TEXAS A&M AGRILIFE EXTENSION

EAN-029 03/21

REPLACEMENT HEIFER SELECTION, DEVELOPMENT, AND REPRODUCTION

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SUMMARY

- Age at puberty influences economic efficiency of beef production through its effects on both age at first calving (2 versus 3+ years of age) and the time that a heifer conceives in her initial breeding season.[1]
  - Heifers of most breeds should have their first calf by 2 years of age.
  - On average, heifers that breed and calve early with their first calf will have higher productivity throughout their lives.
  - Puberty is determined by two things: age, depending on the breed type, and body weight as a percentage of mature weight.
- The risk of re-breeding failure is often highest in 2-year-old, first-lactation cows attempting to breed back for their second pregnancy, especially if their higher nutritional requirements are not met.
  - Nutrient requirements at this age are affected by the interactions of growth, lactation, changing dentition, and a relatively smaller rumen capacity compared to a mature cow.

Age at First Calving (2 versus 3 years) Affects Lifetime Productivity

Heifers that do not calve until they are 3 years old may experience less calving difficulty and wean a heavier calf compared to heifers that first calve at 2 years old.[2] However, total lifetime performance and economic efficiency favor heifers that calve first as 2-year-olds.[2, 3, 4] Also, calving difficulty in heifers of any age can be managed by breeding to lower birth weight bulls. Realize later-maturing Bos indicus—or high-percentage Bos indicus breeds—typically do not reach puberty in time to calve first as 2-year-olds.

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Earliness of Calving Affects Lifetime Productivity

Heifers that become pregnant early in their first breeding season and successfully calve their first calf have been shown to have higher pregnancy rates (Table 1) and weaning weights of calves in later years.[5, 6] Also, early calving heifers have been shown to have increased chances of longevity as cows (Fig. 1) and a higher average lifetime return on investment (Table 2).[6, 7]

Table 1. Calving Period for First-calf Heifers: The Effects on Pregnancy Rates in Later Years[6]

The United States Meat Animal Research Center, 16,549 heifers

Pregnancy	Calving Period 1 n=11,061	Calving Period 2 n=4,372	Calving Period 3 n=1,116
2nd	93	88	84
3rd	93	90	80
4th	94	92	91
5th	94	92	89
6th	94	93	93

Table 2. Period of First Calving: The Effects on Lifetime Average Return on Investment per Female[7]

	1st 21 days	2nd 21 days	3rd 21 days	4th 21 days
Herd 1	14.8%	10.4%	4.7%	8.6%
Herd 2	(-3.2%)	(-10.3%)	(-12.4%)	(-11.2%)
Herd 3	9%	(-1.3%)	(-16%)	(-9%)
Herd 4	18%	9%	3%	(-10%)
Herd 5	14.7%	2%	6%	6%

*Data taken from five commercial herds and includes approximately 1500 calves from females that calved annually throughout their life.
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[1]Day & Nogueria, 2013
[2]Nunez-Dominguez, Cundiff, Dickerson, Gregory, & Koch, 1991
[3]Chapman, Young, Morrison, & Edwards, 1978
[4]Morris, 1980
[5]Lesmeister, Burfening, & Blackwell, 1973
[6]Cushman, Kill, Funston, Mousel, & Perry, 2013
[7]Sprott, n.d.

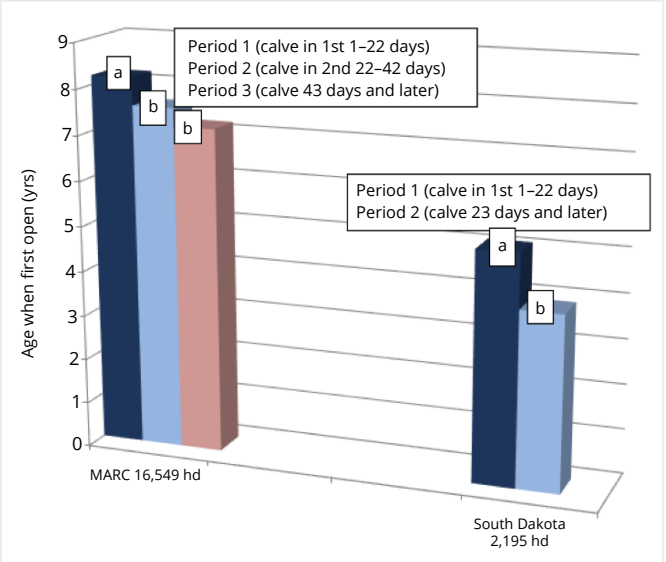

Figure 1. Calving Period for First-calf Heifers: The Effects on Age When First Open in Later Years

Heifer Selection

Most producers select replacement heifers sometime between weaning and the end of their first breeding season. Selection based solely on appearance is not well related to fertility. "Eye appeal" is not related to physiology and is often just one person's opinion.

