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HEIFER DEVELOPMENT AND ECONOMICALLY IMPORTANT TRAITS

Andy Roberts
Fort Keogh Livestock and Range Research Laboratory, ARS, USDA, Miles City, MT

Economic Considerations When Selecting and Developing Replacement Heifers

Traits used for selecting replacement heifers and feed resources used to develop replacements can have a major influence on long-term profitability of a cattle operation. The direct expense of either purchasing or developing heifers is often obvious for producers, however, the impact the management system used for rearing heifers and selection criteria have on lifetime productivity is much less obvious and more difficult to assess. Without knowledge of the level and duration of productivity, it is not possible to determine the actual return on the investment made for replacement heifers. The objective of this presentation is to review how nutritional influences during heifer development may affect production cost and longevity, and to provide information concerning potential impacts production traits may have on lifetime productivity.

Feeding Replacement Heifers

When considering how to feed replacement heifers for proper development, most attention has been placed on providing sufficient feed resources during the postweaning period to ensure heifers will attain puberty prior to breeding, with much less concern towards nutritional influences prior to weaning. It is now evident type and level of nutrition a cow is exposed to during pregnancy can have lifelong affects on the calf. In a recent study by Nebraska researchers, providing protein supplement to cows during the winter altered several traits of the calves that the cows were carrying (2006 University of Nebraska Beef Cattle Report). Thus, greater consideration will need to be given regarding the nutritional environment animals experience in utero. What these considerations should be will become more evident in the near future as more results from research into this subject become available.

Concern or attention towards postweaning management of replacement heifers originated several decades ago when producers began to shift from breeding heifers at 2 to breeding them at 1 year of age. Research conducted during the late 1960’s through the early 1980’s established guidelines that replacement heifers should be fed to achieve 60 to 65% of their expected mature body weight by the time breeding starts to ensure attainment of puberty (reviewed by Patterson et al., 1992). The basis behind this recommendation was onset of puberty was determined to be a function of both age and body weight. Thus, a heifer could become pubertal by 14 months of age if she achieved a sufficient body weight. Subsequent research demonstrated the pattern of growth heifers experience prior to achieving a critical target weight could be varied, and therefore provide an opportunity to decrease feed costs by altering rate and timing of gain (Clanton et al., 1983; Lynch et al., 1997; Freetly et al., 2001). While the recommended target weights have served the industry well over time, it appears genetic change in cattle over the last several decades may allow heifers to be developed to lighter breeding weights, while still achieving acceptable breeding rates. In the mid 1980's, researchers identified an association between scrotal circumference in bulls and age of puberty in their female offspring. Since that time, scrotal circumference has been used as an indicator trait for puberty. An appraisal of the change that has occurred in scrotal circumference from 1985 to the present indicates substantial progress has been made, and a similar response in age of puberty would be expected (see breed association web sites for changes over time in EPD for scrotal circumference). Indeed, the inability of heifers to attain puberty prior to breeding may not be as problematic as precocious puberty has become in today's cow herd.

