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USING STRATEGIC SUPPLEMENTATION TO ENHANCE COW/CALF
PRODUCTIVITY IN SUMMER CALVING HERDS IN THE NEBRASKA
SANDHILLS

by

Nicole M. Woita

A Thesis

Presented to the Faculty of
The Graduate College at the University of Nebraska
In Partial Fulfillment of Requirements
For the Degree of Master of Science
Major: Animal Science

Under the Supervision of Professors

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August, 2022

USING STRATEGIC SUPPLEMENTATION TO ENHANCE COW/CALF
PRODUCTIVITY IN SUMMER CALVING HERDS IN THE NEBRASKA
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Nicole M. Woita, M.S.

University of Nebraska, 2022

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Young range beef cows consuming low-quality forage may result in an imbalance of energy and metabolizable protein, which can negatively affect the nutrient status of the cow and reproductive performance. In a 2-yr study conducted at Gudmundsen Sandhills Laboratory near Whitman, NE, 2- and 3-yr-old May-calving range cows ($n = 181$) grazing native range were individually supplemented daily with one of four supplements: 1) mineral with a target intake of 113 g/d (MIN), 2) MIN with 200 mg per head of Rumensin to with a target intake of 113 g/d (RUM), 3) MIN with a 226 g/d of high RUP sources with a target intake of 340 g/d (RUP), or 4) dried distiller grains at a rate of 907 g/d (DDG). Each year, supplementation started approximately 30 d before the breeding season and continued throughout the 45-d breeding season. Cow body weight (BW), body condition score (BCS), and blood samples were taken biweekly beginning 40 d postpartum and ending 125 d postpartum. Milk production was collected at approximately 60 d postpartum. Cow BW, BW change, and BCS were not different ($P \geq 0.29$) between supplementation treatment. Pregnancy rates were 82, 83, 92, and 89% for MIN, RUM, RUP, and DDG fed cows, respectively ($P = 0.76$). Calf BW at birth, 60-d BW, and 205-d BW were not affected ($P \geq 0.19$) by dam supplementation. Cows receiving DDG had increased ($P = 0.05$) circulating serum glucose concentrations compared to MIN, with no difference between RUM and RUP. Cows receiving DDG and RUP had increased ($P = 0.01$) circulating serum urea nitrogen concentrations. Postpartum supplements did not affect ($P = 0.13$) circulating serum non-esterified fatty acid concentration. Milk production was not affected ($P \geq 0.11$) by postpartum supplements. The results from this study suggest that supplying RUP, energy, or ionophores did not increase cow BW or BCS but, cows were able to maintain these metrics. However, additional protein and energy tended to increase glucose and serum urea nitrogen. The

number of years and cows in this study may not have been enough to find differences among supplementation strategies; however, additional years and data may change observed results in this study.

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“Have I not commanded you? Be strong and courageous. Do not be frightened, and do not be dismayed, for the Lord your God is with you wherever you go.” – Joshua 1:9

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CHAPTER I. REVIEW OF LITERATURE

Introduction

For many years, it has been accepted that the interaction between reproduction and nutrition in beef cows were controlled by energy intake and body energy reserves of beef cows (Wiltbank et al., 1962). Energy requirements of the cow are increased by lactation and additional energy is required for growth and maintenance requirements in young cows. Exposure to environmental stresses such as extreme weather conditions, reduced forage availability, and limited precipitation creates periods of nutritional stress (Hawkins et al., 2000). These environmental stress factors create nutritional challenges during the breeding season for young cows having the inability to consume enough energy to meet their nutrient requirements for maintenance, lactation, and growth (Linden et al., 2014). Thus, nutritionally challenged range cows may result in cows being in a negative energy balance during the breeding season, which can result in increased cows culled from the herd due to decreased pregnancy rates. Efficient productive performance in young cows is difficult since a young cow has not yet reached her mature weight and requires more nutrients for reproduction and growth. Thus, resulting in a 20 to 40 d delay to resume estrous (Wiltbank, 1970) and lower pregnancy rates compared to mature cows. Culling cows before 5 years of age negatively impacts reproduction efficiency, resulting in more years of production to offset those production costs (Roberts et al., 2015). In addition, reproductive performance is one of the biggest factors affecting beef cow production efficiency and profitability (Roberts et al., 2015).

Researchers have demonstrated that reproductive success in nutritionally stressed beef cattle could be improved by increased energy intake during the postpartum interval (Wiltbank et al., 1964). Supplementation with energy, rumen undegradable protein or ionophores, have been shown to have direct effects on reproductive performance in beef cows (DelCurto et al., 2000). These effects involve improved conception rates (Wiley et al., 1991; Triplett et al., 1995) or reduced age at puberty (Lalman et al., 1993). Providing supplements when nutrient availability of the forage is unable to meet the demands of the cow, can also, result in improvements in reproductive performance (Hawkins et al., 2000). Therefore, by providing strategic supplementation to young cows to optimize nutrient utilization and reproductive efficiency, opportunities to increase the financial viability of the enterprise are available.

