Extension
University of Missouri

Selection of Replacement Heifers for Commercial Beef Cattle Operations

In order to maintain herd numbers, commercial cow-calf operations must purchase or develop females to replace culled cows. Decisions relative to replacement females are economically consequential for the farm or ranch. Different strategies can be effective for different operations, so options should be considered carefully. Many commercial cow-calf operations find it more economical to purchase bred heifers or even bred cows rather than developing heifer calves as replacements. For other operations, heifer development may be economical, but genetic considerations may favor development of purchased heifers rather than heifer calves produced by the operation. Nevertheless, it remains common to develop an operation's own heifer calves as potential replacements, and these selection decisions should be made with long-term profitability in mind.

Identifying replacement candidates

In most cases, not every heifer calf that is developed as a potential replacement will ultimately be retained. A proportion of the heifer calves are likely to be screened out as unacceptable at some point in the development program. Likewise, some heifers are likely to fail to become pregnant during the breeding period. Moreover, some heifers that conceive simply may not be profitable investments to retain as replacements.

Heifers that conceive later in their first breeding season calve later in their first calving season. As a result, they are more likely to conceive later in their next breeding season or fail to conceive at all. Long-term research efforts have made it clear that heifers conceiving early in their first breeding season stay in the herd longer, wean more total calves due to their longer productive life in the herd, and wean older and therefore heavier calves each year. Until final selection decisions can be made after pregnancy determination, heifers developed for breeding are best considered to be only replacement candidates (Figure 1). As such, a heifer developed as a candidate will only be retained as a replacement if the heifer conceives early and meets other desired selection criteria.

Figure 1. Replacement heifer candidates at the University of Missouri Wurdack Research Center in Cook Station, Missouri.

Time points for screening and selection

If developing heifers from the operation's own calves, an initial screening of replacement heifer candidates should be made prior to sale of calves. For most commercial producers, this screening would occur at weaning or at the end of a preconditioning program. At this time, the goal should not be to identify the most visually appealing heifer calves to retain. Instead, the goal should be to screen out poor heifers that are clearly

Written by
Jordan Thomas, Assistant Professor, Animal Sciences

Figure 2. Heifer calves should be screened post-weaning before being developed further as replacement heifer candidates.

better suited for feeding and finishing rather than for development as potential replacement heifers.

If possible and profitable, it is advisable to develop a large proportion of the heifer calf crop as replacement heifer candidates, in excess of the number ultimately desired to be retained as bred replacements. However, if resources or financial considerations do not allow for the development of such a large number of replacement candidates, more stringent screening criteria with respect to age and genetic merit can reduce the number of heifers developed post-weaning.

Post-weaning screening

Before development as replacement heifer candidates (Figure 2), heifer calves should be screened for soundness, health, disposition, date of birth, and genetic merit.

Soundness, health, and disposition

A heifer calf should not be developed as a replacement candidate if it is structurally unsound, is in poor health, or has an extremely poor disposition. Such heifers are likely to be culled relatively quickly rather than remain in the herd for many years as productive, profitable cows. Note, however, that screening for soundness at weaning is not the same as simply selecting heifers that have the most desired visual appearance. Visual appearance should not be the primary selection criteria in selection of replacement heifers for commercial production. Rather, appearance-based screening prior to development should in most cases be limited to identifying heifers that exhibit extreme unsoundness or other severe problems. Except in rare situations when structural issues are very prevalent in a herd, only a small percentage of the heifer crop is expected to be screened out for unsoundness at this time.

Date of birth

Heifers born early in the calving season are older and of a heavier weight at weaning. Early-born heifers also have higher rates of puberty attainment prior to the start of their first breeding season. As a result, early-born heifers conceive earlier in the breeding season and therefore calve earlier in the calving season. This in turn results in early-born heifers having older and heavier calves at weaning as well as improved reproductive performance in subsequent breeding seasons.

If there is excessive age variation among heifer calves, a long-term solution is to progressively shorten the calving season in the cow herd. A short-term solution is to screen out younger heifers that are less likely to reach puberty prior to the start of the breeding season. Consider designating a day of the calving season as a cutoff by which heifer calves must be born in order to be developed as a replacement candidate. What day of the calving season is feasible for use as a cutoff will vary based on the current productivity level of the herd.