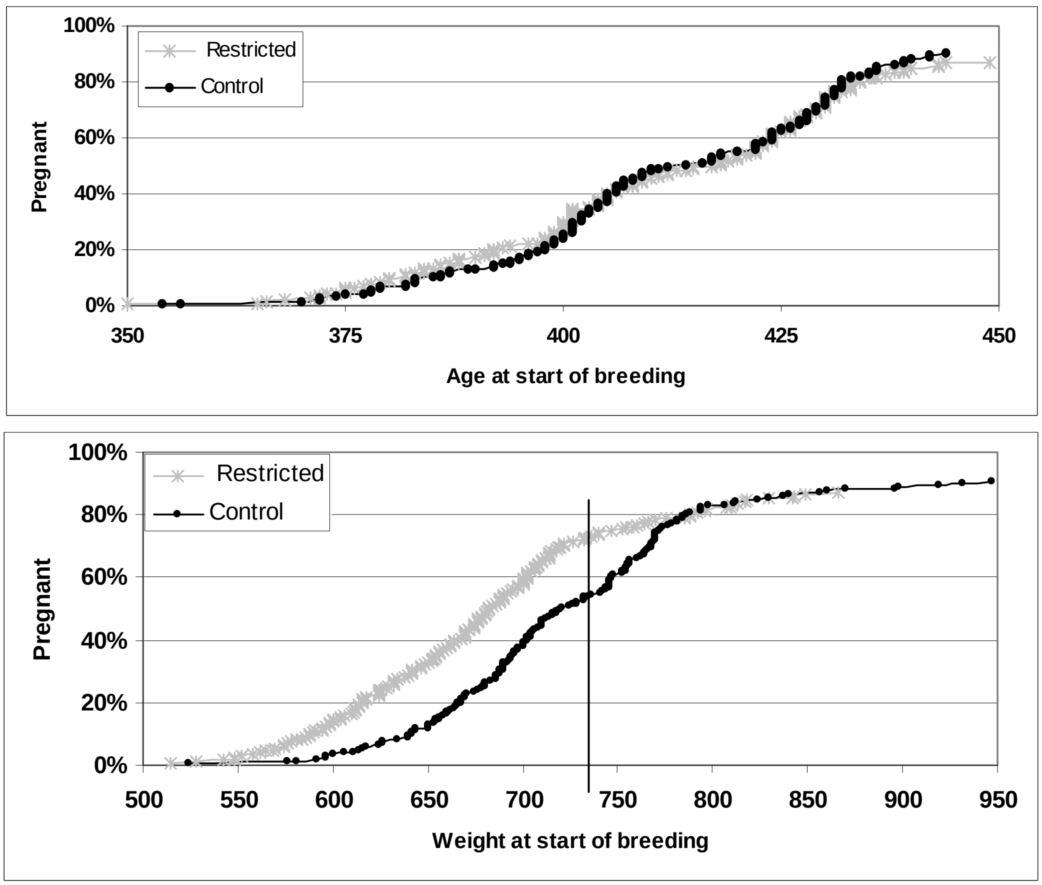

Figure 1. Relationship between age (top panel) and body weight (bottom panel) at the start of breeding (1st week in June) with cumulative pregnancy rate in heifers developed on either ad libitum (Control) or restricted (80% of control at a common body weight) access to feed during a 140-d postweaning period between 1st week of December (approximately 240 d of age) and 3rd week of April (approximately 380 d of age). Vertical line at 730 lbs represents 60 % of mature body weight. See Figure 2 for rate of growth.

Recent research at the University of Nebraska demonstrated reproductive performance was not reduced in heifers developed to begin breeding at between 50 and 55% of expected mature body weight when compared to heifers at about 60% of mature weight (Funston and Deutscher, 2004; Clark et al., 2005). Ongoing research at Fort Keogh evaluating lifetime productivity of heifers developed with either unlimited or restricted access to feed during the postweaning period also supports the potential to reduce target weights when developing replacement heifers (Roberts et al., 2007). As illustrated in the top panel of Figure 1, the association of age at onset of breeding and cumulative pregnancy rate was similar for heifers developed on the two protocols. However, the bottom panel of Figure 1 shows a shift in the association of heifer body weight at the start of breeding and cumulative pregnancy rate, with heifers developed under the restricted protocol being lighter than heifers developed on unlimited access to feed. Based on these observations, it can be concluded age at the beginning of the breeding season was more critical for a successful pregnancy than was body weight.

Average body weights of heifers at time of breeding were very similar between the Nebraska and Fort Keogh studies, as was the type of cattle evaluated (composites approximately ½ Red Angus and ½ continental breeding). In contrast to the Nebraska research, a slight decrease in pregnancy rate (3 to 5%) has been observed in heifers developed under restricted feeding at Fort Keogh (Roberts et al., 2007). Methods used for restricting rate of development differed between Nebraska (fed lower quality diet) and Fort Keogh (restricted amount fed), and this may contribute to difference in reproductive responses observed between studies. After accounting for differences in pregnancy rates between heifers developed on the two levels of feeding at Fort Keogh, the restricted diet resulted in a 22% reduction in harvested feed inputs per pregnant heifer during the 140-d postweaning period. In addition to this decrease in direct cost associated with developing heifers, rearing heifers on limited nutritional inputs resulted in improved efficiency during the winter feeding period and greater rates of gain while grazing after the winter feeding period (Figure 2). These studies indicate an opportunity to decrease cost of production by decreasing amount and/or quality of harvested feeds used for heifer development and improving efficiency. An example of the potential economic advantages of developing heifers under the restricted level of feeding used is shown in Table 1.

