Nutritional and management strategies to increase reproductive efficiency and longevity in young beef cows

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Introduction

For beef producers, production efficiency is essential to maintain long-term profitability and sustainability. Continued viability of beef production systems utilizing semi-arid and arid lands, which account for one third of the earth's surface land area, requires adoption of innovative practices that increase profitability, either by decreasing cost of production, increasing returns, or increasing longevity of the cow herd. With that said, the most important factors affecting financial viability of a cow-calf enterprise are reproduction and nutrition. In a cow-calf enterprise, the ability of a breeding female to produce one calf per year is one of the key drivers of profitability. Therefore, longevity of the cow is a chief concern for productivity on a cow-calf operation. Failure to become pregnant is the primary reason a beef cow is culled from an operation (Cushman et al., 2009). Since, production costs for unproductive cows that fail to achieve pregnancy are a major loss to beef producers, the ability to identify cows with a low likelihood to conceive or a delayed conception would greatly benefit the beef industry. Therefore, being able to develop or select beef females that lead to improved reproductive efficiency and lower production costs will increase economic returns to producers.

Management of young cows prior to first breeding and it effect on cow herd longevity

Replacement heifers play an integral part in sustaining herd size, which are necessary to replace culled cows, maintain herd size, and to improve the genetics of the herd (Bagley, 1993). The most expensive and, arguably, the most critical time in a beef female's life is the development period up to their first breeding. It is also one of the largest expenses for beef cattle operations due to inherent opportunity and development costs for retaining heifers. Management decisions made during this time frame can have lifelong effects on the efficiency of the beef female. While limited information exists about the impacts of heifer development strategies on cow longevity, data from other species implies that limiting caloric intake during juvenile development can increase lifespan. Establishing the impact of heifer development protocols on longevity is complex, requiring consideration for nutritional factors following the start of breeding and through subsequent calvings. Therefore, producers need to be aware of two important aspects in development methods: 1) costs of developing heifers and 2) longevity of replacement heifers in the cow herd.

Implementing a heifer development method which is centered on future compatibility with the environment of the cow herd is imperative to a successful cow-calf operation. Since most components of fertility that influence a successful first calving and continued yearly reproduction are not highly heritable, management practices impact reproduction. Thus, heifer development method from weaning to the beginning of the first breeding period is critical for their subsequent productivity.

The greatest concern with developing heifers on slow rate of gain is decreasing heifer pregnancy rates and increased calving difficulties that may result in decreased longevity and productivity in the cow herd. In New Mexico, Mulliniks et al. (2013a) reported increased retention through 5 years of age for range-developed heifers fed a high-ruminally undegradable protein supplement (68% retained) compared to range-raised counterparts fed a lower-RUP cottonseed meal-based supplement (41% retained) and heifers developed in a feedlot (42% retained). This relationship tended to be significant as early as 2 and 3 years of age. These data suggest that not only where a heifer is developed (extensive versus feedlot) but also what she is fed when developed extensively (high-RUP supplement versus lower-RUP supplement) may influence her longevity in the cow herd. Collectively, rebreeding results from New Mexico would suggest that lower-input heifer development where all heifers are managed together after the postweaning period did not impair rebreeding. 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. Therefore, the compensatory gain period for restricted-growth heifers may be extremely important to the longevity and lifetime productivity.

Lesmeister et al. (1973) reported that heifers that have consumed lower quality diet have decreased pregnancy rates and those that are bred generally calve later, which leads to a decrease in lifetime productivity. However, developing heifers on lower levels of nutrient input has been suggested to improve efficiency and enhance longevity in the cow herd (Roberts et al., 2009). In a 10-yr study, Hughes et al. (1978) reported an advantage in retention rate of beef cows on a lower plane of nutrition compared to higher levels. In addition, Pinney et al. (1972) suggested that differences in retention rate are established rather early in a cow's life and its longevity is maintained thereafter. However, culling non-pregnant heifers developed on a slower rate of gain may be the metabolically and physiologically least efficient heifers leaving the more efficient animals in the herd. If additional feed and expenses are needed to ensure less efficient cows remain productive in a nutrient sparse environment, then this connection leads to the inference that current heifer development guidelines may actually be leading to retentions of less efficient cows and thus counterproductive towards greater lifetime productivity (Roberts et al., 2011). Therefore, is the practice of providing additional nutrient rich resources to attain high (90% or greater) pregnancy rates in heifers an appropriate goal for producers in their heifer development practices or should promotion of heifers that are metabolically and physiologically more efficient in their specific environment be the objective?

Nutritional management after first calving on cow herd longevity

One of the most common reproductive problems is getting young cows rebred after calving. This decrease in reproductive efficiency is due to trying to rebreed during a time period when young cows have calved for the first or second time, lactating, and trying to reach their mature body weight. This problem is often compounded with the inability to consume enough energy to meet the requirements for growth, lactation, and reproduction (Mulliniks et al., 2011). Thus, pregnancy rates in these 2- and 3-yr-old cows are often the lowest in the cowherd. While the interval from calving to resumption of estrus in older cows may be around 40 to 60 days, young cows may require up to 90+ days. However, to maintain a yearly calving interval, cows need to be breed within 80 days after calving. Thus, a key to increasing pregnancy rate among young cows is to shorten the postpartum interval from calving to resumption of estrus to increase the number of opportunities to conceive in a defined breeding season (Wiltbank et al., 1961).