For most producers, an effective strategy is to consider only heifers born in the first half of the calving season for development as replacement candidates. For example, in a herd with a 90-day calving season, only those heifers born in the first 45 days of the calving season would be considered for development. For this purpose, the first day of the calving season can be considered as 285 days (approximate length of gestation) after the start of the previous breeding season. This will likely be later than the actual date on which the first calf was born, due to natural variation in gestation length. In herds with good reproductive performance, a large proportion of the calves should be born in the first half of the calving season. If this is not the case, reproductive management in the cow herd needs to be addressed to increase the proportion of calves born early in the calving season.

Genetic merit

Genetic merit should be a major consideration when selecting replacement heifers. However, consider carefully at what point in the selection process to make screening and selection decisions based on genetic merit. At weaning, screening criteria for genetic merit may help to minimize the number of replacement heifer candidates developed. This may be wise if seeking to minimize costs associated with development and breeding for cash-flow or other logistical reasons.

If genomic testing is performed at or prior to weaning, screening out low-merit heifers based on their genomic test results may be practical (see *At what time point should*

Figure 3. A pre-breeding evaluation is an opportunity to screen replacement candidates prior to continued development and breeding.

I do genomic testing? in the FAQ section). If genomic testing is not performed, the genetic merit of the heifer's sire should be considered. Base considerations of genetic merit on a relevant economic selection index if one is available for the breed(s) in use. This can provide a balanced overview of genetic merit for economically relevant traits. Consider also specific Expected Progeny Difference (EPD) values that are relevant to the operation.

Note that use of artificial insemination in the cow herd at the start of the breeding season can result in the earliest-born heifer calves also having high genetic merit. Therefore, considerations related to birth date and genetic merit can often be complementary.

Pre-breeding evaluation

A prebreeding evaluation of replacement heifer candidates is suggested to be performed 4 to 6 weeks prior to the start of the breeding season (Figure 3). Heifers should again be screened for health, structural problems, or disposition issues that may have arisen during the development period or gone unobserved during post-weaning screening. Additionally, pre-breeding evaluation should include consideration of target weight attainment, reproductive tract score, and pelvic area.

Target weight attainment

When developing replacements, heifers need to reach an adequate target weight to permit attainment of puberty prior to the start of the breeding season. This is commonly expressed as a percentage relative to the mature body weight of a typical cow in the operation (Table 1). Target weight should be treated as the minimum body weight required for an individual heifer rather than as the desired average for the group. If there is significant variation among heifers entering the development phase, it may be necessary to separate heifers into different management groups. This can allow for adequate development of lighter heifers without overfeeding heavier heifers.

The target weight chosen should be based on the breed composition and biological type of the heifers as well as overall goals. Short-term and long-term financials of the farm or ranch should be considered, as the target selected can have a substantial impact on the development costs incurred per replacement retained. A commonly recommended target weight is 65% of mature body weight. However, a lower target weight of 55% can be effective and economical in many cases.

A target weight of 65% of mature weight may involve higher feed inputs but ensures heifers are adequately developed. This target weight is especially encouraged if heifers are known to be later-maturing. Likewise, a target weight of 65% is advisable if stricter screening criteria were used at weaning and a minimal number of heifers are developed. A 65% target weight is also recommended if pre-breeding reproductive evaluations in previous years have suggested that nutritional development was less than adequate in the past.

A lower target weight of 55% of mature weight reduces feed inputs and may place greater selection pressure on heifers for attainment of puberty without these inputs. This target weight is an economical option if heifers are known to be early-maturing and a sufficient number of replacement heifer candidates can be developed without compromising selection intensity. A target weight of 55% may be especially cost-effective if feed costs are high and if heifers that fail to become pregnant can be marketed profitably as feeder heifers. Regardless of whether a 55% or 65% target is used for

Table 1. Example target weight calculations of either 55% or 65% relative to mature cow weight.

Mature cow weight	55% target weight	65% target weight
1000 lbs	550 lbs	650 lbs
1100 lbs	605 lbs	715 lbs
1200 lbs	660 lbs	780 lbs
1300 lbs	715 lbs	845 lbs
1400 lbs	770 lbs	910 lbs
1500 lbs	825 lbs	975 lbs

weight at breeding, ensure that subsequent nutritional development is sufficient. Heifers should be managed to calve at a body condition score of 6 on a 1 to 9 scale. Generally, this involves heifers reaching approximately 80 to 85% of mature body weight prior to calving.