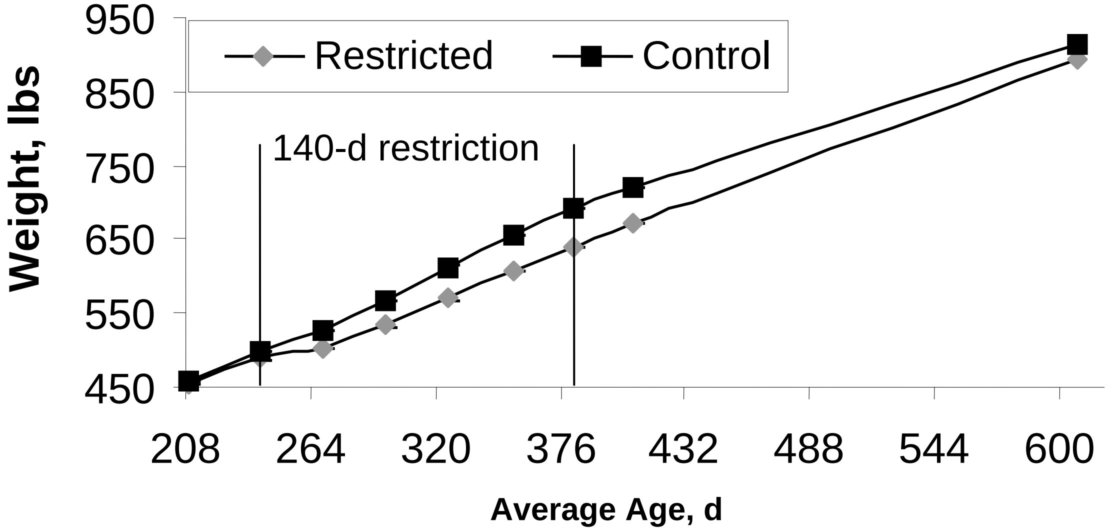

Figure 2. Growth rates of heifers developed on either ad libitum (Control) or restricted levels of feeding during a 140-d period (shown between vertical lines) between weaning and breeding. Restricted fed heifers consumed 27% less feed, had lower ADG (1.14 vs. 1.43 lb/d), and were more efficient during the 140-d period than control heifers. Restricted heifers had greater rates of gain than control heifers (1.13 vs. 1.02 lb/d) during the grazing season after the winter development period. Pregnancy rates were 86 and 90% for restricted and control heifers, respectively. Accounting for this difference in pregnancy rate, restricted heifers consumed 22% less food during the 140-d period per pregnant heifer.

Changing Age Distribution and Longevity

Developing heifers on limited levels of nutrition may also provide advantages in longevity, as suggested for cattle (Hughes et al., 1978) and shown for other species. If ongoing evaluation of longevity in heifers developed under different feeding levels at Fort Keogh substantiates this possibility, then impact on production efficiency will be even greater due to changes in age classifications being replaced (shift from replacing younger to older cows) and/or reduction in overall replacement rate.

Table 2 provides an example of how changing replacement rate from 20 to 15% can influence total lbs. of calf sold. Cows do not reach their maximal production potential until 5 years of age, so changes in the proportion of replacements remaining in the herd beyond 5 years of age further increases level of production and provides more time to recuperate costs of replacement heifers. As shown in Table 2, the cumulative effect of reducing replacement rate from 20 to 15% was an increase of 6.2% in total pounds of calf produced, and a 19% increase in pounds of calf available for sale (i.e., total lbs produced – total lbs retained for replacement). While fewer cull cows would be generated under the 15% replacement rate, net profit from cull cows is expected to improve because the opportunity to reclaim investment cost associated with development of those culls would be greater. In addition, sale weight of young cull cows would be lighter than their respective weights after maturity, and there is little or no price benefit for selling young cull cows as compared to solid mouth mature cows.

Table 1. Economic implications of developing heifers on a restricted level of feeding during a 140-d period between weaning and breeding[1]

	Control	Restricted	Difference (restricted - control)	Cost or savings due to restriction
Final pregnancy rate	90%	86%	-4%	
Weight of heifer calf at time of selection	500	500		
Number calves retained/pregnant heifer[2]	1.10	1.15	0.05	
Pounds retained/pregnant heifer[2]	550	576	26	
Value of calves retained/pregnant heifer, $1.06/lb[2,3]	$583.00	$610.12	$27.12	-$27.12
Weight at fall pregnancy check	916	894	-22	
% open heifers	10%	14%	4%	
Value of open heifer, $0.89/lb[3]	$815.24	$795.66	-$19.58	
Value of open females/pregnant heifer[2]	$81.52	$111.39	$29.87	$29.87
Feed cost				
Per heifer per day, 140-d period	$0.70	$0.51	-$0.27	
Total per heifer, 140-d period	$98.00	$71.75	-$26.25	
Total per pregnant heifer, 140-d period[2]	$107.80	$82.60	-$25.20	$25.20
30 d before breeding, $.70/d/pregnant heifer[2]	$23.10	$24.17	$1.07	-$1.07
6 mo grazing, $16/AUM/pregnant heifer[2]	$105.60	$110.51	$4.91	-$4.91
Savings/pregnant heifer developed under restriction[2,4]				$21.97

[1]Data from Fort Keogh study, see captions of Figures 1 and 2 for details.

