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MANAGING THE COW HERD FOR FERTILITY IN LIMITED FEED ENVIRONMENTS

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Introduction

Beef cattle production regardless of the environment has similar challenges with reproductive success, health of dam and offspring, growth efficiency, and profitability. Nevertheless, each environment has unique opportunities to succeed and overcome production issues. These include feed costs, environmental stressors (weather, forage production and quality), health challenges unique to geographical areas, and local or regional economic climate. Operational resiliency relies on our ability to address challenges. Therefore, a mindset focused on creatively managing the needs of livestock is essential.

Fertility, or the ability to conceive, is one of the benchmarks for a productive female. Publications discussing the factors that impact cow fertility can be found as far back as the early 1900s. Baker and Quesenberry (1944) summarized cow production data from the USDA-ARS Ft. Keogh Station, Miles City MT from 1926 to 1942. Authors discussed issues with bull fertility and year to year environmental conditions impacting fertility. Although, fertility is considered a lowly heritable trait in beef cows and heifers there are obvious genetic influences on the female's ability to conceive. Likewise, there are numerous physiological processes that contribute to fertility, which include nutrient metabolism and health. As producers consider the means to impact fertility, nutritional management is likely the easiest to control. By ensuring animals nutrient needs are met, the animal will be better able to overcome health issues and meet their genetic potential for all aspects of production.

Beef cattle nutrient requirements for various stages of production can be found in the NRC (2000) and NASEM (2016). This document serves as the foundational document for nutritional requirements for all classes of beef cattle. However, challenges exist when trying to predict the requirements of beef females managed in extensive grazing systems (Coleman et al., 2014; Petersen et al., 2014, and Waterman et al., 2014). Despite our advancement in technology in the beef industry the inability to accurately predict forage intake and diet composition in grazing livestock remains. Nevertheless, through judicious use of forage sampling, we can develop a reasonable understanding of basal diet quality, which allows for relatively good information for supplement formulations. Supplement formulation should be specific to each production environment due to the fact that forage species vary a great deal in certain soil types, which is particularly true in the western United States. It is likely not necessary or even feasible to adjust supplements for different regions of a specific ranch with the exception of very large operations or drastic differences between pastures.

Forage analysis should include but not be limited to crude protein (CP), energy (total digestible nutrients, TDN; Net Energy for maintenance, NEm, Net Energy for gain, NEg), Calcium (Ca), Phosphorus (P), Potassium (K), Copper (Cu), Manganese (Mn), Zinc (Zn), and Selenium (Se). On rangeland or a nutrient limited environment, if a producer needed to choose the most important of these; the top 5 would be: 1) CP, 2) TDN, 3) P, 4) Ca, 5) K. These five are typically going to be the first to be in a limited supply during droughts or dormant forage situations. Likewise, forage mineral concentrations do not fluctuate to the same extent as CP and TDN. Therefore, complete mineral analysis may only be warranted at times when forage quality is lowest and highest, so that mineral formulations can be altered to meet the needs during that period of time, with a different formulation being provided during times when forage quality is better. It is important to keep mineral out for cows year-round to ensure adequate body stores. That said, all supplements should be developed with the stage of production in mind.

Nutrient Requirements

In most cases producers are encouraged to work with trained feed salespersons and nutritionists. However, it is important to have a strong understanding of a heifer or cows needs to ensure all requirements are being met. The NASEM (2016) provides documentation of the nutritional needs of beef cattle. This document summarizes all of the nutritional research that has been conducted in beef cattle nutrition. A partial list of growing heifer requirements is presented Table 1 and pregnant heifers is presented in Table 2, with cow information in Table 3. These tables are extremely useful as one begins to contemplate the supplementation programs for beef females. The combination of forage analysis and heifer nutrient requirements provides the ability to formulate effective supplements that meet the animals needs without greatly exceeding them. It is important to keep in mind that these requirements were developed from a number of experiments in various locations and cattle types most of which were conducted under ideal conditions. Therefore, cattle raised and selected for production environments that have climatic extremes (frequent droughts, high heat, extremely cold winter) are likely going to have unique nutrient requirements. For example, beef cows raised at the New Mexico State University Corona Range and Livestock Research Center rarely see forage TDN that meets their requirements (only two months out of the year). Yet, these cows, based on BCS, do not have to be supplemented the other ten months, rather, selection pressure on the cows have resulted in cows that flourish in this environment. The point in all of this is to illustrate that cattle raised in nutrient-limited environments may not have the same requirements as those in other environments. Therefore, maintaining a watchful eye on body condition and reproductive success will help establish or at the very least give an idea of the appropriate supplementation programs.