When determining the desired target weight, accurately estimate the mature weight of a typical cow on the operation. If actual weights of cows cannot be obtained, estimate weight of mature cows based on sale weights of cull cows. Because cull cows are often sold in poorer body condition, it is usually necessary to adjust the reported sale weight of cull cows upward for this purpose. One body condition score is approximately 75 lbs. Finally, consider variation among cows in the herd. In herds with widely varied mature cow size, use of a higher target weight of 65% may minimize risk of under-developing heifers.

Reproductive tract scoring

Rather than relying only on weight as an indirect indicator of pubertal status, consider having a reproductive tract score (Table 2) performed by a veterinarian. Reproductive tract scores, ranging from 1 to 5, are a direct evaluation of the reproductive maturity of a heifer via transrectal palpation of the reproductive tract (Figure 4).

Heifers with an infantile reproductive tract score of 1 should be culled. Heifers with a reproductive tract score of 2 are peripubertal and estimated to be over 30 days from reaching puberty. Some producers elect to cull these heifers as well, in order to avoid incurring development and breeding expenses for heifers that are unlikely to become pregnant early in the breeding season. Heifers with a reproductive tract score of 3 are also peripubertal but estimated to be within 30 days from reaching puberty. Such heifers generally respond well to progestin-based estrus synchronization protocols and often have outcomes similar to pubertal heifers. Heifers with a reproductive tract score of 4 or 5 have already reached puberty, with the only difference being the phase of the estrous cycle at the time of the exam. Heifers with a reproductive tract score of 4 were in the follicular phase of the cycle, whereas heifers with a reproductive tract score of 5 were in the luteal phase.

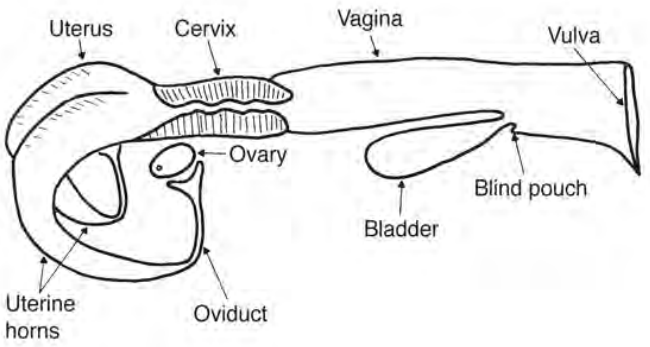

Figure 4. Reproductive anatomy of the cow or heifer; adapted from Rich and Turman, n.d. eproductive tract anatomy and physiology of the cow [Beef Cattle Handbook BCH-2200]. Stillwater: Oklahoma State University.

Reproductive tract scoring is most informative as part of a pre-breeding evaluation performed 4 to 6 weeks prior to the start of breeding. Scores taken before this time are less informative, as a large proportion of heifers likely will not be cycling simply due to age. Likewise, scores taken too close to the start of breeding are less informative, as this gives less time to implement management changes (e.g., changes in nutrition) if reproductive tract scores suggest a problem in the development program.

If planning to use a progestin-based estrus synchronization protocol, a common recommendation is to ensure that over 50% of the heifers have reached

Table 2. Reproductive tract scoring system for pre-breeding evaluation of replacement heifer candidates.

Reproductive tract score	Pubertal status	Ovarian structures	Uterine development
1	Infantile	No palpable structures	< 20 mm diameter, no tone
2	Peripubertal > 30 days from puberty attainment	< 8 mm diameter follicle(s)	20 - 25 mm diameter, no tone
3	Peripubertal < 30 days from puberty attainment	8 - 10 mm diameter follicle(s)	25 - 30 mm diameter, slight tone
4	Pubertal Follicular phase of the estrous cycle	> 10 mm diameter dominant follicle	≥ 30 mm diameter, coiled
5	Pubertal Luteal phase of the estrous cycle	Corpus luteum	≥ 30 mm diameter, distended

Adapted from Anderson et al., 1991, Agri Practice 12(4):123-128.

puberty prior to the start of the estrus synchronization protocol. In other words, 50% of heifers should have a reproductive tract score of 4 or 5 when prebreeding evaluations are performed 4 to 6 weeks prior to the start of breeding. If this is not the case, poorer results with estrus synchronization should be expected, and management and selection practices for heifers may need to be reevaluated.

