BEEF HEIFER DEVELOPMENT AND LIFETIME PRODUCTIVITY[1]

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Introduction

The heifer development paradigm is adapting to less traditionally inexpensive feed available and changes in cattle genetics over the last 40 years, making it critical to understand how management practices affect lifetime production efficiency. Increased feed costs have negatively impacted heifer development protocols that rely heavily on harvested feeds. Much of the research leading to the paradigm of developing heifers to a target BW of 60 to 65% mature BW at breeding was conducted during the late 1960s through the 1980s. However, trait selection based on EPDs has created substantial genetic change in the last 40 years. This impact of genetic change on heifer development has not been widely considered. Research in the last decade has compared traditional, more intensive systems with systems using less feed and relying on compensatory gain. These studies provide evidence that developing heifers to a lighter target BW at breeding, that is, 50 to 57% of mature BW compared with 60 to 65% BW, reduced development costs while not impairing reproductive performance (Funston and Deutscher, 2004; Roberts et al., 2009; Funston and Larson, 2011; Mulliniks et al., 2012). However, much heifer development research is limited in its consideration of long-term applications. Longevity has a relatively low heritability; thus, heifer development and other management strategies have a greater potential to impact cow retention in the breeding herd. While limited information exists about the impacts of heifer development strategies on cow longevity, data from non-ruminant and non-livestock species implies that limiting caloric intake during juvenile development can increase lifespan (Speakman and Hambly, 2007).

Heifer Development System and Pubertal Status

Association among BW, puberty, and heifer pregnancy rate appears to have changed over time (Funston et al., 2012). Earlier research demonstrated limiting postweaning growth negatively affected age of puberty and pregnancy rates, whereas more recent studies demonstrate less of a negative impact of delayed puberty on pregnancy rate. Funston et al. (2012) hypothesized that changes over time may have resulted from:

1) the shift from calving heifers at 3 yr of age to calving at 2 yr of age and subsequent

[1]Adapted from Endecott et al. (2013).

selection pressure for decreased age at puberty;

2) genetic changes in age of puberty resulting from selection for bull scrotal circumference; and
3) perhaps a change in fertility of pubertal estrus compared with subsequent estrous cycles.

Other factors may also contribute to the change over time. Establishment and use of EPDs in selecting for growth, milk, and carcass characteristics have contributed to changes in reproductive performance due to genetic associations with these and other traits (American Angus Association, 2012; American Hereford Association, 2014; American International Charolais Association, 2014). For example, genetic trend for increased mature weight would be expected to correspond with an increase in BW at puberty. Results summarized in Figure 1 illustrate that BW at time of puberty has increased over time. Although information concerning mature size is not provided in most studies represented in Figure 1, the progression from a mature size of 1,100 lb in the initial studies to 1,300 lb in the most recent studies may be reasonable. Even though different management and feeding practices were implemented within and among studies summarized in Figure 1, the data indicate a majority of heifers would achieve puberty at or below 60% mature BW, assuming mature BW of 1,100; 1,200; or 1,300 lb for heifers used in the 3 time periods. Data in Figure 1 also indicate average age of puberty was prior to 430 d of age, which would correspond to the start of breeding in order to begin calving at 2 yr of age. Furthermore, it is expected that selection and management processes implemented over time have contributed to a greater proportion of heifers achieving puberty at lower target BW.

Fertility of the pubertal estrus is another component of the heifer development paradigm that needs to be reevaluated. Industry recommendation that heifers be developed so they experience puberty prior to start of breeding is derived from results of Byerly et al. (1987) who observed 21% lower pregnancy rate in heifers bred on their first estrus compared with heifers bred on their third estrus. However, mean age and BW of heifers at the time of breeding were confounded by estrus status classification. Mean age at breeding for heifers bred at first estrus was 322 d, whereas heifers bred on third estrus averaged 375 d old. Furthermore, age of breeding accounted for increased pregnancy in heifers classified to be bred at first estrus, but not in heifers assigned to be bred on the third estrus. Thus, the implications of data from the first estrus group bred at an average age of less than 11 months for the industry where the majority of heifers would traditionally be bred 13 to 15 mo of age is questionable. Recently, research reported 6% lower pregnancy rates in heifers that were not pubertal at the start of the breeding season compared with heifers that were pubertal (Roberts et al., 2013; Vraspir et al., 2013). Although these results are not a direct assessment of first estrus fertility, the results indicate the magnitude of infertility is not near the extent indicated in the original study by Byerly et al. (1987).