Selecting heifers at weaning. If heifers are selected at weaning, age is no doubt the most useful criteria. Selecting heifers born in the first half of the calving season results in more mature animals that will require less time to reach puberty when compared to younger herdmates. Thus, calving records—the actual date, or at least the period within the calving season (early, middle, or late)—are the best way to identify these more mature animals. Some producers with extensive or remote pastures may not be able to observe cows during the calving season and may not know the ages of their heifer calves. If they select replacements at weaning, they usually just keep the biggest or heaviest, expecting them to be the oldest, which they often are. However, over time, selecting bigger heifers at weaning can subsequently lead to bigger cows. A correlation of 0.67 to 0.85 between these two traits has been reported.[8] Moderate cow size is necessary for many environments.

Genomic testing of calves to predict their future fertility and overall performance as cows is an emerging technology. Currently, it is limited to the Black Angus breed because of the large database required (GENEMAX®, Zoetis).

Selecting heifers as yearlings. Some producers simply keep a large number (or all) of their heifers at weaning and select replacements from those that get pregnant after their first breeding season. This does add significant cost to development because more heifers than are needed for replacements are being kept and managed. However, the added value of selling surplus heifers that are heavier and/or pregnant as yearlings has the potential to mitigate the extra development cost.[9] This strategy allows pregnancy to be the initial basis for selection.

Selection for puberty and/or early pregnancy. Heifers that have had one or more estrous cycles before, rather than during, their first breeding season have been reported to have higher pregnancy rates both as yearlings and again as 2-year-olds (Table 3).[10] Some strategies used to identify these kinds of pubertal heifers—and to refine the selection process among those that are pregnant—are discussed below.

One strategy is to use a short 45-day breeding season, either with or without artificial insemination (AI). Pregnancy rates will likely be somewhat lower than with longer 60- to 90-day breeding seasons, so plan on retaining an extra 20 to 25 percent more heifers. Heifers that become pregnant are fertile and are set up to begin their reproductive careers as early calvers, the importance of which has been discussed. Open heifers have added value due to older age and heavier weights.

Table 3. The Impact of the Number of Estrous Cycles Exhibited Prior to the Start of Breeding and Reproductive Performance of Heifers[10]

	Number of estrous cycles before the start of breeding				
	0	1	2	3	4
Heifers first season, n	395	205	211	116	249
Weight before start of breeding (lb)	671^{a}	702^{b}	702^{b}	715^{bc}	715^{c}
Age at start of breeding in days	420^{a}	426^{b}	426^{b}	426^{b}	430^{c}
First-season heifer pregnancy percentage	**84^{a}**	**90^{b}**	**88^{b}**	**89^{ab}**	**94^{b}**
Start of breeding to calving, days	300^{a}	296^{b}	295^{b}	295^{b}	296^{b}
Weight of calves at weaning (lb)	396^{a}	411^{b}	414^{b}	416^{b}	405^{b}
2-year-old cows, second season pregnancy percentage	**73^{a}**	**85^{b}**	**79^{b}**	**90^{c}**	**92^{c}**

Means within a row without a common superscript differ (P <.05)

Pregnancy testing shortly after the end of longer breeding seasons by a skilled individual using either ultrasound or palpation is another way to identify and select early breeders. Another alternative is to blood test all heifers 30 to 50 days into the breeding season. Those identified as pregnant by blood test will have been bred in the first

[8]Kaps, Herring, & Lamberson, 1999
[9]Carpenter & Hogan, 2018
[10]Adapted from Roberts, Ketchum, Funston, & Geary, 2013

30 to 40 days. A second pregnancy test of negative heifers is required at a later date to identify both later-bred and open animals.

Using estrous synchronization (ES) at the beginning of their first breeding season, either with AI or natural bull service, identifies pubertal animals because the response to ES treatment is dependent on puberty. Therefore, pregnancy to first synchronized estrus signifies both an animal that was already cycling prior to the breeding season—or very close to it—and an animal that is fertile. That is, she was able to conceive at her first breeding opportunity, and she is now set up to begin her reproductive years as an early calver. Using a blood pregnancy test in first-calf heifers at day 30 post-AI is one way to determine conception to AI versus clean-up bulls. To do this, wait to turn in clean-up bulls until day 14 after a single AI mating. Then, blood test all heifers at day 30 post-AI. Only those that conceived to AI (early breeders) will test positive for pregnancy at this stage. All other heifers testing negative at this stage are either pregnant by clean-up bulls or open. Again, all animals in the negative group will need to be pregnancy tested again at the end of that breeding season.