Nutrient Requirements for May-calving Young Range Cows

Cow nutrient requirements change with physiological stage throughout the production cycle, with increased nutrient requirements occurring at peak lactation and then late gestation (NASEM, 2016). The stress of calving and combined effects of growth and lactation create nutritional challenges that are often not met when cows graze low-quality forages. Thus, inadequate nutrient intake before or after calving has greater detrimental effects on postpartum reproduction in primiparous than in multiparous cows (Ciccioli et al., 2003). The need of primiparous beef cows to grow and lactate makes them different than the multiparous cow, requiring them to have an increase in energy (Freetly et al., 2006) and metabolizable protein (NASEM, 2016) requirements. There are two distinct periods of maintenance requirement differences for net energy maintenance (NEm) and metabolizable protein (MP) requirement, when the cow is lactating and

nonlactating. About a 20% difference of maintenance requirements exist between these two periods (NASEM, 2016). This increased maintenance requirement associated with lactation is due to the increased metabolic demand upon body tissues and not the production of milk. The range in maintenance energy requirements for grazing cattle could be from 10 to 50% depending upon the grazing conditions and forage availability (Hersom et al., 2011).

Nutrient Utilization of Beef Cows

Ruminants are obligate herbivores whose evolutionary success has, in large part, resulted from their pregastric, fermentative mode of digestion. This allows them to efficiently utilize cellulose and other fibrous feed components, and derive much of their protein requirements from digestion of rumen microbes (Bell and Bauman, 1997). After the consumption of feedstuffs, nutrients are broken down and absorbed by the animal, and then utilized by body tissues for maintenance, growth, and reserves including energy stores, glucose reserves, and amino acid reserves (Bauman and Currie, 1980). Utilization of these nutrients are dependent on the physiological stage, age of the animal, and nutrient availability. Physiological stages of lactation and gestation result in increased demand for nutrients from the fetus and mammary tissues. This is an example of homeorhesis, changes in metabolism to match the demands of the physiological stage (Bauman and Currie, 1980).

Reproductive performance is dependent on variables such as quantity and quality of feed intake, nutrient reserve stores in the body and competition for nutrients from other physiological functions besides reproduction, using energy as a variable (Short et al., 1990). Short et al. (1990) stated that allocation of nutrients to various body functions is

commonly referred to as nutrient partitioning and proposed that nutrients are partitioned by priority to first maintain life and then to propagate the species. These authors proposed the approximate order of nutrient priority to be: 1) basal metabolism, 2) activity, 3) growth, 4) basic energy reserves, 5) maintenance of pregnancy, 6) lactation to support existing offspring, 7) additional energy reserves, 8) estrous cycles and initiation of pregnancy, and 9) excess energy reserves. However, priority of these nutrients can be altered depending on energetic cost, physiological state, and environmental changes that may occur.

Synthesis and catabolism of body energy reserves has an energetic cost, which is assumed that maintaining body weight is biologically more efficient (NASEM, 2016). Efficiency of energy retention in cows in a nutrient restriction, followed by nutrient realimentation, has been shown to not differ from cows fed to maintain energy balance in mature nonpregnant and nonlactating beef cows (Freetly and Nienaber, 1998). Freetly et al. (2008) did not observe a difference in intake between pregnant primiparous beef cows fed at a low-high weight gain versus cows fed for moderate weight gain using different patterns of BW gain. These authors concluded that the ability of the cow to adapt energy metabolism during periods of moderate feed restriction and realimentation allows development of management strategies that alter the time interval of the production cycle.

To match the energy demands of maintenance and physiological stage, ruminants utilize volatile fatty acids (VFA), glucose, and protein. Volatile fatty acids are byproducts of the microbes during pregastric fermentation. The primary VFA produced by the microbes are acetate, propionate, and butyrate. Upon absorption through the rumen wall, the utilization of the VFA differs (Preston and Leng, 1978). Propionate is the primary

precursor for gluconeogenesis and 80-95% of it is absorbed, via the ruminal epithelium into the portal bloodstream, then transported to the liver and converted into methylmalonyl-CoA, succinate, and oxaloacetate. However, acetate and butyrate do not contribute to glucose supply (NASEM, 2016). Butyrate is metabolized by the ruminal epithelium with the production of ketone bodies, which are absorbed and oxidized in many tissues for energy production (NASEM, 2016). Acetate is the main precursor for lipogenesis (Bergen and Mersmann, 2005) and small amounts of acetate absorbed from the rumen also, contribute to the formation of ketone bodies (NASEM, 2016).

Diets of low-quality forage give rise to a high rumen production rate of acetate relative to that of propionate (Cronjé et al., 1991), resulting in a decrease in energy metabolism. As discussed previously, propionate is the primary precursor for gluconeogenesis. Therefore, propionate needs to be in sufficient quantities to satisfy glucose energy demand for metabolism (Leng et al., 1967). Propionate goes through several anabolic and catabolic reactions, which is the central process for energy metabolism. 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 (Mulliniks, 2008). Ketones 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 has been shown to impair insulin action in rat cardiomyocytes (Tardif et al., 2001).