[2]Calculations account for differences in pregnancy rates between feeding protocols.

[3]Average of Sept. through Nov. prices for 2000 to 2006 from Montana auction barns.

[4]Minimum feed cost required for a saving under restricted feeding was $0.11/d.

Selection Traits for Replacement Heifers

Reproductive Traits

The example provided in Table 2 demonstrates the impact reducing replacement rate can have on productivity. Indeed, it has been known for numerous decades reproductive performance is the most important aspect affecting production efficiency of a cow-calf enterprise. However, the relatively low heritability of reproductive traits (i.e., less than 0.2), including longevity and stayability, and their difficult measurement requires a long term commitment to make progress in these traits through traditional selection. Crossbreeding can also provide a method for improving reproductive traits and longevity, as heterosis has large effects on lowly heritable traits. As indicated above, scrotal circumference has been used as an indicator trait for fertility and age of puberty, and substantial genetic change has occurred for this trait. However, beyond selling of open females, producers often make selection decisions based on other production and or carcass traits, and simply manage their animals in attempt to maximize reproductive efficiency, by providing sufficient feed to achieve a threshold weight or body condition score, as recommended in the industry. As discussed above, a limitation to this approach is the cost of providing any type of feed has continued to increase over the last several decades, and the recent mandate for conversion of grains into ethanol will further increase prices of all feedstuffs. In addition, this approach actually works against any natural selection for cows best adapted for a particular environment.

Weaning Weight and Milk

For commercial cow-calf producers, selection for weaning weight and or milk production is a logical approach to increase market weight of calves. However, producers need to be aware of genetic associations among the traits being selected and other traits that may drive the cow herd in a direction contradictory to that desired. For example, selection for weaning weight will result in an increase in mature cow size, due to the high genetic correlation between these traits (~0.57). Over time, this will result in increases in feed resources required for development and winter feeding of larger-sized cows to sustain a given level of reproductive performance. In addition, the approach of providing ample feed resources to maximize reproduction fails to allow selection of animals with increased fitness for limited nutrient environments. Similarly, selection for increased milk production results in increased maintenance requirements when cows are lactating as well as between lactations. Failure to adjust management strategies to meet these increased requirements can result in increased reproductive failure (Rogers et al., 2004). Thus environmental conditions under which a producer operates may be working against the genetic progress being pursued. Some approaches to address this problem include 1) use of a crossbreeding system to capture advantages of heterosis for growth and reproductive performance; 2) use of different sires for generating replacements (sires with desired maternal traits) and market calves (sires with desired growth potential); 3) use of a selection index that controls changes in yearling weight or mature weight when selecting for weaning weight; and 4) pursue selection criteria that allow for optimizing reproductive efficiency of the cow herd in the most feasible nutritional management system available. Consider the increase in product produced in the example shown in Table 2 is essentially equivalent to the change expected from a 30 lb difference in EPD for weaning weight or maternal milk.

Table 2. Influence of changing replacement rate from 20 to 15% on cow age distribution and pounds of calf produced for a 100 head breeding herd[1]

	% of Cow Herd		Pounds calf weaned[2]		%
Age Replacement rate:	20%	15%	20%	15%	Change
1	20	15			
2	16	13	7176	5852	-19.5
3	12	12	5681	5388	-5
4	10	10	4914	4918	0
5 &older	42	50	21000	25000	19
Number & lb calf weaned	81	85	38770	41157	6.2
Number & lb replacement	20	15	9585	7241	-25
Pounds of calf to sell			29185	33916	16

[1]Does not account for the reduction in numbers/or pounds of cows sold as culls.
[2]Assuming cows 5 years old and older wean 500 lb of calf, and a conservative estimate of a 20 lb reduction in weaning for every year of age less than 5. Data are not adjusted for differences in weaning weight due to sex of calf.