Often times in semi-arid and arid environments, cows are required to calve and rebred while grazing low-quality dormant forage. Ruminal fermentation products of dormant native range yields small amounts and potentially inadequate quantities of glucogenic precursors, particularly propionate. Propionate is the primary precursor for gluconeogenesis for ruminants. Therefore, propionate needs to be in sufficient quantities to satisfy glucose energy demand for metabolism (Leng et al., 1967). Glucose is required for oxidative energy metabolism of acetate and other fatty acids so as the supply of these metabolites increase the need for glucose proportionally increases. Thus, a large supply of acetate may result in a slow rate of acetate clearance due to inadequate supply of glucose and subsequently the body will change acetate into ketones. Ketones unfortunately can cause metabolic distress in addition if acetate is not quickly oxidized the cell will convert it to β-hydroxybutyrate, a specific ketone body which had been shown to impair insulin action in rat cardiomyocytes (Tardif et al., 2001). The elevation in ketones, free fatty acids and quality of the diet has been implicated in insulin resistance (Kaneko, 1997).

Tovar-Luna (1997) demonstrated that lactating ewes fed higher levels of ruminally undegradable protein (RUP) cleared acetate faster after intravenous infusions than ewes fed a lower level of RUP. Supplying RUP supplements to ruminants can increase gluconeogenic amino acids to the small intestine, which can replenish oxaloacetate and promote acetate utilization. Waltz et al. (1989) found that feeding a combination of feather meal and blood meal (50:50) increased the amount of available amino acids flowing to the small intestine compared with soybean meal. Furthermore, increasing the supply of amino acids to the small intestine would increase the amount of glucogenic precursors and could increase glucose supply. Cronjé et al. (1991) evaluated supplementation of low-quality roughage diets and acetate clearance rate in sheep. These researchers fed urea treated wheat straw with increasing amount of high bypass protein supplement to supply additional glucogenic precursors (Overton et al., 1999) and compared this basal diet to a diet that supplied 46 g of propionate fed as sodium propionate. Acetate clearance was increased with increasing amount of protein supplement fed, but was further increased when propionate was fed in addition to the bypass supplement. With the incorporation of glucogenic precursors in range supplements improvements in the availability most likely increase in postpartum cows. Due to the uniqueness of ruminant metabolism, glucose that is fed directly will be changed during digestion and will be absorbed as volatile fatty acids (fermentation productions). So in order to improve the glucose status of a cow, she must be fed a product that she can absorb and synthesize into glucose in her body. Range supplements that contain a higher amount of bypass protein can supply glucogenic amino acids for glucose production.

In addition to feeding supplement high in RUP, other feed additives like calcium propionate have been used to increase glucogenic potential of the diet. Waterman et al. (2006) found improved tissue response to insulin, weight gain, and reproductive performance when glucogenic precursors in the form of RUP plus 100 g/d of calcium propionate were added to range supplements. Cows supplemented with the 100 g/d of calcium propionate and the RUP (both glucogenic precursors) had a shorter glucose half-life after a glucose tolerance test, returned to estrus 9 d sooner, and gained more weight from the end of supplementation to the end of breeding than cows fed traditional cottonseed meal-based supplement with no additional glucogenic precursors. In addition, Mulliniks et al. (2011) found that supplements with added calcium propionate increased pregnancy rates in young cows from 88% to 95%.

More recently, we have found a chute-side measurements of β-hydroxybutyrate (BHB) or ketones that may provide producers opportunity to proactively manage cows (depending upon β-hydroxybutyrate concentration) to improve overall reproductive efficiency. Before breeding is initiated in a herd each year, there are no objective tools to predict timing of a cow's conception. If cows could be classified as a late potential breeder then she could receive alternative management to stimulate earlier breeding. We have evidence that ketones (a metabolite resulting from metabolic imbalances due to dry dormant forage) may play a role in the resumption of estrus after calving and identify cows that could possibly be late breeding cows. Nutrient imbalances resulting from inadequate supply of metabolic intermediates or poor metabolic adaptation to negative energy balance are often accompanied by a high level of circulating ketone bodies, which are by-products of enhanced fatty acid mobilization and inhibited oxidative metabolism. In dairy cows, lower serum BHB concentration pre-breeding was associated with increased pregnancy rates from first service AI (Walsh et al., 2007) and decreased interval to first ovulation (Reist et al., 2000). In agreement, Iwata et al. (2011) reported elevated BHB concentrations suppressed LH pulses and proposed that ketone bodies might function as a negative energy signal to inhibit gonadal function through suppression of gonadotropin secretion. Furthermore, elevated circulating BHB concentrations in the blood delayed resumption of estrus after calving and conception date in beef cattle (Mulliniks et al., 2013b). Therefore, β-hydroxybutyrate concentrations may be a useful indicator of days to resumption of estrus and conception date when metabolic dysfunctions are present.

Conclusion

One limitation of most research concerning influences of nutrition is little or limited consideration of long-term implications. In addition, longevity has a relatively low heritability; thus development during early life and other management strategies have a great potential to impact cow retention and future productivity. Cow longevity may be improved by decreasing days to first estrus, resulting in increased percentage of young cows pregnant earlier in the breeding season, while maintaining a yearly calving interval.

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