Not all producers are able to use AI. Still, giving a single shot of Prostaglandin $F2_{\alpha}$ (PG) and using a natural bull service on the first day of the breeding season is a well-known and inexpensive way to group cycling females to calve early, as most cycling females will come into heat within 4 days of the shot. However, a small percentage will be unable to respond to that treatment because they are in a stage of their estrous cycle where they do not have a functional corpus luteum on the ovary. Waiting 4 days after turning the bull(s) in to give PG shots is a strategy that may increase the opportunity to identify all—rather than most—pubertal heifers and, therefore, increase the opportunities for early pregnancy in response to that protocol among all pubertal animals.[9, 11, 12] A word of caution: Do not administer prostaglandin **after** day 4 to 5 of bull exposure, as it can cause abortions after this time. Blood pregnancy testing all animals at day 40 of the breeding season can identify those that conceived to natural bull service in the first 12 days and were, therefore, pubertal before the start of the breeding season. Again, the benefits of early puberty, early conception, and early calving have been described.[5, 6, 10] All animals that tested negative for pregnancy at day 40 will need to be re-tested for pregnancy after the end of the breeding season as would normally be done.

Reproductive tract scoring (RTS) has been used to identify mature and pubertal heifers just prior to their first breeding exposure.[13, 14] Additionally, it might be a useful tool to manage even lifetime reproductive performance.[14] RTS is a heritable trait, with an estimate of 0.32.[14] Heifers with higher RTS just prior to their first breeding season had higher pregnancy rates both as yearlings and again as 2-year-olds. In turn, these heifers calved earlier, and because of that, weaned heavier calves.[14] Age, body weight, and body condition score are all positively associated with RTS, and among these three, age was the most highly associated.[14] The main limitation to using RTS to predict puberty, in many areas, is finding qualified people who can palpate and/or ultrasound and then score the reproductive tract accurately (cervix, uterus, and ovarian structures).

Finally, predicting the number of replacements needed is related to culling rate in the cowherd. Cows are culled for reproductive failure, unsoundness, temperament, old age, drought, and other reasons. Overall cull rate and age makeup of the cowherd will thus be a consideration when estimating replacement heifer needs. Under good management, one might reasonably expect an 85 percent pregnancy rate in yearling heifers being bred for their first calf. Under that scenario, heifer retentions would likely need to be about 15 percent higher than whatever the predicted cowherd replacement rates are.

[11]Whittier, Caldwell, Anthony, Smith, & Morrow, 1991
[12]Larson, Musgrave, & Funston, 2009
[13]Anderson, LeFever, Brinks, & Odde, 1991
[14]Holm, Thompson, & Irons, 2009

Heifer Growth, Development, and Puberty

As stated, heifers of most breeds should have their first calf at 2 years old. Puberty is determined by age and weight in concurrence. After weaning, heifers are grown and developed to reach a "target" age that is based on their breed type and an estimated "target" weight for the first breeding. Research conducted during the late 1960s through the early 1980s indicated that puberty occurs at a genetically predetermined weight. Only when heifers reach their target weight can high pregnancy rates be obtained. Age targets are 12 to 14 months for English breeds such as Angus and Hereford, and 15 to 16 months for Continental breeds, such as Charolais or Simmental, and American breeds like Brangus or Beefmaster. Straight-bred or predominantly Bos indicus breeds typically reach puberty later and are usually not bred until they are 2 years old in order to calve first as 3-year-olds. The target weight is usually 60 to 65 percent of "expected" mature weight. Some research has reported that heifers developed to lighter target weights (50 to 57 percent of mature body weight) or those that were fed restricted diets were able to reach puberty and breed at acceptable rates.[15, 16, 17, 18] It should be noted that in studies that used mature cow weight, these weights were estimated from extensive databases and were essentially a "known" factor. Most producers can only guess what expected mature cow weight is, given the variation in mature cow weight within most herds. Target weight as a percentage of actual expected mature weight can be difficult to predict accurately. Therefore, the 60 to 65 percent rule probably offers some "insurance" when estimates of mature weight may be off.

If producers are interested in measuring and managing weight gain during development, one methodology might be:

1. Obtain individual heifer body weights at weaning;
2. Determine the correct target age and weight at first breeding for puberty;
3. Calculate the number of days between weaning and first breeding;
4. Calculate the needed average daily weight gain needed to reach the target weight (target weight–weaning weight/number of days);
5. Check-weigh heifers midway through the development phase (some might even prefer to weigh heifers every month); and
6. Adjust the feeding program if weight gain is too low.

[15]Funston & Deutscher, 2004
[16]Funston, Martin, Larson, & Roberts, 2012
[17]Roberts, Geary, Grings, Waterman, & MacNeil, 2009
[18]Endecott, Funston, Mulliniks, & Roberts, 2013

Research has shown that it does not matter if heifers grow at an even weight gain (the same amount each day) or at an uneven rate (low to high or high to low), as long as they arrive at the correct target weight for puberty.