Maternal nutrition impacts female progeny fertility

Nutritional management of the dam during pregnancy can have long-lasting impacts on the fertility of her female offspring (Cushman et al., 2014, Roberts et al., 2016, Lopez-Valiente et al., 2019). There has been a tremendous amount of work published in recent years on the effect that maternal nutrition can have on the developing fetus. In the vast majority of the work, nutrient restriction and its influence on development was the primary focus with limited reports on the impact of overnutrition on fetal development.

Cushman et al. (2014) evaluated the impact of three levels of maternal nutrition on subsequent female progeny reproductive development. Treatments were designated as low or moderate nutrient levels during the second trimester and low, moderate or high nutrient levels during the third trimester. The moderate diet was designed to meet 100% of maintenance with low being 75% and high being 125% of maintenance as controlled by intake. Interestingly, authors did not report any deleterious effects by reducing intake by 25% (Low treatment) during the second and third trimester. Increasing energy supply to dams during the third trimester did increase their female progeny's first service conception rates. This report points out an important concept when it comes to nutrient limited environments. Namely, the finding that limiting intake by 25% of maintenance does not necessarily result in appreciable reduction in performance. This is due to the ruminant's unique ability to adapt to lower intake environments by slowing ruminal passage rate and increasing ruminal digestion of forage and feedstuffs (Scholljegerdes et al., 2004). Therefore, cattle are able to extract a greater amount of nutrients when intake is limited, as long as they are available for fermentation. This phenomenon has limitations if the forage quality is of poor quality. Grings and Roberts (2013) reported that heifers born to dams that grazed either native rangeland (6.7% CP) or seeded pasture (10.2% CP) stayed in the herd for 1,074 days versus 1,480 days, respectively. Feeding the beef female at levels below requirements must be cautioned as limiting nutrient supply can negatively impact fetal development. However, there is a point where challenging a cow's metabolic system can enhance her and her offspring's resilience to nutrient limited environments.

Roberts et al. (2016) conducted a study that supplemented pregnant beef cows at marginal or adequate levels of supplement during pregnancy and then subjected their female offspring to one of two treatments that were adequate or marginal. Heifers born to dams fed the marginal level of supplement and who were also subjected to ad libitum or 80% of ad libitum during their development period were able to remain in the herd at the same level as heifers born to dams fed at the adequate level. Interestingly heifers subjected to restricted levels of feed during the development period that were born to cows fed adequate levels during their pregnancy had a lower herd retention rate. In other words, when dams were subjected to a nutrient limited feeding program, their female progeny performed similarly no matter the nutritional level they were subjected to as heifers. Heifers that were born to dams that were adequately fed, were less resilient to restricted nutrients during their development period and did not remain in the herd as long. Taken together, these studies demonstrate that placing modest nutritional stress on the cow herd can improve the resiliency of their offspring. The keyword being modest, as greater than 20% nutrient restriction will likely have deleterious impacts on offspring. That said, it is impractical for beef producers to manage their cow herds for this level of restriction, but what this does demonstrate is that one does not need to spend an exorbitant amount of money on feed to maintain animals in a high body condition.

Overall, it is important to make certain nutritional distinctions when feeding cattle, one is to acknowledge that meeting the cow's maintenance needs is critical. Meeting the cows most basic needs can be accomplished with a wide variety of feedstuffs and it is possible to utilize feeds that provide beyond simple crude protein or energy but may provide unique types of protein or energy that enhance performance above just meeting their most basic needs.

Protein

Protein is typically considered the first limiting nutrient on rangelands in beef cow production. Forage crude protein (CP) varies throughout the year and depends on temperatures, rainfall patterns, and soil type. Therefore, nutrient limited environments can exist no matter where the operation is located.

In general, forage crude protein concentrations of 7% or greater do not provide additional benefit to the animal as measured by improvements in intake. Whereas, when forages are fed that are below 7% CP an improvement in forage intake is observed with supplemental protein (Mathis et al., 2000). When forage protein is below 7%, mixtures of urea and natural protein work well to assist the ruminal bacteria in breaking down dietary fiber. However, when forage CP is low (< 5% CP), a greater inclusion of true protein sources to that of urea is generally more useful in improving low-quality forage digestibility (Köster et al., 1997). The reason natural protein works better in low-quality forage situations is they supply branched amino acids to the ruminal bacteria, which require these to produce cellulolytic enzymes used to degrade fiber.