Carcass Traits

Interest in selection for carcass traits has increased in the last several years due to premiums received for these traits. While there is little doubt these traits affect profit in the industry and impact consumer acceptance of beef, the benefit for commercial cow-calf producers selling in the commodity market is less obvious. For producers who do not retain ownership or don't market calves to feeders who provide premiums based on slaughter data, there does not appear to be support for selecting for these traits. As was discussed for weaning weight and milk production, genetic correlations among carcass traits and other traits influencing the cow herd also need to be considered. In general, positive associations exist for carcass weight and weights at other stages of production and ribeye area and weights at different stages of production. Deposition of intramuscular (marbling) or subcutaneous fat is genetically associated with early maturation (including puberty) and feed intake in a positive fashion, but marbling is negatively associated with yearling weight and ribeye area. Unfortunately, little research is available on genetic associations among tenderness and other traits, due to the limited evaluation of tenderness in the past. This is likely to change in the near future because of the large interest in tenderness and newly available DNA markers for this trait. The primary markers currently available for tenderness measure genetic variation in two genes, an inhibitory (calpastatin) and stimulatory (u-calpain) enzyme of postmortem muscle degradation. While a great deal of research has been conducted concerning the postmortem actions of these enzymes, much less is known about the role these proteins have in the living animal. There is very little evidence genes evolve in animals for the simple reason of altering the texture of their muscles after death. Therefore, some caution should be used in selecting animals based on specific genotypes of these genes until the physiological role of each protein is better understood.

For producers who realize some market advantage from carcass characteristics, three options can minimize undesired changes to the cow herd through genetic antagonisms similar to those described above. One option is multi-trait selection indices to control for changes in genetically associated traits. Another option is using different sires or breeds to generate replacements (sires or breeds with desired maternal traits) and market calves (sires or breeds complementary for carcass traits). It is well established crossbreeding of Continental and British breeds is a very efficient approach to optimize carcass quantity and quality. A third option is placing emphasis on management strategies resulting in desired carcass characteristics. Factors such as early weaning, management in the feedlot and post-slaughter treatments of the carcass may have as much or more influence on carcass characteristics than genetics. Because consumer demand ultimately dictates the demand for beef, both purebred and commercial producers should make a conscientious effort to eliminate cattle with very undesirable carcass traits (i.e., select against animals at the negative extremes for carcass traits).

Efficiency

Although there is great interest in selecting animals for improved feed efficiency, development of an EPD for efficiency has been impeded due to costs and limitations associated with measuring feed intake on an individual animal basis. Currently, most researchers believe differences in maintenance requirements drive much of the differences in efficiency. A few breed associations have developed EPDs for maintenance energy requirement. However, these EPDs are based on average requirements for cows of a specific mature size and level of milk production, and do not reflect an animal's actual variation from the average maintenance requirement. Based on the current interest in efficiency, it is expected true estimates of genetic merit for efficiency will become available for some breeds or animals within a breed in the next several years. Presently, the best measure of efficiency is under debate. Traditional measures of efficiency have included a ratio expressed as units of feed input per unit of product produced (feed conversion) or unit of output per unit of feed input. There are problems with any type of ratio in a selection process, making use of these measures unfavorable. As discussed above, measures of growth (i.e., output) at different physiological stages are genetically associated with each other as well as other traits. Thus, use of these ratios can lead to increased mature size. A selection index including a measure of inputs and a measure of output can be used to overcome the problems associated with the use of a ratio. Another measure of efficiency currently receiving a great deal of attention is residual feed intake (RFI). This measures how much more (positive RFI value, not efficient) or less (negative RFI value, efficient) feed an individual animal consumed to achieve a certain rate of gain compared to the average of the group being tested. One advantage of this measure is little or no association with traits other than feed intake. However, there is debate among researchers as to whether RFI is the best approach for improving efficiency. As indicated above, management approaches can alter efficiency of an animal, at least on a short term basis. These include using differing feeding strategies resulting in body weight differences (maintenance requirements are less for lighter animals) and compensatory responses, such as those described under "Feeding Replacement Heifers."

Summary

The genetic composition and method used for developing replacement heifers can have major impacts on efficiency and lifetime productivity. Nutritional influences on replacement heifers begin in utero and continue throughout life. Genetic changes in age and weight of puberty achieved over the last several decades may provide opportunities to reduce cost of developing heifers by decreasing the industry guidelines for heifer weights at time of first breeding. Developing heifers on lower levels of nutrient input can also improve efficiency and may alter longevity. Although a large number of traits exist for producers to choose from, reproductive traits have the largest influence on productivity in commercial cow-calf enterprises, as these traits culminate in less open cows, older calves at weaning, increased longevity and decreased replacement rate of younger animals. However, feeding to maximize reproductive performance or any other trait may not equate to the most efficient productivity. In this respect, greater efficiency is probably achieved by matching the genetics to the environment rather than altering the management (increase feed inputs) to support changes resulting from genetic selection. Genetic antagonisms exist between desirable traits for market animals and desirable traits for replacement heifers. Crossbreeding and/or terminal breeding systems can result in improved reproductive efficiency and/or allow for differential selection pressure for maternal traits in replacements and growth and carcass traits in market animals.

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NOTES