Glucogenic potential of the diet is evaluated by an acetate tolerance test, which illustrates the relationship between glucose and acetate metabolism. Glucose enters the adipose or muscle cells via an insulin dependent transporter (GLUT 4) and enters glycolysis to be converted to oxaloacetate. Once insulin binds to its receptor on the cell membrane, it will stimulate a chain of events in which GLUT 4 vesicles go to the membrane and uptakes glucose into the cell. Acetate enters the cell via diffusion across a concentration gradient to enter the TCA cycle as acetyl- CoA. For efficient and complete oxidative metabolism to occur in ruminants, cellular oxaloacetate is essential for the conversion of acetyl-CoA resulting from ruminal acetate or fatty acid catabolism, to be converted to adenosine triphosphate (ATP) in the TCA cycle (Mulliniks and Beard, 2019). If the diet is high in glucogenic potential, more glucose will be available to maintain the supply of oxaloacetate to clear acetate from the cell through the TCA cycle, thus creating a concentration gradient for the diffusion of acetate into the cell, and infused acetate would be expected to clear faster. If the glucogenic potential is low, less glucose will be available to the cell and the concentration gradient will be lost, thus circulating blood acetate would be expected to clear more slowly (Mulliniks, 2008). Therefore, acetate utilization is dependent upon glucose supply due to this requirement of oxaloacetate (Preston and Leng, 1978).

Cows grazing on native range pastures after calving can lose BW at a rate close to 0.454 kg per day, due to an imbalance of nutrient demand (especially milk production) compared to nutrient intake (Petersen et al., 1995). Body weight loss can occur after calving to supply nutrients for milk production due to the potential decrease in forage quality and quantity. If the period of BW loss is extended before the breeding season, the

duration of anestrus will also be extended (Petersen et al., 1995). To ensure that BW loss does not occur, along with an extended anestrus, nutrient requirements of protein and energy need to be met. Cows that receive sufficient amounts of protein and energy are more likely to experience: 1) earlier positive BW change, 2) less tissue protein catabolized, 3) cows may become pregnant sooner, and 4) increased weaning weights (Petersen et al., 1995). Therefore, the nutrient status of the animal is communicated to the reproductive system.

Dynamic changes in nutritional and physiological stressors create nutritional and metabolic challenges, in which failure to cope and adapt to those challenges can result in decreased production efficiency (Mulliniks and Beard, 2019). Range livestock are dependent on the quality and quantity of forage produced on a given rangeland. Forage production is reliant on timing and amount of precipitation, optimal temperatures to promote plant photosynthesis for growth, soil type and nutrient availability, and soil microbial activity that aids in nutrient supply to plant roots, among other factors (Mulliniks et al., 2016). During certain seasons a cow's nutrient and forage availability may become limited in environments.

In the Nebraska Sandhills, later calving seasons are prevalent to avoid calf death loss from inclement early spring weather and to see a reduction in labor, feed, and winter cost. May-calving cows in the Sandhills have an advantage to March-calving cows due to calving in a greater plane of nutrition prepartum and immediately postpartum. However, May-calving cows grazing native upland range tend to be nutrient deficient in July and prior to the start of the breeding season. As the native upland range forage begins to mature as summer months progress, the forage leads to an imbalance of energy and MP

as they are not meeting cow requirements. For instance, May-calving cows are estimated to be deficient in both energy and MP balances (Mullinks and Adams, 2019). Depending on the level of milk production during early lactation, estimated net energy balance can be as low as -6 Mcal/d and MP as low as -300 g/d. Due to their decreased nutrient intake during breeding, May-calving herds typically have lower pregnancy rates compared to March-calving herds in the Nebraska Sandhills (Springman et al., 2018).

Low-quality forage and an imbalance of energy and MP during the breeding season, can result in a negative energy balance (NEB). As a result, cows lose BW and BCS due to mobilization of fat and catabolism of body tissues. These body tissues will become less responsive to the actions of insulin, which results in a longer glucose half-life (Waterman et al., 2007), inadequate gluconeogenesis, and depletion of oxaloacetate. The restricted supply of oxaloacetate redirects metabolism of acetate from ATP production and causes a reduction in energy efficiency due to increases in serum beta-hydroxybutyrate (BHB) or ketone concentrations. Plasma glucose declines to a limited extent compared to other metabolites (Miner et al., 1990; Wiley et al., 1991). Additionally, blood urea nitrogen (BUN) elevation will exceed the decline in blood glucose and amine groups will be released during amino acid carbon utilization for gluconeogenesis or oxidative metabolism (Hawkins et al., 2000). Due to this series of events, the growth hormone becomes elevated, resulting in tissue catabolism and the decline of gluconeogenesis, insulin, and insulin-like growth factor I (IGF-I). A decrease in IGF-I can lead to a reduction of progesterone synthesis and release of gonadotropins. Insulin-like growth factor I is a hormone that may be involved in the effects of nutrition

on reproduction (Strauch et al., 2003) as a potential endocrine regulator of return to estrous cyclicity in postpartum cattle (Spicer et al., 2002).

The greater amplitude of adaptive responses or increased plasma concentrations of non-esterified fatty acids (NEFA), BHB, and IGF-I in high response (high NEFA cows) cows may indicate a rapid ability for the sufficient supply of mobilization-derived nutrients (Mullinks et al., 2016). Greater NEFA concentrations in cows indicate mobilization of body fat from reserves for additional energy, which corresponds with the reduction in BCS (Radunz et al., 2010). The massive mobilization of NEFA from adipose tissue during and after parturition is the metabolic hallmark of the transition from pregnancy to lactation (Bell, 1995). High levels of NEFA can be correlated with an increase in milk production and longer interval to first ovulation (Vizcarra et al., 1998). Increased milk production will ultimately increase mobilization of body reserves and lower reproductive performance (Mulliniks et al., 2011). It is an enormous metabolic burden for a lactating range cow to synthesize glucose in a NEB to support milk production, especially for younger cows who are still growing.

