December 2007

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Proceedings, The Range Beef Cow Symposium XX
December 11, 12 and 13, 2007 Fort Collins, Colorado

HEIFER DEVELOPMENT – THEN AND NOW

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INTRODUCTION

Studies in numerous species provide evidence that diet during development can partially control physiological changes necessary for puberty (Frisch, 1984). Energy balance or plane of nutrition influences reproductive performance in heifers and cows (Short and Adams, 1988; Butler and Smith, 1989; Swanson, 1989; Randel, 1990; Robinson, 1990). Numerous studies have reported inverse correlations between postweaning growth rate and age at puberty (Wiltbank et al., 1966, 1969, 1985; Short and Bellows, 1971; Arije and Wiltbank, 1971; Ferrell, 1982), and pregnancy rates in heifers were shown to be dependent upon the number displaying estrus prior to or early in the breeding season (Short and Bellows, 1971; Byerley et al., 1987). Thus, rate of postweaning growth was determined to be an important factor affecting age of puberty, which in turn influenced pregnancy rates. This and other research conducted during the late 1960s through the early 1980s indicated puberty occurs at a genetically predetermined size, and only when heifers reach their target weight can high pregnancy rates be obtained (reviewed by Patterson et al., 1992). Guidelines were established stating replacement heifers should be fed to achieve 60 to 65% of their expected mature body weight by the time breeding starts in order to reach puberty. Therefore, traditional approaches for postweaning development of replacement heifers used during the last several decades have primarily focused on feeding heifers to achieve or exceed an appropriate target weight, and thereby maximize heifer pregnancy rates. However, substantial changes in cattle genetics and the economy have occurred over this time, indicating traditional approaches should be re-evaluated. Intensive heifer development systems may maximize pregnancy rates, but not necessarily optimize profit or sustainability. Developing heifers in this manner requires significant use of fossil fuels and cereal grains, and high capital investment in equipment and facilities. The fuel requirement to harvest feed and deliver it to cattle creates high energy demands in this development system. Cereal grains, often used as a major energy source in heifer diets, detract from the system's sustainability due to growing demand for human food and ethanol production.

Since the inception of the target weight guidelines, subsequent research demonstrated the pattern of growth heifers experience prior to achieving a critical target weight could be varied. This provides an opportunity to decrease feed costs by altering rate and timing of gain, creating periods of compensatory growth and/or allowing producers to limit supplementation to critical periods of heifer development (Clanton et al., 1983; Lynch et al., 1997; Freetly et al., 2001). For example, delaying heifer gain until 47 or 56 d prior to the breeding season did not negatively influence reproductive performance, but reduced the amount of feed needed (Lynch et al., 1997). In one year of this study, puberty was delayed in heifers fed to achieve lower early gains, but first-service conception rate tended to be improved in these same heifers. Similarly, Freetly et al. (2001) found delaying gain until the later part of the postweaning period reduced total energy intake, but calving rate, age at calving, postpartum interval, and second year pregnancy rate were not impacted. This suggests total energy intake, and possibly heifer development costs, may be reduced by limiting heifer gain early in the postweaning period followed by accelerated gains before the breeding season.

REVIEW OF TARGET WEIGHT

As indicated previously, substantial research has been conducted contributing to the traditional guidelines of developing heifers to 60 to 65% of mature body weight at time of breeding. In general, studies evaluating different postweaning rates of gain or target weights have used either different amounts of feed, or different types of feeds varying in energy and/or protein content to obtain differences in rates of growth. A review of these studies conducted over the last several decades along with new research discussed later, indicates the association among BW, puberty and heifer pregnancy rate appears to be changing over time. In general, research reports published through the late 1980s have shown much greater negative effects of limited postweaning growth on age of puberty and subsequent pregnancy (Short and Bellow, 1971; Wiltbank et al., 1985; Patterson et al., 1989), where as more recent studies indicate less of a negative impact of delayed puberty on pregnancy response (Buskirk et al., 1995; Lynch et al., 1997; Freetly et al., 1997). Several factors likely contribute to this change over time. Initial research in this area of interest corresponds to the industry shift from calving heifers at 3 years of age to calving at 2 years of age. Thus, selection pressure for age of puberty was probably minimal in the animals used in the early studies. While selection intensity would have increased with the reduction in calving age of heifers, genetic progress would take time due to the long generation interval in cattle. In the mid 1980s, researchers identified the association between scrotal circumference in bulls and age of puberty in their female offspring. Since then, scrotal circumference has been used as an indicator trait for puberty. The change occurring 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 heifers reaching puberty before weaning (Gasser et al., 2006a and 2006b).