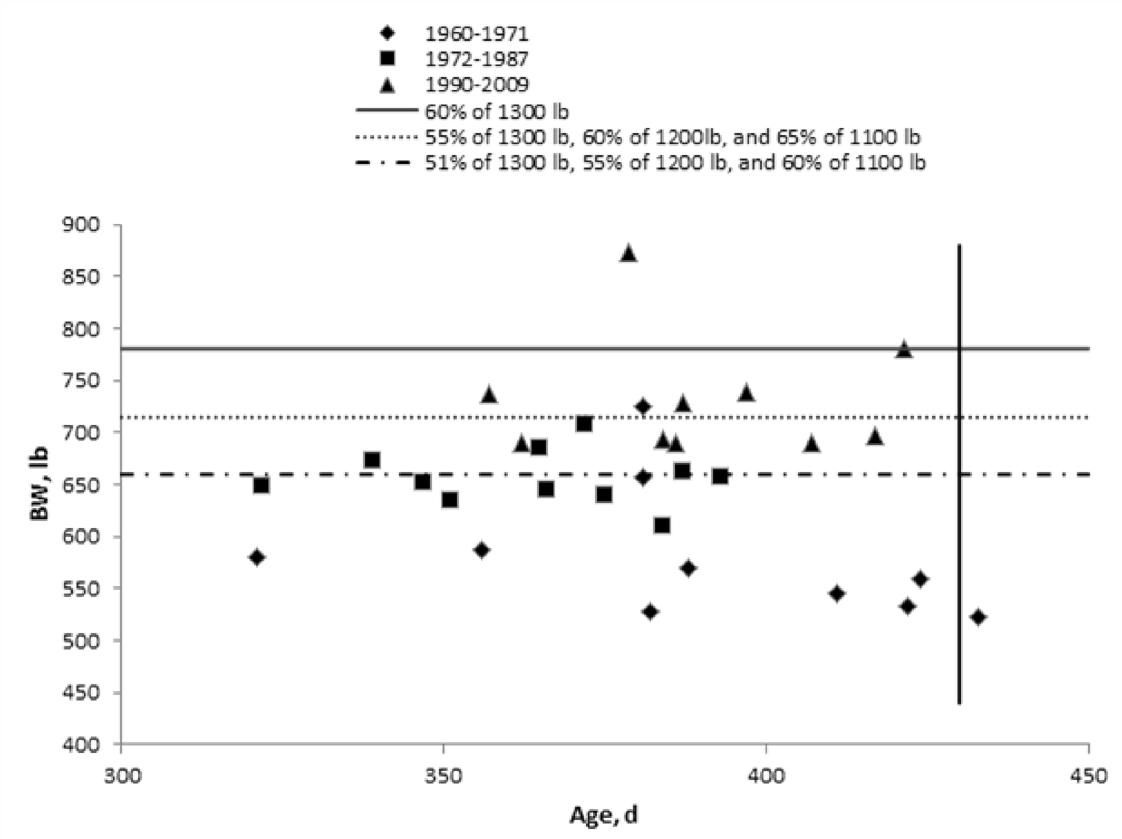

Figure 1. Body weight (BW) and age of heifers at puberty in studies over the last 5 decades where heifers were developed on 2 or more levels of growth during the post weaning period. Data from 1960 to 1971 are depicted with black diamonds (Wiltbank et al, 1966 and 1969; Short & Bellows 1971). Data from 1972 to 1987 are noted with black squares (Ferrell, 1982; Greer et al., 1983; Byerly et al., 1987). Data from 1990-2009 are shown as black triangles (Hall et al., 1995; Lynch et al., 1997; Freetly et al., 1997; Ciccioli et al., 2005; Roberts et al., 2009). The data indicate that BW at puberty has increased over the time periods that different studies were conducted. Horizontal lines represent BW representing 60, 55, and 51% of 1,300 lb mature BW; 60 and 55% of 1,200 lb BW; and 65 and 60% of 1,100 lb BW. The black vertical line at 430 d of age represents the age to start breeding in order to calve at 2 yr of age. Not all heifers achieved puberty in the time frame encompassed by some of the studies depicted. However, the data indicate genetic potential of heifers under different management strategies to achieve puberty at or below 60% of a mature BW predicted to be representative of cows for each time period.

Nutrition Following the Start of Breeding and Through Subsequent Calvings

Establishing impact of heifer development protocols on longevity is complex, requiring consideration for nutritional factors following the start of breeding through subsequent calvings. Resulting maintenance requirements and behavior traits associated with development protocols must be considered. Most longer-term heifer development studies manage replacement heifers as a group on breeding pastures after development. Heifers developed under conditions of dormant or scarce forage, low precipitation, undulating terrain, and large pastures, or those that are restricted gain, pen-developed often exhibit compensatory gain during summer grazing (Olson et al., 1992; Roberts et al., 2009; Funston and Larson, 2011; Mulliniks et al., 2012). Examples of this include comparisons of heifers developed in a drylot at 1.52 lb/d ADG from initiation of the study to breeding with heifers developed at 0.57 lb/d on a low-quality pasture with protein supplementation (Mulliniks et al., 2012). Development treatments resulted in 77 lb difference in weight at start of breeding. However, the pasture-developed heifers had greater gain (1.83 lb/d) from start of breeding to pregnancy diagnosis than drylot heifers (1.34 lb/d). Range-developed heifers compensated for their minimal pre-breeding ADG and gained more weight during the breeding season than feedlot-developed heifers, due to lower maintenance requirements and the ability to respond to a seasonal improvement in forage quality (Marston et al., 1995; Ciccioli et al., 2005). Pasture developed heifers tended to have greater pregnancy rates than heifers developed in a drylot (91 vs. 84).