Protein Supplementation Strategies

Protein and energy are often limiting nutrients when forage quality is declining in semi-arid environments, and supplementation of these nutrients can improve cow performance by increasing or maintaining BW and BCS, decrease days to first estrus and, increase pregnancy rates in primiparous cows (Wiley et al., 1991; Mulliniks et al., 2013; McFarlane et al., 2018; Waterman et al., 2006). Supplementation can be utilized strategically to elicit a metabolic response, which can positively alter important economic production traits such as conception and overall pregnancy rates (Mulliniks and Beard,

2019). Response of beef cattle to protein supplementation depends on the type of supplemental protein (RUP vs. RDP), forage quality and species, cow age, and physiological state.

For protein supplementation to be effective, one must supply the minimum requirement of rumen degradable protein (RDP) to the rumen to meet the nitrogen (N) requirements of ruminal microbes. Once RDP requirements are met, additional RDP does not increase amino acid flow to the small intestine (Mulliniks, 2008). Mathis et al. (2000) observed no effect of increased RDP supplementation when warm season hay was supplied, suggesting that with low-quality forages a decreased concentration of RDP is required. Therefore, feeding rumen undegradable protein (RUP) after meeting the requirements for RDP can increase the supply of MP if the requirement is not met by microbial protein. Metabolizable protein is defined as the true protein digested in the intestine, supplied by microbial protein and RUP (NASEM, 2016). By providing additional MP by supplementation of RUP, it can encourage repartitioning of nutrients away from lactation (Hunter and Magner, 1988; Triplett et al., 1995) or promote synthesis of maternal tissues for maintenance, growth, or reproduction by improving nutrient utilization (Miner et al., 1990; Wiley et al., 1991).

Sawyer et al. (2012) concluded that 40 g/d of CP from a high RUP supplement can replace 160 g/d of CP of a RDP supplement and maintain ruminal function. The different protein sources fed at the same quantity, showed similar rates of forage disappearance suggesting that only a small amount of RDP was required. Thus, protein sources that are greater in RUP may improve CP efficiency when fed at lesser amounts and could be added to a supplemental program for maintenance of beef cows grazing

dormant rangeland in extensive environments. In agreement, mature range cows fed a high RUP supplement at a lower amount had similar BW and BCS during late gestation as cows fed greater amounts of RDP (Mulliniks et al. 2012). Miner et al. (1990) reported that supplementing late gestation cows during the winter with RUP supplements may reduce BCS and BW loss, concluding that the addition of RUP to RDP may provide enhanced resistance to environmental and physiological (pregnancy) stress.

Wiley et al. (1991) reported that feeding 2-yr-old lactating cows a RUP supplement resulted in greater weight gains, shorter postpartum interval, and greater conception rates compared to cows receiving a RDP supplement. When RUP supplements are fed to young, postpartum beef cows, more nutrients may be available for tissue growth, thus partitioning nutrients to reproduction and allowing for shorter postpartum intervals. Hunter and Magner (1988) speculated that feeding RUP protein after the first 8-week postpartum repartitioned nutrient use away from milk production to maternal growth by changing insulin and growth hormone concentrations. These authors also observed greater BW gains and shorter postpartum intervals with feeding RUP supplements. Patterson et al. (2003) supplemented 2-yr-old cows to meet MP or RDP requirements and also reported that postpartum BW gain was greater for RUP supplemented cows compared to RDP supplemented cows. These authors also reported a 6%-point increase in pregnancy rates for RUP supplemented 2-yr-old cows.

Studies have suggested that RUP supplementation to postpartum cattle may increase milk production, but a high amount of RUP supplementation may stimulate BW gain at the expense of milk production (Hersom et al., 2011). Blasi et al. (1991) showed that 230 g/d of RUP supplemented to lactating cows increased milk production, but 340

g/d of RUP decreased milk production. Triplett et al. (1995) fed three levels of RUP (low, medium, and high) to evaluate the influence RUP has on production characteristics and reproductive performance. Heifers consuming the medium RUP supplement responded to the increased RUP in their diet with an increase in milk production, while the heifers consuming the high RUP did not and had a decrease in milk production.

Rumen undegradable protein supplements have been shown to act more as a catalyst of metabolic and hormonal activity than as a nutrient satisfying protein requirement for milk production and BW (Wiley et al., 1991). Hawkins et al. (2000) stated that feeding protein supplements with RDP can result in increased acetate production, exacerbating the inefficiencies in animal metabolism due to imbalances in acetate and glucose. A strategy such as this could result in an increase in microbial protein flow and possibly increase availability of glucose precursors. However, supplementation of protein high in RUP will more predictably alter the composition of metabolizable nutrients, by increasing the supply of MP and potential glucose precursors to the animal. Strategic feeding of glucose precursors or compounds that can spare glucose oxidation should reduce the demand for glucose by the mammary gland, thereby sparing glucose for other uses, especially those involved with reproduction (Hawkins et al., 2000). Glucose is one of the most important metabolic substrates for proper function of the reproductive process in beef cows (Short and Adams, 1988). Insulin is a promoter of glucose metabolism and can be used to understand the nutritional status of the animal. Insulin is a hormone, secreted from the pancreas, that allows nutrients into tissues after nutrient concentration in the blood increases following eating. Rumen undegradable protein supplements have shown to be a potent stimulator of insulin release (Petersen et