Another factor that seems to have changed is the association between timing of puberty and subsequent pregnancy rate. Early research indicated heifers should experience two or three estrous cycles before the onset of the breeding season because fertility of the first estrus is lower than subsequent estrous cycles (Byerley et al., 1987). Thus it was expected delayed onset of puberty would be associated with lower pregnancy rates. However, several studies have not shown strong associations between nutritionally related changes in age of puberty and final pregnancy rates (Ferrell, 1982; Buskirk et al., 1995; Lynch et al., 1997; Freetly et al., 1997). Evidence for a genetic basis for these differences is provided by Freetly and coworkers (1997), who reported pregnancy rates were greater in heifers AI sired by bulls born after 1988 than bulls born between 1982 and 1984, but age and weight at puberty were not. These changes, combined with the continued increase in cost of harvested feedstuffs indicate the need for alternative development systems which allow heifers the opportunity to conceive early as yearlings at reduced cost.

Feeding replacement heifers to a traditional target weight increases development costs relative to more extensive heifer development (Funston and Deutscher, 2004; Clark et al., 2005; Martin et al., 2007). Funston and Deutscher (2004) reported similar pregnancy rates from the initial through fourth breeding season for heifers developed to reach either 53 or 58% of mature weight prior to breeding as yearlings. This demonstrated heifers developed to only 53% of mature weight could achieve similar initial pregnancy rates and retention compared to heifers developed to 58% of mature weight. Further research using the same herd found pre-breeding weights as low as 51% of mature weight (RLX) was more cost effective than development to 57% of mature weight (INT) when lighter heifers were allowed 60 d to become pregnant (Martin et al., 2007). Extending the breeding season by 15 d for lighter heifers resulted in first-calf conception rates being similar between systems (45 vs. 60 d breeding season for INT and RLX systems, respectively). Retrospective analysis considering only RLX heifers bred within the first 45 days of the breeding season, based on days pregnant at pregnancy diagnosis, revealed 45-d pregnancy rates of 89.8 and 77.9% for INT and RLX systems, respectively. During the extended 15 d breeding period (from 45 to 60 d) for the RLX heifers, an additional 9.3% of heifers became pregnant.

Interestingly, further characterization of non-pregnant heifers within each system revealed 78.9% (14 of 17) of open RLX heifers (after a 60-d breeding season) but only 45% (5 of 11) of open INT heifers (after a 45-d breeding season) were pre-pubertal prior to start of the breeding season. This lends support to the hypothesis that one of the major determinants to a heifer's ability to conceive during her first breeding season is the age she reaches puberty, especially in relation to the start of the breeding season. However, feeding heifers to meet traditional recommendations may be unnecessary for successful heifer development. In fact, feeding heifers to traditional target weights increases development costs per pregnant 2-yr-old cow (Clark et al, 2005; Martin et al., 2007).

Heifers calving early during their first calving season have greater lifetime calf production than those calving late and are more likely to become pregnant again at two years of age and calve early in the season at three years of age (Lesmeister et al., 1973). However, there was no difference in second-calf conception rates between cows developed to 51 or 57% of mature weight prior to breeding as yearlings (Martin et al., 2007). This indicates lighter weight heifers that became pregnant during the 15 d extension during the first breeding season rebred with similar efficiency as those pregnant within the initial 45 days of the breeding season. Therefore, proportion of heifers retained as pregnant 2-yr olds was similar between systems. Thus, heifers may be developed to lighter than traditional target weights without negative effects on profitability or future productivity.