Other research (Funston and Larson, 2011; Larson et al., 2011) compared heifers grazing on corn residue or winter range as an alternative to drylot feeding. Heifers grazing corn residue gained 0.5 lb/d more than heifers developed on winter grass or a drylot. Heifers grazing winter grass or corn residue were supplemented with the equivalent of 0.31 lb/d of protein and gained between 0.42 and 0.93 lb/d during winter grazing. Once placed on higher quality spring pasture, the heifers gained 1.19 to 1.61 lb/d during the breeding season. Heifers grazing corn residue weighed less prior to breeding than heifers developed in the drylot, had achieved 56% of their mature BW, had similar pregnancy rates at the end of the breeding season, and achieved similar BW prior to calving with a similar percentage (> 60%) calving in the first 21 d of the calving season and calf birth date. Decreased winter gain in the low input development systems resulted in greater gain during the breeding season, which may explain similar overall pregnancy rates.

If nutrition following start of breeding is inadequate, poor reproductive performance may result. White et al. (2001) found restricting nutrients to 40% of maintenance prevented ovulation in 70% of heifers with no change in BCS. Perry et al. (2009) reported decreased pregnancy success for heifers moved from feedlot to summer grazing post-AI. Post-insemination nutrition may affect embryonic survival through a variety of mechanisms. Nutritionally-mediated changes to the uterine environment can occur by changing components of uterine secretions or by influencing the circulating concentrations of progesterone that regulate the uterine environment (Foxcroft, 1997). Arias et al. (2012) determined yearling heifers that gained BW had greater AI pregnancy rate (77%) than heifers that maintained (56%) or lost (61%) BW during the first 21-d period post-AI. Therefore, nutritional plane post-AI may be as or more important than pre-breeding nutritional plan in yearling heifers. Collectively, the studies discussed above provide evidence that developing heifers to lighter weights at start of breeding reduces maintenance requirements providing them with greater opportunity to be in positive nutrient balance in conditions when forage quality is marginally sufficient around the time of breeding.