Supplemental protein in ruminants can be placed into two categories: 1) ruminally degradable protein (RDP) and 2) ruminally undegradable protein (RUP, also known as by-pass protein). Ruminally degradable protein is primarily utilized by the ruminal bacteria, whereas the RUP escapes ruminal degradation and travels to the small intestine of the animal and is absorbed. The ruminant has a requirement for both and one can influence the supply of the other. Most commercial feeds, depending on the region of the country, will use a combination of plant sources of protein to achieve the advertised protein level of the feed. Depending on the source of protein, the RDP or RUP level can vary. Simply meeting a cow's protein supply is important but working with nutritionists to ensure that the supply of RDP and RUP is adequate is important because there are added metabolic advantages for both.

As stated above, provision of supplemental RDP is very important to meet the needs of the ruminal bacteria. That said, there are reports in the dairy literature where high levels of RDP can be problematic when it comes to fertility and the uterine environment (reviewed by Butler, 2005). If this is true in beef cattle, it could be a major concern for ranchers who only feed two to three times per week a high protein supplement. This means that on each feed day, cows will consume large amounts of protein, which could negatively impact fertility. Cappellozza et al. (2015) investigated the impact of supplements with high levels of RDP fed daily, 3 times/week or once/week. These authors reported no negative impact on uterine pH or progesterone concentrations, which would suggest that infrequent supplementation does not cause the physiological changes previously reported in the dairy literature. Furthermore, Gunn et al. (2016) examined blood samples from 15 experiments and 1,331 beef females and found that increased blood and plasma urea nitrogen did not negatively impact first service conception rates and in some cases, actually improved conception. In general, the quality of the basal diet plus supplements offered to grazing beef females is likely going to be much lower in protein than that of a dairy-type diet. Therefore, supplements with a high level of ruminally degradable protein should not be worrisome for producers. However, high inclusion rates of urea should be avoided in supplement formulations for grazing beef cattle, particularly when grazing forages with less than 5% CP.

Geppert et al. (2017a) evaluated the impact of feeding excess CP from two sources formulated to provide low or high amounts of RUP when consuming corn stalks. Sources of RUP where soybean meal (low RUP) or corn gluten meal (high RUP). In this experiment Geppert et al. (2017a) showed that beef cows consuming corn gluten meal had greater ovulatory follicle growth post-dominance, dominant follicle size at luteolysis and shortened proestrus duration (period between luteolysis and expression of estrus). In additional study, Geppert et al. (2017b) fed corn gluten meal at a level that provided 150% of the cow's requirement for metabolizable protein (MP) while being offered cornstalks. Metabolizable protein is the supply of protein available to the tissues and is made up of RUP and ruminally bacteria that have passed out of the rumen. Authors found that feeding 150% of the MP requirement did increase circulating levels of plasma urea nitrogen but did not change duration of dominance, size at spontaneous ovulation or length of proestrus. However, ovulatory follicles were larger and cows possessed a greater antral follicle count when compared to cows fed at 125% of requirement. Commercial protein supplements contain feedstuffs that contain a mixture of RDP and RUP. If there are ingredients that include dried distillers' grains plus solubles, corn gluten meal, or animal by-products (feather meal, fish meal, porcine blood meal) they will have a greater proportion of RUP than something like soybean meal or cottonseed meal. That said, if the ability to custom formulate supplements with more by-pass protein is limited, producers are encouraged to procure individual commodities to achieve their nutritional goals.