al., 1995), resulting in reductions in BW loss and repartition of nutrients to maintenance or replacement of body tissues. Insulin also stimulates re-esterification of fatty acids by increasing uptake of glucose into adipose tissue and inhibiting mobilization of fatty acids (Hawkins et al., 2000). Greater circulating insulin levels change the response and sensitivity of fat tissue, resulting in a decrease of mobilization. However, for supplemental RUP to be effective, animals may need to be in a NEB for it to influence nutrient metabolism. Animals in a NEB receiving supplemental protein are more capable of coping with nutritional stresses, due to an improvement in the efficiency of body energy depot utilization and protection of endogenous protein stores (Hawkins et al., 2000).

Protein and Energy Supplementation Strategies

Although protein supplements provide energy and may stimulate additional energy intake, generally the term “energy supplement” refers to either cereal grains or by-products of the grain milling industry (Bowman and Sanson, 1996). Energy supplementation is often practiced during summer dormancy and in winter months to maintain desired production levels or minimize losses. Providing additional energy in the form of supplement has often produced reductions in intake of grazed forages (Caton and Dhuyvetter, 1997) and may alter energy requirements of grazing ruminants by altering grazing behavior or by influencing efficiency of nutrient use (Caton and Dhuyvetter, 1996). Inclusion of supplemental energy in the form of starch may decrease the amount of time spent grazing, but greater concentrations of starch can have a negative associative effect on fiber digestibility. Declining ruminal pH associated with increasing dietary starch should affect the ruminal bacteria toward greater amylolytic and lower cellulolytic

and fibrolytic populations, resulting in a reduction of fiber digestion (Caton and Dhuyvetter, 1997). High concentrations of starch could encourage rapid growth of amylolytic microbes that require amino acids, which in turn would limit availability of amino acids and ammonia nitrogen required for fibrolytic microbes (Hoover, 1986).

Supplementation with fibrous by-product feedstuffs that contain low levels of non-structural carbohydrates has been shown to have less negative impact on forage intake, fiber digestibility, and ruminal pH than starch-based energy supplements (Bowman and Sanson, 1996; Caton and Dhuyvetter, 1997). Marston et al. (1995) supplemented 1.22 kg/d of a 20% CP soybean hull-based supplement (energy) or 2.44 kg/d of a 40% CP soybean meal-based supplement (protein) to postpartum beef cows. These authors reported that BW gains were greater for energy-fed cows than protein-fed cows during gestation and the breeding season. Milk production was also greater for cows fed energy than those fed protein. Feeding additional energy also resulted in a greater incorporation of rumen ammonia and amino acids into microbial protein, resulting in reduced losses of N from the rumen. Radunz et al. (2010) supplemented 3 dietary energy sources: grass hay (high fiber concentration; HAY), limit-fed corn (high starch concentration; CORN), or limit-fed corn DDGS (high fiber, protein, and fat concentrations; DDGS). Cows fed DDGS gained more BW than cows fed HAY and CORN. Supplementation of DDGS also resulted in a greater amino acid absorption post-ruminally and ruminal propionate production, due to the increase of insulin secretion. Dried distiller grains is not only a good source of energy, but it is also high in RUP.

Reproductive success in nutritionally-stressed beef cows has been shown to be improved by increased energy intake during the postpartum interval (Wiltbank et al.,

1964). Energy intake during early lactation and through the breeding season has been shown to increase pregnancy rates while increasing the number of cows returning to estrus before the start of breeding (Wiltbank et al., 1964; Dunn et al., 1969). Marston et al. (1995) reported that cows fed a soybean hull-based energy supplement had greater pregnancy rates than cows fed a soybean meal-based protein supplement (90 vs 80%). Similarly, cows consuming a high-energy diet for 70 days postpartum not only resumed ovarian activity earlier after calving, but also had greater pregnancy rates from artificial insemination (AI) at the first estrus compared to cows that received a 38% CP range cake (Ciccioli et al., 2003). Vizcarra et al. (1998) proposed that cows fed to gain 0.9 kg/d versus 0.45 kg/d from parturition to breeding, had greater postpartum nutrition, increased energy intake, and increased propionate production. This increase in propionate resulted in an increase in insulin concentrations during the breeding season, resulting in an increase in reproduction efficiency. However, the effect of energy and protein supplementation on 2- and 3-yr-old summer calving range cows performance during postpartum has not been broadly examined.