Differences in size and corresponding maintenance requirements may persist over time to result in greater retention in subsequent years. Pregnancy rates through the 4th calf remained similar between high- and low-gain heifers developed in Nebraska, where nutrition following the development period was considered adequate (Funston and Deutscher, 2004). In contrast results from New Mexico, where nutrition may have been limiting. Mulliniks et al. (2012) reported 68% retention in the breeding herd through 5 yr of age for range-developed heifers fed a high-RUP supplement compared with 41% retention for range-raised counterparts fed a lower-RUP cottonseed meal-based supplement, and 42% retention for heifers developed in a feedlot. This relationship tended to be significant as early as 2 and 3 yr of age, respectively. These data indicate not only where a heifer is developed (i.e., low-input vs. feedlot), but also what she is fed when developed (i.e., high-RUP vs. lower-RUP supplement) may influence her longevity in the cow herd.

Nutrition through subsequent calvings may interact with heifer development protocol to influence cow longevity. In the Nebraska and New Mexico studies discussed above, heifers were managed in common after the respective heifer development treatments. In contrast to the Nebraska and New Mexico data sets, a study in Montana evaluated cows provided different levels of feed inputs during postweaning development and subsequent winter supplementation over a 10 year period. Each year following weaning, heifers were developed in dry lots on a corn silage-based diet. Heifers were fed to appetite (control) or restricted to fed 20% less than controls at similar weight. In subsequent winters, control females were provided supplemental feed expected to be adequate for production on winter range, whereas restricted heifers were fed level of supplemental feed expected to be marginal for range conditions. Heifers used in this study were produced by dams that had received either marginal or adequate levels of winter supplemental feed, thereby creating 4 classifications: restricted heifers from dams provided marginal levels of winter supplemental feed; restricted heifers from dams provided adequate levels of winter supplemental feed; control heifers from dams provided marginal levels of winter supplemental feed; control heifers from dams provided adequate levels of winter supplemental feed. All females were required to wean a calf each year of production to remain in the herd. Retention at year 1 (heifer pregnancy) and at start of the 2nd breeding season were influenced by the interaction of heifer and dam nutritional treatments; being greater for restricted heifers from dams on marginal level of supplement than restricted heifers from adequately supplemented dams. Retention from 2 to 3 years of age was less for restricted animals than controls. No differences in loss were observed between 3 and 4 years of age, but control animals incurred greater loss between year 4 and 5 resulting in similar percent retention among the different classification groups at 5 years of age. Collectively, rebreeding results from New Mexico and Nebraska would indicate that lower-input heifer development where all heifers are managed together after the postweaning period did not impair rebreeding, but continued subsequent restriction in the form of marginal winter supplementation, as experienced by the Montana heifers, resulted in lower retention rates in 2 to 3 year old cows. Restricted heifers that failed to rebreed in the Montana study were lighter prior to calving (871 vs 888 lb) and prior to start of breeding (818 vs 842 lb) as 2-yr-olds compared with pregnant heifers from both development groups and non-pregnant heifers developed on ad libitum feed. This primary difference between lower-input heifer development programs emphasizes the importance of managing extensively developed heifers for continued growth after lower inputs during postweaning development. The data also indicate that the way the dams are fed may program the heifer fetuses to respond differently to low input development later in life.