Lastly, an additional benefit of reproductive tract scoring is that a veterinarian can identify heifers with abnormal or incomplete tracts (e.g., Freemartinism) as well as heifers with treatable conditions (e.g., an ovarian cyst). Likewise, if heifers have been exposed to bulls inadvertently at some point during the development program, heifers that have already become pregnant can be identified.

Figure 5. A Rice pelvimeter commonly used for pelvic measurement; Lane Manufacturing, 2075 South Valencia, Unit C, Denver, CO 80231.

Pelvic measurement

A prebreeding evaluation can also include measurement of the size of the pelvic opening. A veterinarian can measure pelvic area using a pelvimeter (e.g., a Rice pelvimeter; Figure 5). The veterinarian will also place his or her hand inside the rectum to guide the pelvimeter and ensure proper placement. Some experience is necessary for proper placement of the pelvimeter and accurate measurement (Figure 6). The height of the pelvic opening will be measured from the pubic symphysis on the floor of the pelvis to the sacral vertebra at the top of the pelvic opening. To ensure an accurate measurement, the pelvimeter must not slip off of the pubic tubercle ventrad during measurement. Measurements will be reported in centimeters, with height and width measurements multiplied together to calculate pelvic area in square centimeters.

The minimum pelvic area required should be based on an understanding of the mature size of the animal as well as the anticipated birth weight and calving ease of the intended service sire. The pubertal status of the heifer at the time of the exam should also be taken into account when deciding whether to cull or remeasure a heifer at a later date, as pelvic area is smaller before attainment of puberty.

The Show-Me-Select Replacement Heifer Program provides a good example of a standardized expectation and evaluation process for commercial replacement females. In this program, heifers are required to have a minimum pelvic measurement of 150 cm^2 at the time of the pre-breeding exam. If a heifer fails to meet this minimum at the pre-breeding exam, pelvic area can be remeasured at a pregnancy diagnosis performed within 90 days of the start of the breeding season. Pelvic area at that time must be a minimum of 180 cm^2.

Pelvic area is a highly heritable trait and will respond rapidly to selection pressure. However, pelvic area is correlated with overall frame size and mature cow size, and selection of heifers based on large pelvic area is likely to result in selection for larger overall size. Larger overall body size is not desirable for commercial cows from an efficiency perspective, as larger cows have greater maintenance energy requirements and therefore greater year-long feed costs. Unless there is a history of very high rates of calving difficulty among heifers, it is strongly suggested to use pelvic measurement as a screening tool rather than as a selection tool. Therefore, instead of ranking heifers with respect to pelvic area and selecting the heifers with the largest pelvises, simply cull heifers with small or abnormally shaped pelvises. This helps minimize rates of dystocia without inadvertently placing undesired selection pressure on size and frame.

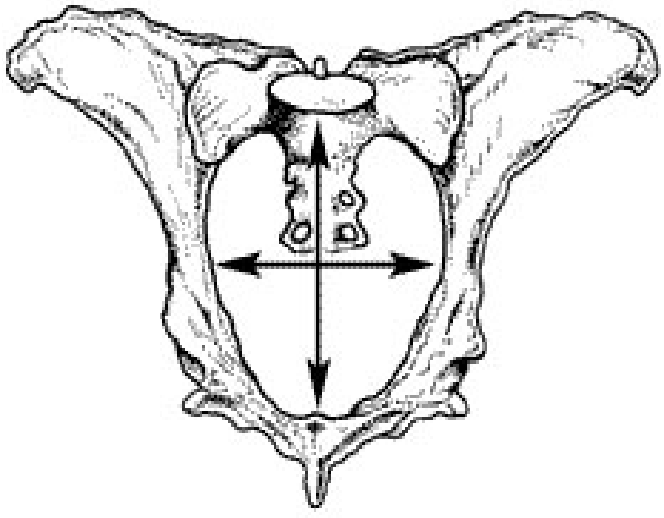

Figure 6. Measurement points for determining height and width of the pelvic opening. Adapted from "Pelvic Measurements for Reducing Calving Difficulty," by Gene H. Deutscher, NebGuide G88-895, of the Nebraska Cooperative Extension Service, University of Nebraska Institute of Agriculture and Natural Resources.