Energy

Reproductive success is highly dependent on the nutrient status of the female. The higher brain centers that control reproductive events are sensitive to circulating concentrations of glucose. In general, ruminants do not receive a large amount of glucose from the diet due to rumen fermentation. They do however create glucose in the liver from fermentation end products (volatile fatty acids). Most range nutritionist assume that the supply of glucose comes to the animal in the form of cellulose or starch and the rangeland contains all the cellulose the animal will need. It is the job of the nutritionist and the rumen microbes to liberate the glucose that is in the forage. In other words, when the ranch was purchased, all the glucose a cow would need is stored in the forage base of the ranch. Typically, the provision of additional protein can often liberate the carbohydrate (glucose) from the plant cellulose and the animal will see an improvement in ruminal digestibility of fiber and an increase in intake. However, in times of drought or during the winter months, the cellulose can be relatively low in digestibility and no amount of protein supplement can liberate the glucose for animal use, thus, provision of additional energy becomes important. Protein supplements do contain energy, and protein itself can be used for energy. Commercial cattle protein supplements can also vary in energy. Although feed companies do not include energy content of a feed on the tag, a producer can select a supplement that contains more energy than another simply based on the protein content. For example, a 20% CP commercial cube will have more energy (TDN) than a 32% cube. This is because nutritionists will use certain ingredients that are relatively high in CP as the base ingredient and in order to make a 20% cube, they will dilute the protein using ingredients low in protein but high in TDN that are not sources of starch (e.g. wheat middlings). If forage supply is limited, then one can conclude that the cows are likely energy deficient and a 20% CP cube would be the best option. However, if forage is adequate but dormant and not green, energy is likely adequate and protein is deficient, therefore, a 32% CP supplement would be warranted. There are times that both energy and protein are deficient and something that is high in both TDN and CP is required. In extreme cases when cow intake is extremely limited, limit feeding a starch source like corn can be useful to keep energy status of the cows up. This of course must be done with extreme caution due to the high chance for digestive upsets. Chase and Hibberd (1987) demonstrated that supplementing corn at no more than 1 kg per day per animal (approximately 0.2% of body weight) did not depress fiber digestibility and increased digestible organic matter intake. Pordomingo et al. (1991) fed corn to steers grazing summer native rangeland and found that feeding at 0.2% of body weight did not negatively impact diet digestibility. Both studies demonstrated that feeding a modest amount of corn to grazing animals can increase energy density of the diet so long as it does not exceed 0.2% of body weight. Again, this feeding program must be conducted with extreme caution with animals being provided ample bunk space and feed on a daily basis or the use of an intake limiter is encouraged. The take home point here is that if the situation arises where energy is extremely low in the diet, the use of common commodities can be used if one understands how to manage feeding.

Supplemental glucogenic precursors is another way to boost glucose supply by the addition of RUP and/or propionic salts. These ingredients provide additional amino acids and glucose precursors that will improve insulin sensitivity in tissues (Waterman et al., 2006). Boland et al. (2001) conducted an extensive review of the literature and reported that energy status and glucose supply, when deficient, will reduce follicular wave cycles, lower progesterone concentrations and embryo quality. Conversely, when energy is fed in excess, similar negative physiological changes occur. Therefore, it is important to meet the energetic needs of the animal and excess energy is not beneficial.

Fat

It is often challenging to ensure that grazing ruminants meet their energy needs, particularly when forage quality is very low. In some cases, the animal cannot physically eat enough dry matter to meet energy needs. Supplementing fat is an excellent way to increase the energy density of the diet as it has 2.25 times more energy per unit than carbohydrates or protein. However, there are downside to supplementing fat. Fat is typically an expensive ingredient and on large range operations is likely cost prohibitive when included in a commercial feed. Additionally, fat, if fed above 3% added dietary fat, negative impacts on ruminal fiber digestibility have been observed (Hess et al., 2008). Nevertheless, fat or, more importantly, fatty acids are required by the animal for proper growth and reproduction. Supplemental fats have been shown to increase circulating concentrations of progesterone (Hawkins et al., 1995; Williams and Stanko, 2000) and LH (Hightshoe et al., 1991). Unfortunately, there are reports where prostaglandin (as measured by prostaglandin metabolite, PGFM) is increased with supplemental fats (Filley et al., 2000), particularly ones high in linoleic acid (Grant et al., 2005; Scholljegerdes et al., 2007). An increase in PGFM is an indicator of prostaglandin $F_{2\alpha}$ production, which, if increased high enough can cause early regression of the corpus luteum and induce a short cycle. That said, there are a number of reports summarized by Funston (2004) on the impact of fats on reproduction. The challenge for producers is to find a cheap source of fat and not to exceed 3% added fat. These sources can include oilseeds and high fat supplements. Feeding rates need to be carefully calculated as to not exceed 3% added fat. In most cases, high-fat commercial supplements would not be fed at a rate high enough to be problematic. However, oilseeds often contain up to 30% fat, which would mean that one would not want to feed over 2.5 lbs of an oilseed per head per day.

Minerals

Mineral supplementation is absolutely critical for the proper metabolic function of our beef herd. Provision of key minerals year-round ensures that our herd has ample stores of key minerals used for a plethora of metabolic functions including reproductive processes (Pugh et al., 1985). In general, most commercial mineral supplements meet the needs of cows and heifers in a normal production year. However, there are times when forage quality is such that more phosphorus, potassium or other trace minerals are required. Phosphorus is generally considered the first limiting macromineral in range forages. Other minerals, particularly the trace minerals become limited in dormant forages as well and can be sensitive to antagonists that reduce their availability (e.g. copper and Sulfur antagonism).

