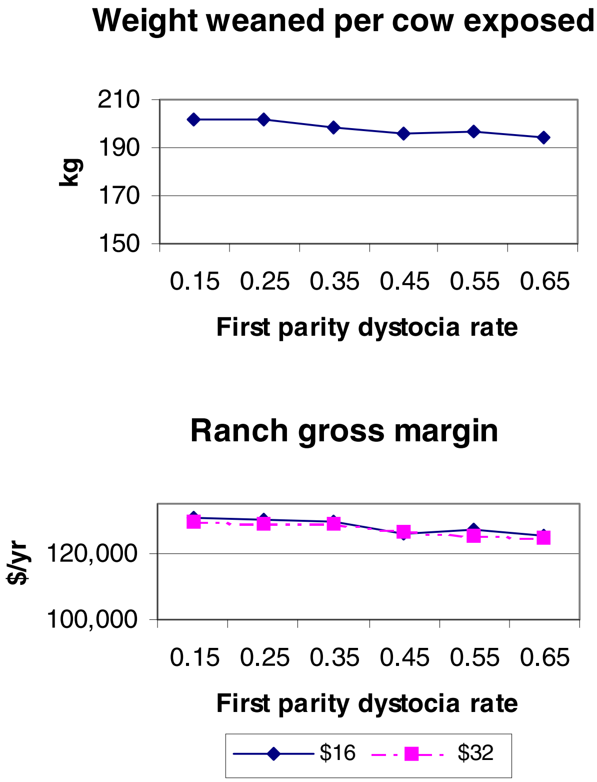

Figure 3. Effects of first parity dystocia rate on weight weaned per cow exposed and ranch gross margin. Added variable cost per incident was either $16 or $32.

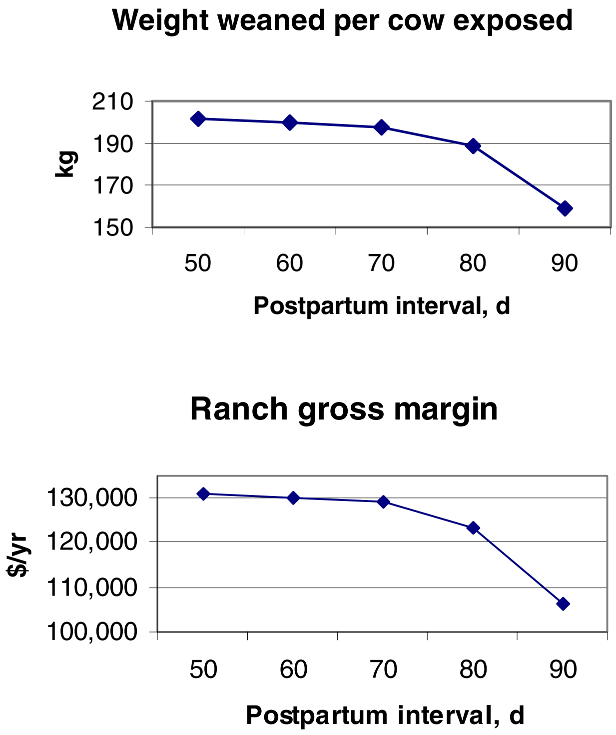

Figure 4. Effects of postpartum interval to estrus on weight weaned per cow exposed and ranch gross margin.