Feed Additive Supplementation Strategies

Ionophores are antibiotics that affect gram positive bacteria, protozoa, and fungi in the rumen. When ionophores are added to a diet they change the profile of fermentation products by selectively inhibiting growth of gram-positive bacteria, which produce acetate, lactate, and hydrogen in the rumen (Schelling, 1983). This favors growth of gram-negative bacteria and production of propionate (Schelling, 1983). This mode of action improves the efficiency of nutrient use (Huntington, 1997) and allows the animal to capture more dietary nutrients for growth and production (Kunkle et al., 2000). The

most common ionophore feed additives fed to cattle are monensin (Rumensin[®]) and lasalocid (Bovatec[®]). Three changes that occur with ionophore use are 1) increased production of propionate and decreased production of methane 2) decreased protein degradation and amino acid deamination, and 3) decreased production of lactic acid (Huntington, 1997). Furthermore, supplementation of monensin has been shown to increase the metabolizable energy of the diet by increasing the ratio of propionate to acetate and butyrate produced in the rumen (Lemenager et al., 1978).

Ionophores have been shown to increase BW gains and feed efficiency in beef cattle without any detrimental effect on other measures of performance such as fertility and milk production (Sprott et al., 1988). However, cow BW, BCS, and forage intake responses to ionophore supplementation are dependent on forage quality and physiological stage of the cow (Sprott et al., 1988). Moseley et al. (1977) supplemented a 20% natural protein range cube that carried either 0 mg or 200 mg of monensin per head daily. These authors proposed that monensin supplementation may be beneficial as a means of increasing BW gains on forage-based diets when feed intake is restricted by forage availability and cattle are maintained on a low plane of nutrition. In a review, Goodrich et al. (1984) indicated that on average, a 13% improvement in BW gains and beef cows are able to maintain on approximately 10% less feed in response to monensin.

Use of ionophores in diets have also shown positive effects on reproduction. In the study conducted by Hixon et al. (1982), one of their objectives was to determine the effects of monensin supplementation on nutritional and reproductive measurements on energy-stressed primiparous range cows. These authors reported that inclusion of 200 mg/d of monensin with a creep diet consisting of cracked corn, crushed oats, dried

molasses, and linseed pellet in the diet improved feed efficiency, resulting in net energy available for gain. The increase in energy resulted in increased birth weights, which led to an increase in calving difficulty. However, supplementation of monensin decreased PPI, milk yield, and BCS at 120 d postpartum. In a review, Sprott et al. (1988) suggested that the impact of ionophores on PPI may be due to the impact of ionophores on BCS and BW gain during the supplemental feeding period. However, the effect of adding Rumensin to mineral to summer calving cows on range pasture during postpartum has not been evaluated.

Conclusion

Nutrition and reproduction are the most important factors affecting the financial viability of a cow-calf enterprise. The demands of growth and lactation in young May-calving cows may result in deficiencies of energy and MP, potentially resulting in a failure to return to estrus and to conceive. To maintain a 365 d calving interval and a profitable enterprise, cows must return to estrus and conceive by day 80 to 85 d postpartum. In the Nebraska Sandhills when forage quality starts to decline in July and throughout the breeding season, reproductive success in young cows is hardly achieved without supplementation to meet nutrient demands. Supplementation strategies of RUP, energy, or ionophores may be used to improve energy balance allowing nutrients to meet lactation demands and excess nutrients partitioned towards reproductive success. However, further research needs to be conducted to determine if these supplementation strategies can improve nutrient utilization and reproductive performance in young May-calving cows grazing Nebraska Sandhills native upland range.

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CHAPTER II. The effect of postpartum supplementation strategy on performance in
May-calving 2- and 3-yr-old range cows

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Abstract:

Young range beef cows consuming low-quality forage may result in an imbalance of energy and metabolizable protein, which can negatively affect the nutrient status of the cow and reproductive performance. In a 2-yr study conducted at Gudmundsen Sandhills Laboratory near Whitman, NE, 2- and 3-yr-old May-calving range cows (n = 181) grazing native range were individually supplemented daily with one of four supplements: 1) mineral with a target intake of 113 g/d (MIN), 2) MIN with 200 mg per head of Rumensin to with a target intake of 113 g/d (RUM), 3) MIN with a 226 g/d of high RUP sources with a target intake of 340 g/d (RUP), or 4) dried distiller grains at a rate of 907 g/d (DDG). Each year, supplementation started approximately 30 d before the breeding season and continued throughout the 45-d breeding season. Cow body weight (BW), body condition score (BCS), and blood samples were taken biweekly beginning 40 d postpartum and ending 125 d postpartum. Milk production was collected at approximately 60 d postpartum. Cow BW, BW change, and BCS were not different ($P \geq 0.29$) between supplementation treatment. Pregnancy rates were 82, 83, 92, and 89% for MIN, RUM, RUP, and DDG fed cows, respectively ($P = 0.76$). Calf BW at birth, 60-d BW, and 205-d BW were not affected ($P \geq 0.19$) by dam supplementation. Cows receiving DDG had increased ($P = 0.05$) circulating serum glucose concentrations compared to MIN, with no difference between RUM and RUP. Cows receiving DDG and RUP had increased ($P = 0.01$) circulating serum urea nitrogen concentrations. Postpartum supplements did not affect ($P = 0.13$) circulating serum non-esterified fatty acid concentration. Milk production was not affected ($P \geq 0.11$) by postpartum supplements. The results from this study suggest that supplying RUP, energy, or ionophores did not

increase cow BW or BCS but, cows were able to maintain these metrics. However, additional protein and energy tended to increase glucose and serum urea nitrogen. The number of years and cows in this study may not have been enough to find differences among supplementation strategies; however, additional years and data may change observed results in this study.

