

Can we improve fertility with nutrition or just avoid disasters?

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The relationship between nutrition and reproduction is bidirectional; that is, reproductive status alters nutrient requirements but the nutrients assimilated by the cow also alter reproductive function. Most cows in production systems are pregnant, lactating or both thus her nutrient requirements consistently exceed maintenance requirements. For this author, the relation of nutrition to fertility can be divided into: 1) initiation of cyclicity in the pre-pubertal heifer or resumption of cyclicity in the post partum cow, 2) ovulation of a competent ovum, and 3) maintenance of the embryo and fetus in a competent reproductive tract. These steps are sequential, thus resumption of cyclicity must be achieved first. The antagonism between lactation and the resumption of cyclicity is also evident in the cow. The purpose of this presentation is to outline nutrient requirements of cows relative to her reproductive status and nutrition-related factors associated with fertility in cows with a minor focus on nutrition and fertility in bulls.

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Nutrient requirements have classically been determined by what is called a factorial approach. The first requirement is maintenance and then additional internal requirements such as growth, lactation, and fetal growth are added to maintenance. External factors such as temperature, wind, and housing (confinement vs grazing, mud vs dry footing) can also be factored into requirements. Reproductive performance is maintained when the cow is fed a balanced ration to meet these factors. The concept of conditionally essential nutrients infers that under certain conditions, addition of single or a series of nutrients can positively enhance outcomes. Although enticing, the author is unaware of single nutrients that enhance reproductive performance, thus the focus should be directed to providing all essential nutrients relative to the cow's requirements.

The goal of meeting requirements is relatively easy for maintenance animals. We accept, however, in common production systems that many cows in late gestation and early lactation will not consume enough feed to meet all requirements, especially energy. The cow will meet her energy requirements via self catabolism of body fat and protein which is visualized as a loss of body condition or is called negative energy balance. While the cow can maintain muscle and nervous system function with lipids and ketones, the ovum and fetus require glucose as an energy source. This differentiation in nutrient supply is part of the antagonism between lactation and reproduction and must be considered when feeding for fertility.

Nutritionally, the cow year can be divided into four time periods

- 1) Calving to conception (82 days): Nutrient requirements for a cow are greatest during this period and most cows lose body condition during this period to support lactation. Resumption of cyclicity in this time period is crucial to reproductive success.
- 2) Pregnant and lactating (123 days): The primary demand for nutrients during this stage is lactation, thus increased nutrient support during this period will support lactation in addition to potential weight and condition gain in the cows
- 3) Midgestation and non-lactating (140 days): Nutritional requirements are lowest during this period and beef cows can be maintained on low-quality feeds during this period. This is an excellent time and maybe the only time to increase the body weight and condition of thin cows.
- 4) Precalving (50 days). Nutrient requirements rapidly increase during this phase and body condition should be maintained in addition to the increase in the weight of fetal tissues, placenta, uterine fluid and mammary gland.

Body condition scoring (BCS), at critical periods, like calving, breeding, and weaning can be utilized to monitor and manage feeding programs. As to beef cattle, body condition scoring at calving appears to be the best predictor of subsequent fertility. In the dairy cow, the change in body condition score between calving and breeding is the best predictor of subsequent fertility. Although body weight is

a more objective measure than body condition score, the actual correlation between body condition and body weight is less than desired. For example, the cow can lose up to 10-15% of her body weight at calving as the feto-placental unit, whereas the increase in dry matter intake after calving and subsequent increase in gut fill will increase body weight without changing body composition. Likewise, the change in body weight between condition scores is not consistent across scores. For example, 50 to 70 pound differences were noted between condition scores lower than 5/9 and 85 to 100 pound differences were found between condition scores greater than 5/9 in Angus cows. Part of this reflects a difference in body composition as cows go from thin to obese. In beef cows, most of the increase in body condition in scores $> 6/9$ is fat, while decreases in BCS in scores $< 4/9$ are mostly muscle. This becomes crucial when modeling body condition score loss as a kg of fat provides approximately 8 Mcals of energy while a kg of muscle provides approximately 1 Mcal of energy. This difference can be reflected as a relative slow decrease in body condition in overweight/obese cows and a rapid decrease in body condition in thin cows, even when the negative energy deficit is the same. Likewise, the fuel supply to the cow differs, depending on body condition score when negative energy balance begins.

In general, beef cows that calve in thin condition (BCS ≤ 4) are less fertile than beef cows that calve in adequate condition (≥ 5). This effect can be represented by several metrics: 1) lower pregnancy rates, e.g. 50-70% vs 80-95% and 2) delay in first postpartum ovulation, e.g. 30 days vs 70-100 days. This defect in reproductive performance has been correlated to lower IGF-1 and luteinizing hormone (LH) pulse frequency in thin cows. This effect is maintained, but not as obvious in cows that are thin at breeding but the scores are lower, i.e. cows at BCS ≤ 3 were less fertile than cows at BCS ≥ 4 . Fertility of thin cows (BCS ≤ 4) may be improved with supplemental feeding between calving and breeding, but they do not reach the fertility of cows calving in adequate BCS and there is some evidence that first calf heifers may be most responsive to supplemental feeding. In general, supplementation with energy appears to be more beneficial than supplementation with protein. In addition, flushing, or increased feed for two weeks prior to breeding, does not seem to be beneficial. Thus when faced with a thin group of postpartum cows, additional feed or energy supply is of minimal benefit in increasing fertility. In conclusion, maintenance of body condition prior to and throughout the periparturient period is associated with optimal fertility in cows.