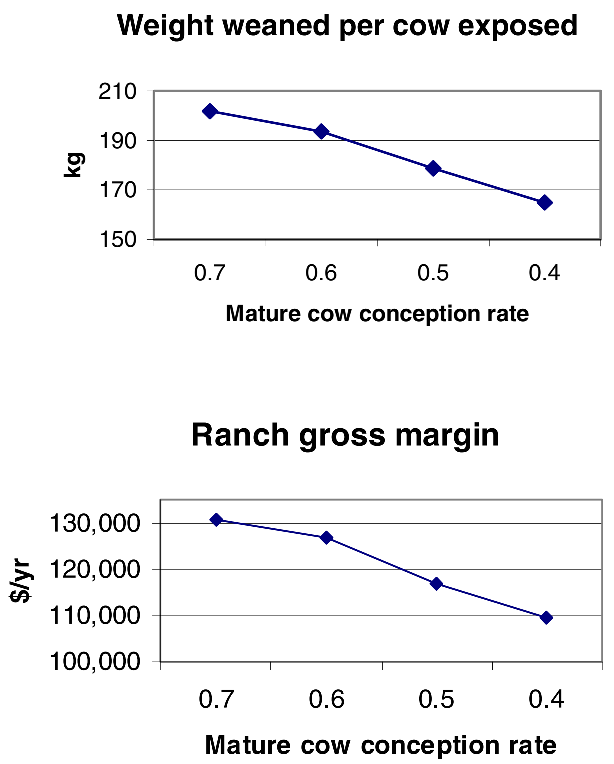

Figure 5. Effects of mature cow conception rate per cycle on weight weaned per cow exposed and ranch gross margin.

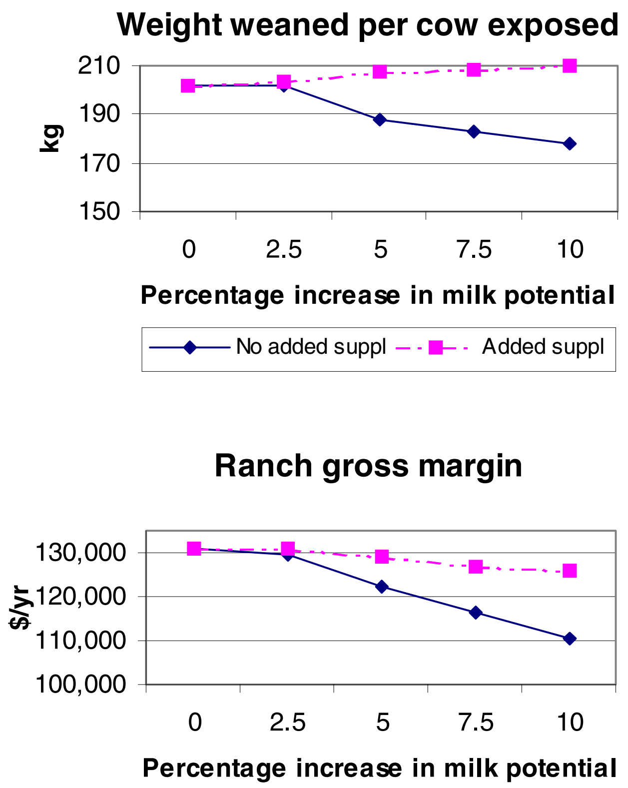

Figure 6. Effects of increased milk yield potential on weight weaned per cow exposed and ranch gross margin under two management scenarios.

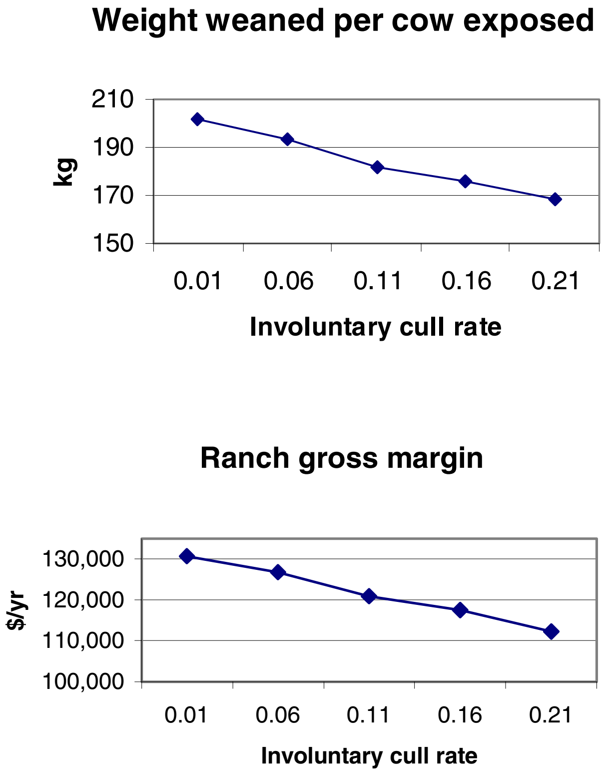

Figure 7. Effects of involuntary cull rate on weight weaned per cow exposed and ranch gross margin.