Key words: reproductive performance, postpartum supplementation, nutrient status

Introduction

Young May-calving cows grazing primarily dormant native upland range in the Nebraska Sandhills can experience a negative energy balance (NEB) postpartum and throughout the breeding season. As the native upland range forage begins to mature as summer months progress, the forage quality declines resulting in an imbalance of energy and metabolizable protein (MP) thus, the forage does not meet a young, lactating cows requirements (Mulliniks and Adams, 2019). In addition, young cows have an increased energy demand due to energy requirements to support maintenance, growth, and lactation (Bauman and Currie, 1980; Ferrell and Jenkins, 1985) but, have the inability to consume enough forage (energy) to meet these requirements (Linden et al., 2014). Thus, putting these cows in a NEB during the breeding season and increasing the risk for body weight (BW) loss and reproductive failure. Therefore, a beef cow's nutritional needs may not be met by forage alone, and thus strategic supplementation is necessary to minimize these deficiencies and increase cow performance. Previous research in the Nebraska Sandhills has shown that supplementation of a 32% crude protein (CP) supplement to young May-calving range cows during the breeding season resulted in pregnancy rates as low as 71% (Lansford et al., 2017). Supplementation of specific compounds such as, energy, rumen undegradable protein (RUP) or ionophores, have shown to have direct effects on reproductive performance in beef cows (DelCurto et al., 2000). Supplemental RUP can

serve to meet MP requirement and thus decrease days to first estrus, BW loss, (Wiley et al., 1991) and may increase first-service conception rates as shown in first-calf heifers (Triplett et al., 1995). In addition, supplementation of monensin has been shown to increase the metabolizable energy of the diet (Lemenager et al., 1978), resulting in an increase in BW and BCS and reduced postpartum interval (Sprott et al., 1988). Our hypothesis was that postpartum supplementation of either RUP, energy, or rumensin to young cows will result in maintenance or improvement of BCS and BW, improve reproductive performance, and offset nutrient deficiencies. The objectives of this study were to determine the effects of supplementation strategies on reproduction, milk production, circulating serum metabolites, and calf performance in young lactating May-calving range cows.

Materials and Methods

All animal care and management procedures were reviewed and approved by the University of Nebraska Institutional Care and Animal Use Committee (IACUC approval number 1787).

Site Description

Warm-season grasses dominate upland range pastures at the University of Nebraska Gudmundsen Sandhills Laboratory (GSL), Whitman, NE. The primary plants on range pastures include little bluestem [*Andropogon scoparius* (Michx.) Nash], prairie sandreed [*Calamovilfa longifolia* (Hook.) Scribn.], sand bluestem (*Andropogon halli* Hack.), switchgrass (*Panicum virgatum* L.), sand lovegrass [*Eragrostis trichoides* (Nutt.) Wood], and blue grama [*Bouteloua gradis* (H.K.B.) Ex Griffiths]. Subirrigated meadows at GSL are dominated by cool season grasses, including slender wheatgrass [*Elymus*

trachycaulus (Link) Matte], redtop bent (*Agrostis stolonifera* L.), timothy (*Phleum pratense* L.), Kentucky bluegrass (*Poa pratensis* L.), and smooth brome (*Bromus inermis* Leyss.) (Griffin et al., 2012). Average annual precipitation at GSL from 2005 to 2017 was 54.09 cm with an SD of 16.60 cm. Upland, native range pastures at GSL were stocked at 0.6 animal unit months (AUM), whereas sub-irrigated meadows were stocked at 3.0 AUM.

Cow Management

This study was conducted over a two-year period (2020 to 2021) utilizing 2- and 3-yr-old range beef cows from the May-calving herd at the University of Nebraska Gudmundsen Sandhills Laboratory (GSL) located near Whitman, NE. Cows (n = 181) were Husker Reds (5/8 Red Angus, 3/8 Simmental) in their first or second parity. Cows were stratified by calving date, cow body weight (BW), and age, and assigned randomly to a supplementation treatment. Supplementation was offered 30 days prior to the start of the breeding season (45-d postpartum) and throughout the 45-d breeding season (125-d postpartum). Supplementation was provided daily with treatments being: 1) mineral with no additive for a negative control at a targeted intake of 113 g/d (**MIN**; Ag Valley CO-OP, North Platte, NE), 2) MIN with Rumensin (200 mg per cow) with a targeted intake of 113 g/d (**RUM**; Ag Valley CO-OP, North Platte, NE), 3) MIN (113 g/d) with an additional 113 g/d of blood meal and 113 g/d of feather meal with a total daily targeted intake of 340 g/d (90% CP, **RUP**; Ag Valley CO-OP, North Platte, NE), or 4) dried distiller grains at a targeted intake of 907 g/d (30% CP, **DDG**; Central Valley Ag, Ainsworth, NE). Treatments RUP and DDG were designed to be isonitrogenous with DDG to be supplying increased dietary energy. Costs of each supplementation strategy

were calculated to determine \$/head/day (Table 2.1). Supplement was offered daily using the Super SmartFeed (SSF; C-Lock Inc., Rapid City, SD). The SSF is an electronic individual feeding system that drops an allotted amount of feed upon reading the cow's electronic identification (EID) tag. Once allotted daily supplement was consumed, cows were not dispensed any more supplement. Cows that consumed <15% of the feed provided per week were removed from the trial. This resulted in removal of data for 69 cows (20 MIN, 15 RUM, 26 RUP, 8 DDG; respectively).