Dietary deficiencies of cobalt, copper, iodine, manganese, phosphorus, and selenium as well as excesses of molybdenum have been reported to cause infertility through direct or indirect actions on the reproductive system. Proposed mechanisms include: 1) decreased activity of rumen microorganisms with depression in digestibility, 2) alteration of enzymatic action, which involves energy or protein metabolism or alteration of hormone synthesis, 3) inability to maintain the integrity of the cells of the reproductive system and 4) decrease immunocompetence, which could increase the risk of infectious causes of infertility. Trace element supplementation improves pregnancy rates as compared to no supplementation, however, consistent increases in fertility between trace element sources is less evident. As most of the elements are involved in enzyme systems, time is needed to incorporate these minerals. Supplementation at the time of breeding does not appear to be beneficial.

Most production systems require that heifers calve at 23 to 24 months of age. To meet this goal, heifers need to reach puberty at 12 to 13 months of age to allow one or two estrous cycles before breeding at 14 months of age. Heifers that calve early in the calving season wean more and heavier calves during their lives which reflects lifetime benefits when maximizing heifer fertility. Age at puberty is influenced by plane of nutrition but also by breed, by season. Growth rates to achieve puberty can be linear or stair-step, e.g. periods of slow growth followed by rapid growth. Producers have classically used a target breeding weight of 67% of mature weight to assure adequate fertility of replacement heifers. Recent workers, however, have suggested that the target weight can be lowered to 55% of mature weight. Subtle changes in plane of nutrition can promote earlier puberty, whereas once a heifer begins cycling, severe nutrient restriction is needed to stop cycling. For example, it took 61 to 148 days of restriction to cease cycling in yearling heifers. The establishment of cyclicity carries momentum thus the magnitude of signals to initiate cyclicity are more smaller than the magnitude needed to cease cyclicity.

Nutrition and the male

Young bulls maintained on low planes of nutrition had reduced testicular growth, ejaculate volume, sperm production, and seminal vesicle development. Conversely, overfeeding energy to young bulls can decrease reproductive performance due to increased fat deposition in the scrotum or the pampiniform plexus. A critical feeding period for bulls may be prior to 26 weeks of age, i.e. pre-weaning rations may have more influence than traditional development rations fed after weaning. Restriction of nutrients prior to 26 weeks of age resulted in delayed puberty and reduced testicular size as yearlings and nutrient intake prior to 26 weeks of age had a more profound influence on age of puberty and testicular size than postweaning rations. Zinc and selenium deficiencies have been associated with decreased fertility in bulls as well as males of other species. Gossypol, a compound found in cottonseed reduces fertility in male rats and humans. Consistent effects of gossypol or feeding cottonseed on bulls are conflicting, however, the author recommends that high rates of whole cottonseed should be avoided.

Conclusion

The practitioner is faced with several challenges in making the diagnosis of nutrition-associated infertility. First, the inherent time lag between the pregnancy check and relevant rations makes it difficult to identify the relevant ration. For example, beef cows at pregnancy check may be in poor body condition, however the critical body condition was when they calved four to eight months previously. Second, research trials that investigate the relationship between nutrition and reproduction may be inadvertently biased to false-negative results because of the number of cows needed to detect small differences in pregnancy rates. An investigator needs 335 cows in each group to detect a difference between an 85 percent pregnancy rate and a 90 percent rate and 1400 cows per group to detect a difference between 50 percent at 55 percent at $P < 0.05$. Conversely, a trial with 50 cows per treatment group can only detect a difference between a 75 percent pregnancy rate and a 90 percent pregnancy rate at $P < 0.05$. Studies with small numbers per group, therefore, should be evaluated carefully.

Nutrient supply to the cow prior to parturition and the resulting BCS at calving appear to be the most important factors in determining reproductive performance. Postpartum energy intake above maintenance can increase reproductive success in thin cows. In addition, the key period to increase condition in thin beef cows is between weaning and late gestation. In beef systems, the management decisions of when to breed the cows and when to wean the calves are critical to maintaining reproductive success and should match the available nutrient supplies to the demands of the cows.

Selected references

1. Richards MW, Spitzer JC, Warner MB: Effect of varying levels of postpartum nutrition and body condition at calving on subsequent reproductive performance in beef cattle. *J Anim Sci* 1986;62:300-306.
2. Apple JK, Davis JC, Stephenson J, et al: Influence of body condition score on carcass characteristics and subprimal yield from cull beef cows. *J Anim Sci* 1999;77:2660-2669.
3. DeRouen SM, Franke DE, Morrison DG, et al: Prepartum body condition and weight influences on reproductive performance of first-calf beef cows. *J Anim Sci* 1994;72:1119-1125.
4. Selk GE, Wettemann RP, Lusby KS, et al: Relationship among weight change, body condition and reproductive performance of range beef cows. *J Anim Sci* 1988;66:3153-3159.
5. Kasimanickam R, Whittier DW, Currin JC, et al: Effect of body condition at initiation of synchronization on estrus expression, pregnancy rates to AI and breeding season in beef cows. *Clin Therio* 2011;3:29-41.
6. Ahola JK, Baker DS, Burns PD, et al: Effect of copper, zinc, and manganese supplementation and source on reproduction, mineral status, and performance in grazing beef cattle over a two-year period. *J Anim Sci* 2004;82:2375-2383.
7. Funston RN, Summers AF, Roberts AJ: Alpha beef cattle nutrition symposium: Implications of nutritional management for beef cow-calf systems. *J Anim Sci* 2012;90:2301-2307.
8. Bagley CP: Nutritional management of replacement beef heifers: a review. *J Anim Sci* 1993;71:3155-3163.
9. Funston RN, Deutscher GH: Comparison of target breeding weight and breeding date for replacement beef heifers and effects on subsequent reproduction and calf performance. *J Anim Sci* 2004;82:3094-3099.
10. Barth AD, Brito LF, Kastelic JP: The effect of nutrition on sexual development of bulls. *Theriogenology* 2008;70:485-494.