Figure 7. After breeding, pregnancy determination provides an opportunity to select early-conceiving heifers to retain as replacements.

Pre-breeding screening for adequate pelvic area is one important management strategy to minimize incidence of calving difficulty among heifers. However, screening for pelvic area will not eliminate instances of calving difficulty that result from malpresentation. Likewise, there are limitations to the size of calf that can be delivered safely by a heifer. Pelvic screening does not eliminate the need to select service sires with low likelihood of causing calving difficulty. If available, consider the service sire's EPD for calving ease direct (CED). If CED is not reported, the sire's EPD for birth weight should be considered. Additionally, consider using service sires with greater accuracies for CED or birth weight when servicing heifers. One advantage of performing artificial insemination (AI) is that the risk of calving difficulty can be reduced by using high-accuracy calving ease AI sires to service heifers.

Pregnancy determination

Until pregnancy status is determined, all heifers developed are only candidates to potentially be retained as replacements. Selection of replacements ultimately cannot occur until pregnancy status is known (Figure 7). Depending on a number of factors, it is likely that not all heifers have conceived during the breeding period. Additionally, depending on the breeding management, not all bred heifers may be profitable replacements to retain. After pregnancy status is determined, heifers should again be screened for health, structural problems, and disposition issues that may have arisen during the breeding period or may have gone unobserved previously. After screening out problematic heifers, replacements should then be selected. Selection of replacements should be based on their date of conception within the breeding period as well as consideration of genetic merit, dam performance, and visual phenotype.

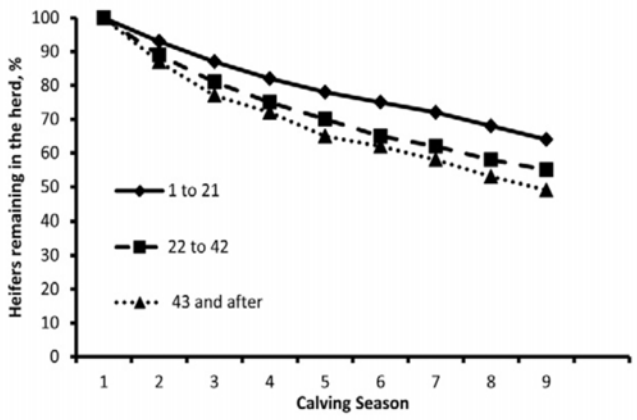

Figure 8. Results from 16,549 heifers at the U.S. Meat Animal Research Center illustrating the relationship between productive longevity in the herd and date of conception during the first breeding season. Heifers that calved in the first 21 days of their first calving season remained in the herd longer as productive cows. Adapted from Cushman et al. 2013, Journal of Animal Science 91:4486-4491.

Date of conception

Ultimately, date of conception within the breeding period is the most important consideration when selecting commercial replacement heifers. Heifers conceiving early in their first breeding season have greater lifetime productivity (Figure 8) and should receive priority when selecting replacements. With this understanding, short breeding seasons for heifers are recommended, unless late-conceiving heifers can be marketed profitably as bred females. If longer breeding seasons are used, an initial pregnancy determination, ideally via ultrasound, should be performed within 90 days from the start of the breeding season. This allows for an accurate determination of fetal age in order to identify early-conceiving heifers to retain as replacements.

Genetic merit, dam performance, and visual phenotype

Of course, genetic merit should also be considered when selecting which bred heifers to retain as replacements. If a sufficiently large number of replacement heifer candidates became pregnant early in the breeding season, this permits more intense selection for genetic merit when deciding which bred replacement heifers to retain. Pregnancy determination is a very cost-conscious time point to submit samples for genomic testing, as only bred heifers considered as potential replacements would need to be tested (see "At what time point should I do genomic testing?" in the FAQ

section). When comparing heifers that became pregnant at similar points in the breeding season and have similar genetic merit, consider also the production records and performance of the heifers' dams.