Source of minerals is also an important consideration. Inorganic sources are typically less available than organic sources. Although this can be overcome by increasing the concentration of inorganic sources in the mineral, this can only work to a point. In New Mexico, water sources can be extremely high in sulfur. Therefore, it is important for producers in this area to understand that additional copper in mineral supplements is important as sulfur can interact with copper and bind so that it becomes unavailable to the animal. Regular water analysis is an important component of a good mineral program along with forage analysis. Recommendations for what source is best is difficult to make in a broad sense because there are numerous reports of inorganics from a sulfate-based source being equivocal to organic sources. Where organic sources consistently improve performance when a significant antagonism or deficiency exist. Injectable trace minerals are also widely available and have shown varying results. Animals with unknown mineral backgrounds or producers wish to target specific physiological events, like breeding, have shown positive impacts. That said, injectable trace minerals still require a strong foundational mineral program.

Ahola et al. (2004) compared non-supplemented to inorganic or organic trace mineral supplement programs and their impact on reproduction in beef cows. Year had an impact on treatment outcomes and overall supplemented groups had greater pregnancy rates with no differences being observed between the inorganic and organic groups. Conversely, Stanton et al. (2000) reported an improvement in success to AI when cows received organic trace mineral supplements. Mineral source requires on ranch tests to determine best options.

Overall, mineral supplementation formulations should include the forage and water mineral composition. A high level of antagonist or very poor forage quality may necessitate the use of organic trace minerals. It is highly recommended that producers work with trusted nutritionists and feed companies to evaluate forages and water and develop a mineral program that fits their environment.

Conclusion

It is difficult to ascribe a one size fits all nutritional program to maintain or improve beef female fertility. The wide variation observed in beef production systems make development of nutritional management programs challenging to say the least. Nutritional needs are a moving target and environmental challenges exist at each physiological stage. Producers must understand the need of their own cattle and environmental constraints. Development of resiliency in individual beef herds are key to maintaining low-input costs. This is not to say animals must be improperly managed but balancing needs to optimize inputs and outputs is important for the long-term sustainability of any beef production operation. Cows that are nutritionally challenged to managed their maintenance and pregnancy/reproductive nutrient requirements and nothing more will develop a resilient animal with greater stayability for her and her offspring when compared to those that are pampered.

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Table 1. Daily nutrient requirements for growing beef heifers[1,2]

	DMI, lb/d		CP, lb/d		TDN, lb/d		MP, lb/d	
ADG	0.7 lb/d	1.9 lb/d	0.7 lb/d	1.9 lb/d	0.7 lb/d	1.9 lb/d	0.7 lb/d	1.9 lb/d
BW								
550	15.2	16.1	1.08	1.58	7.6	9.7	0.33	0.63
600	16.2	17.2	1.13	1.63	8.1	10.3	0.31	0.59
650	17.3	18.2	1.19	1.67	8.7	10.9	0.28	0.54
700	18.2	19.3	1.24	1.70	9.1	11.6	0.26	0.50
750	19.2	20.3	1.29	1.73	9.6	12.2	0.24	0.46
800	20.2	21.3	1.31	1.73	10.1	12.8	0.22	0.41

[1]DMI, CP, and TDN information are adapted from the 2000 NRC.
[2]MP information is adapted from the 2016 NASEM.

Table 2. Daily nutrient requirements for pregnant heifers (1200 lb mature body weight)

	DMI, lb/d	CP, lb/d	TDN, lb/d	MP, lb/d
Months				
1	19.3	1.39	9.75	0.94
2	19.8	1.42	10.00	0.98
3	20.3	1.46	10.29	1.00
4	20.9	1.51	10.64	1.03
5	21.5	1.57	11.05	1.07
6	22.2	1.67	11.61	1.13
7	23.0	1.81	12.37	1.24
8	23.7	2.02	13.32	1.39
9	24.4	2.35	14.62	1.63

[1]DMI, CP, and TDN information are adapted from the 2000 NRC.
[2]MP information is adapted from the 2016 NASEM.

Table 3. Daily nutrient requirements for beef cows (1200 lb mature body weight and 10 lb of milk)

	DMI, lb/d	CP, lb/d	TDN, lb/d	MP, lb/d
Months				
1	24.4	2.06	13.5	1.72
2	24.9	2.19	13.9	1.87
3	26.0	2.11	14.0	1.78
4	25.6	1.98	13.5	1.62
5	25.1	1.84	13.1	1.46
6	24.8	1.74	12.8	1.32
7	24.2	1.45	10.9	1.23
8	24.1	1.49	11.0	1.18
9	24.0	1.56	11.3	1.18
10	23.9	1.67	11.8	1.22
11	24.1	1.86	12.6	1.34
12	24.6	2.16	13.8	1.54

[1]DMI, CP, and TDN information are adapted from the 2000 NRC.
[2]MP information is adapted from the 2016 NASEM.