Some producers may begin breeding yearling heifers 21 days prior to the start of breeding for their mature cows. In some environments, this may increase the chances of re-breeding as 2-year-olds. The trade-off is that there will be 21 fewer days to reach target weight for their first breeding as yearlings.

In summary, nutritional management of heifers is critical between weaning and the first breeding season. It can also be a factor during pre-weaning as well. Therefore, it is the overarching factor that influences age at puberty in heifers.[1] Nutrition is similarly critical prior to and after the birth of their first calf in order for successful re-breeding to occur.

BIBLIOGRAPHY

Day, M. L., and G. P. Nogueira. "Management of age at puberty in beef heifers to optimize efficiency of beef production." *Animal Frontiers* 3, no. 4, (2013): 6–11.

Nuñez-Dominguez, R., L. V. Cundiff, G. E. Dickerson, K. E. Gregory, and R. M. Koch. "Lifetime production of beef heifers calving first at two vs three years of age." *J. Anim.* Sci. 69, no. 9, (1991): 3467–3479.

Chapman, H. D., J. M. Young, E. G. Morrison, and N. C. Edwards, Jr. "Differences in lifetime productivity of Herefords calving first at 2 and 3 years of age." *J. Anim.* Sci. 46, no. 5, (1978): 1159–1162.

Morris, C. A. "A review of relationships between aspects of reproduction in beef heifers and their lifetime production: 1. Associations with fertility in the first joining season and with age at first joining." *Anim. Breed. Abstr.* 48, no. 10, (1980): 655–676.

Lesmeister, J. L., P. J. Burfening, and R. L. Blackwell. "Date of First Calving in Beef Cows and Subsequent Calf Production." *J. Anim.* Sci. 36, no. 1, (1973): 1–6.

Cushman, R. A., L. K. Kill, R. N. Funston, E. M. Mousel, and G. A. Perry. "Heifer calving date positively influences calf weaning weights through six parturitions." *J. Anim.* Sci. 91, no. 9, (2013): 4486–4491.

Sprott, L. R. Unpublished data.

Kaps, M., W. O. Herring, and W. R. Lamberson. "Genetic and environmental parameters for mature weight in Angus cattle." *J Anim* Sci. 77, no. 3, (1999): 569–574.

Carpenter, B. B., and R. J. Hogan. "Rangeland heifer development strategies." *Proc. Appl. Repro. Strategies in Beef Cattle.* https://beefrepro.org/wp-content/uploads/2020/09/Carpenter-Rangeland-Heifer-Development-Strategies.pdf

Roberts, A. J., J. Ketchum, R. N. Funston, and T. W. Geary. "Impact of number of estrous cycles exhibited prior to start of breeding on reproductive performance in beef heifers." Western Section of Animal Science Proceedings. *J. Anim.* Sci. 64, (2013): 254–257.

Whittier, J. C., R. W. Caldwell, R. V. Anthony, M. F. Smith, and R.E. Morrow. "Effect of a prostaglandin F2α injection 96 hours after introduction of intact bulls on estrus and calving distribution of beef cows." *J. Anim.* Sci. 69, no. 12, (1991): 4670–4677.

Larson M., J. A. Musgrave, and R. N. Funston. "Effect of estrus synchronization with a single injection of prostaglandin during natural service mating." Paper 527. 2009 *Nebraska Beef Report.* (2009): 10–11.

Andersen, K. J., D. G. LeFever, J. S. Brinks, and K. G. Odde. "The use of reproductive tract scoring in beef heifers." *AgriPractice* 12, no. 4, (1991): 19–26.

Holm, D. E., P. N. Thompson, and P. C. Irons. "The value of reproductive tract scoring as a predictor of fertility and production outcomes in beef heifers." *J. Anim.* Sci. 87, no. 6, (2009): 1934–1940.

Funston, R. N., and G. H. Deutscher. "Comparison of target breeding weight and breeding date for replacement beef heifers and effects on subsequent reproduction and calf performance." *J. Anim.* Sci. 82, no. 10, (2004): 3094–3099.

Funston, R. N., J. L. Martin, D. M. Larson, and A. J. Roberts. "Physiology and endocrinology symposium: Nutritional aspects of developing replacement heifers." *J Anim* Sci. 90, no. 4, (2012): 1166–1171.

Roberts, A. J., T. W. Geary, E. E. Grings, R. C. Waterman, and M. D. MacNeil. "Reproductive performance of heifers offered ad libitum or restricted access to feed for a one hundred forty-day period after weaning." *J. Anim.* Sci. 87, no. 9, (2009): 3043–3052.

Endecott, R. L., R. N. Funston, J. T. Mulliniks, and A. J. Roberts. "Implications of beef heifer development systems and lifetime productivity." *J. Anim.* Sci. 91, no. 3, (2013): 1329–1335.