While data-driven selection for economically relevant traits should take priority in commercial cow-calf operations, there is still a role for phenotypic selection to improve structure, conformation, and visual appearance. These considerations should include feet and leg structure, udder quality, muscling, and other aspects that can be evaluated visually. Some physical characteristics of an animal can also indicate poor adaptation to the environment. For example, poor shedding of the winter hair coat during summer months is associated with lower productivity in most environments. In Missouri operations where the dominant forage base is endophyte-infected tall fescue, producers are advised to cull heifers exhibiting symptoms of fescue toxicosis. These symptoms may include a rough and poorly-shed hair coat, hind limb lameness, loss of the tail switch, excessive time wading in water sources or mud, and general unthriftiness.

Frequently asked questions (FAQ)

How many bred replacement heifers do I need to retain?

If maintaining a constant herd number, the number of replacement heifers retained through calving needs to equal the total number of cows culled, marketed, lost due to death, or otherwise exiting the herd in the last year. Expressed as a percentage, this number is referred to as the annual replacement rate. Annual replacement rate will vary from operation to operation based on age, condition, and reproductive performance of the cow herd. Typical cow-calf operations often assume a replacement rate of around 15% (e.g., 15 bred replacement females for a herd with 100 cows at the start of the breeding season). Of course, additional females will be needed if an increase in herd numbers is desired.

How many heifer calves do I develop as candidates?

This calculation is more difficult, as it will depend on reproductive performance and the intensity of the selection criteria used on the operation. Calculate backwards, starting with the desired number of replacement heifers retained. Consider the anticipated reproductive performance and the anticipated intensity of selection. For example, if 15 bred replacement heifers are required, 60% of the heifer candidates developed are expected to become pregnant by the desired cutoff date of the breeding season, and only the top 70% of the bred heifers will be retained based on selection criteria, approximately 36 heifer calves should be developed.

How do I have enough heifer calves to do this?

If the operation does not have the number of acceptable heifer calves needed based on the calculated replacement rate and assumptions related to screening and selection, carefully assess records to determine the cause. Is poor reproductive performance of cows resulting in an inadequate number of early-born heifer calves? Are calf death losses resulting in low percent calf crop weaned? Are heifer development practices resulting in inadequate numbers of heifers reaching target weight, attaining puberty, or becoming pregnant early in the breeding season? Depending on what management factors are affecting heifer availability, selection criteria of heifers may need to be less strict until these problems are corrected. Alternatively, it may be necessary to source additional heifer calves or simply purchase rather than develop and breed replacements.

At what time point should I do genomic testing?

Genomic test results provide an estimate of the genetic merit of heifers. Therefore, genomic testing of replacement heifers may have value at any point in which genetic merit is considered during the selection process. To generate a return on investment, genomic test results need to be used in the decision-making. If the same heifers will be retained as replacements regardless of test results, rate of genetic progress will not be increased. With this understanding, it is necessary to test more heifers than will be ultimately retained. If investing in genomic testing, thoughtfully consider what proportion of the heifer calves should be tested and at what point in the development process testing should occur.

Consider testing the entire crop of heifer calves before the development of replacement heifer candidates if one or more of the following considerations apply:

- There are profitable marketing options for heifer calves that do not meet the operation's selection criteria
- Genomic test results will enhance the value of marketed heifer calves to prospective buyers
- The operation needs to minimize the number of replacement heifer candidates that enter the development period because of high development costs or for other logistical reasons
- The operation may be able to leverage the genomic test results of heifer calves in the marketing of steer calf mates

Alternatively, consider testing only bred heifers after pregnancy determination if one or more of the following considerations apply:

- The operation has more than a sufficient number of bred heifers that meet other selection criteria, and genomic test results will inform which bred heifers are retained as replacements
- There are profitable marketing opportunities for bred replacement heifers, and genomic test results will enhance the bred heifers' value to prospective buyers

Extension
University of Missouri

Issued in furtherance of the Cooperative Extension Work Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Director, Cooperative Extension, University of Missouri, Columbia, MO 65211 • MU Extension provides equal opportunity to all participants in extension programs and activities and for all employees and applicants for employment on the basis of their demonstrated ability and competence without discrimination on the basis of race, color, national origin, ancestry, religion, sex, sexual orientation, gender identity, gender expression, age, genetic information, disability or protected veteran status. • 573-882-7216 • extension.missouri.edu