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). The association of age at onset of breeding and cumulative pregnancy rate was similar for heifers developed on the two protocols. However, a shift in the association of heifer body weight at the start of breeding and cumulative pregnancy rate was observed, where cumulative pregnancy rate (up to 80%) for heifers at a given pre-breeding body weight was greater for heifers developed under the restricted protocol than heifers developed on unlimited access to feed. Based on these observations, age at the beginning of the breeding season was more critical for a successful pregnancy than was body weight.

Average body weight of heifers at time of breeding were similar between the Nebraska and Fort Keogh studies, as was the type of cattle evaluated (composites with ~½ Red Angus and ½ continental breeding). In contrast to the Nebraska research, a slight decrease in pregnancy rate (3-5%) 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 (lower quality diet) and Fort Keogh (restricted quantity 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 reduced harvested feed inputs per pregnant heifer by 22 % during the 140-d postweaning period. In addition to this direct cost decrease associated with developing heifers, rearing heifers on limited nutritional inputs improved efficiency during the winter feeding period and increased rates of gain while grazing after the winter feeding period, which is consistent with research at Nebraska (Funston and Deutscher, 2004; Freetly et al., 1997) . These studies indicate an opportunity to improve efficiency and decrease production costs by decreasing amount and/or quality of harvested feeds used for heifer development. An estimate of developing heifers under the restricted level of feeding revealed a $22 savings per pregnant heifer, when average prices over six years for calves and open heifers sold from Montana auction barns were used. Interestingly, this is similar to the cost savings observed in the Nebraska research (Funston and Deutscher, 2004).

SYSTEM OF DEVELOPMENT

Limited research has been performed to determine whether inherent differences in development systems affect reproductive efficiency or future productivity of heifers. By design, these studies are confounded by differences in total energy intake. Grings et al. (1998) determined heifers grazed on pasture regrowth for the initial 56 d of development achieved similar reproductive performance as those developed entirely in drylot. Heifers grazing pasture gained less during the initial 56 d but were placed in a drylot following the grazing period and achieved similar pre-breeding weight as those developed entirely in drylot. In a similar study, heifers developed in drylot reached puberty 29 d earlier than their contemporaries fed protein supplement on pasture (Marston et al., 1995), despite similar growth rates. However, this did not result in improved pregnancy rate or reduced age at first calving. Collectively, these two studies provide evidence that heifer development systems can influence reproductive performance, but do not provide evidence of effects independent of energy intake and/or growth rate.

In a more recent study, Ciccoli et al. (2005) compared heifers grazing pasture supplemented with 42% CP over the winter to heifers in a drylot fed high-starch diets for either 30 or 60 d and heifers self-fed low starch diets on pasture. Pre-breeding weight (595 lb) and ADG (1.12 lb/d) of heifers supplemented with only 42% CP pellets on pasture were substantially lower than traditional recommendations. As a result, pasture-developed heifers were older at puberty. However, pregnancy rates were similar across groups. The same study compared heifers developed on pasture and supplemented with energy for 60 d prior to breeding to heifers receiving only 2 lb/d 42% CP pellets. When pubertal development was limited by winter ADG, supplementation improved pregnancy rates. However, if heifers achieved moderate (1.12 lb/d) winter gains, pregnancy rates were not improved by supplementation.

Early weaning in combination with feeding a 60% corn high-energy diet from 126 to 402 d of age induced puberty in 67% of heifers (Gasser et al., 2006b). In a related study, (Gasser et al., 2006a) early weaning and feeding high-concentrate diets to heifers beginning at 99 d of age also induced puberty at an early age. Heifers fed high-concentrate diets only from 126 to 196 d or 196 to 402 d of age had lower rates of puberty (47%), but higher than heifers fed 30% corn diets from 126 to 402 d of gestation. Numerous studies have been performed to determine how energy inputs, defined in numerous ways, affect the success of heifer development programs.

SUMMARY

Postweaning management of heifers to achieve traditional target weights, particularly by feeding high-energy diets, is not supported by available research. Heifers developed on forage, however, generally require some protein supplementation to achieve even modest gains. One reason reproductive performance has not been drastically impaired by feeding to lower weights may relate to genetic changes in age of puberty.

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