Heifer development protocols may influence resulting behavior traits associated with the environment in which the heifer was developed. Range-developed heifers may retain better grazing skills and be more productive during the subsequent summer (Olson et al., 1992; Perry et al., 2009). In a recent study at 2 locations in Nebraska (Summers et al., 2013), heifers were either developed on winter range vs. corn residue or drylot vs. corn residue. Pregnancy rate based on heifer development system was similar; however, heifers developed on corn residue exhibited greater ADG when placed on corn residue as a pregnant heifer compared with either winter range or drylot developed heifers (Summers et al., 2013), supporting the hypothesis of a learned behavior for grazing corn residue. However, drylot-developed heifers that graze dormant forage during the winter prior to development in a pen may not exhibit a change in grazing skills upon returning to a grazing environment. Mulliniks et al. (2012) reported similar ADG in drylot-developed heifers between the drylot phase (1.52 lb/d) and grazing phase (1.34 lb/d). Data from other species indicates the environment experienced during development can have lifetime impacts.

Adequate heifer growth and development to ensure minimal calving difficulty can be important for longevity (Rogers et al., 2004) however, providing additional supplemental feed during postweaning development to accomplish this may be less efficient than later in development. Similar calving difficulty has been observed between low- and high-gain heifers developed in confinement (Funston and Deutscher, 2004), between heifers developed with low-inputs on corn residue and winter range and feedlot-developed heifers (Funston and Larson, 2011), and between low-input developed heifers grazing either winter range or corn residue (Larson et al., 2011). Within study, all heifers were exposed to a low-birthweight EPD bull battery in the same breeding pastures.

Calving date for first calf heifers may impact cow longevity and productivity. Calving late in yr 1 increases the proportion of cows that either calve later next year or do not conceive (Burris and Priode, 1958). Research has indicated heifers having their first calf earlier in the calving season remained in the herd longer compared with heifers that calved later in the calving season (Rogers et al., 2004; Cushman et al., 2013). Therefore, heifers calving earlier in the calving season have greater potential for longevity and lifetime productivity. However, the above-mentioned studies do not demonstrate that heifer development affected date of calving or longevity.

Economic Analysis of Heifer Development Systems

Mulliniks et al. (2012) evaluated enterprise budgets for the 3 New Mexico heifer development treatments. Assumptions included comparing 100 heifers in each treatment, and all heifers would be sold in the fall of their yearling year, regardless of pregnancy status. Gross returns were greatest for the RUP-supplemented range heifers and least for heifers developed in the feedlot; feed costs were greatest for feedlot-developed heifers. Compared with feedlot-developed heifers, net returns were $99.71 and $87.18 greater per heifer developed for the high-RUP and cottonseed meal-supplemented heifers grazing dormant native range, respectively. The increase in net returns for range-raised heifers was due to greater pregnancy rates and decreased development costs.

A similar approach was used to evaluate the heifer development protocols in the Montana data set. Gross returns were greater for control heifers, but restricted heifers had lower feed costs. This resulted in an increase of $37.24 in net returns per developed heifer for the restricted group.

Research from the University of Nebraska reports similar savings in development costs, where developing heifers on dormant winter forage resulted in a $45 savings per pregnant heifer compared with drylot development (Funston and Larson, 2011), and a similar development cost comparing 2 extensive development systems, winter range vs. corn residue (Larson et al., 2011). Studies from New Mexico, Montana, and Nebraska illustrate that restricting gain during postweaning development by limiting DMI or developing heifers on dormant winter forage resulted in increased economic advantages compared with developing heifers at greater rates of ADG to achieve a greater target BW.

Summary and Conclusions

Developing heifers to lighter target BW may be advantageous in maintaining positive energy balance or adapting to negative energy balance through the breeding season in many range settings. Likewise, heifers developed under a range setting may be better adapted to maintain desired metabolic status during breeding than heifers reared in a pen or developed at a high rate of gain. Implications of heifer development system on cow longevity must be considered when evaluating economics of a heifer enterprise; however, studies evaluating the effects of heifer development systems on cow longevity are extremely limited.

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