Approximately d 40 postpartum, biweekly cow (BW) and body condition score (BCS; 1 = emaciated, 9 = obese; Wagner et al., 1988) by palpation were measured and recorded. One trained technician assigned BCS for both years of data collection. Biweekly blood samples were collected via coccygeal venipuncture into serum separator vacuum tubes (Greiner Bio-One, Kremsmünster, Austria). Samples were centrifuged at 2,500 x g at 4°C for 20 min. Serum was removed and stored at -20°C until further analysis. Non-esterified fatty acid (NEFA) and glucose were analyzed using a 96-well enzyme-linked immunosorbent assay (WAKO Diagnostics, Richmond VA; MedTest Dx, Canton, MI; Sigma-Aldrich, St. Louis, MO). Serum Urea Nitrogen (SUN) were analyzed by a Vitros – 250 Chemistry Analyzer (Ortho Clinical Diagnostics, Linden, NJ) by the University of Nebraska Biomedical and Obesity Research Core.

Forage samples of upland native range were taken at the start and at the end of the supplementation period. Forage samples were collected with 3 esophageal cannulated cows grazing for 30 min on pasture of use. After grazing, bags were removed and extrusa were collected with excess saliva hand squeezed from each sample. Samples were freeze-dried and ground through a 1-mm screen of a Wiley mill. Samples were analyzed in a

commercial laboratory (Ward Labs, Kearney, NE) for crude protein (CP) and total digestible nutrients (TDN; Table 2.2). Analysis for neutral detergent fiber (NDF) was conducted using the ANKOM filter bag technique (ANKOM Technology, Macedon, NY; Table 2.2).

At birth, calves received a 7-way clostridial vaccine (Alpha 7, Boehringer/Ingelheim, Duluth, GA). At branding, calves were castrated and received vaccinations for infectious bovine rhinotracheitis, bovine viral diarrhea types I and II, bovine parainfluenza 3 virus, bovine respiratory syncytial virus, Mannheimia haemolytica, and Pasteurella multocida (Bovi-Shield Gold One Shot, Zoetis, Parsippany – Troy Hills, NJ). At pre-breeding, calves received a vaccination of a 7-way clostridial (Vision 7, Merck, Kenilworth, NJ) and an injectable de-wormer (Cydectin, Bayer Leverkusen, Germany). At weaning, calves received one vaccination of Bovi-Shield Gold One shot and received a second dose 14 d later. A 7-way clostridial vaccine with somnus (Vision 7 Somnus, Merck, Kenilworth, NJ) was also given at weaning. Calf BW was collected at birth, pre-breeding, and at weaning each year. Adjusted 60-d and 205-d weights were calculated without adjustments for cow age or sex of calf.

Approximately d 60 postpartum, milk production was measured using a modified weigh-suckle-weigh method. Prior to milking, cows were separated from calves by 1000 h and allowed to suckle at 1700 h before being separated again. On day of milking, cows were administered with an intravenous injection of oxytocin (1mL; Aspen Veterinary Resources LTD., Loveland, CO) ten minutes prior to milking to facilitate milk letdown. Cows were milked using a portable milking machine (Porta-Milker, Coburn Company Inc., Whitewater, WI). Cows were milked until machine pressure ceased to extract

additional fluid and milk weight was recorded for calculation of 24-h production. An aliquot was collected and analyzed for milk protein, butterfat, lactose, solids non-fat (SNF), and milk urea nitrogen (MUN) concentrations (Heart of America DHIA, Kansas City, MO).

Approximately d 80 postpartum cows were estrus synchronized using a controlled internal drug release (CIDR; Eazi-Breed CIDR, Zoetis Inc, Kalamazoo, MI) protocol (7-d CO-Synch + CIDR), with cows receiving 2 mL intramuscularly of gonadotropin-releasing hormone (GnRH; Fertagyl, Merck, Kenilworth, NJ). Seven days later, CIDR inserts were removed and a single injection of prostaglandin F₂-alpha (5mL; PGF_{2α}; Estroplan, Parnell Technologies, Overland Park, KS) was administered. Artificial insemination (AI) was conducted approximately 65 hr after CIDR removal, with administration of 2 mL GnRH for fixed time AI. Fertile bulls were introduced 7 days after AI for a 45 d breeding season. Pregnancy diagnosis was detected via rectal palpation 35 d following bull removal.

Statistical Analysis

Data were analyzed as a randomized block design using the MIXED procedure (SAS Inst. Inc., Cary, NC, USA) with cow as the experimental unit using the Kenward-Roger degrees of freedom method. The model included fixed effects of year, age, treatment, and their interactions. Concentrations of NEFA, SUN, and glucose were analyzed as repeated measures with date of collection serving as a repeated factor with a compound symmetry structure. Separation of least squares was performed by the PDIFF option in SAS when a significant ($P \leq 0.05$) effect was detected. Significance level was set at $P \leq 0.05$.

Results and Discussion

Supplement Effects. Cow BW and BW change intervals were similar among supplement groups at all measurement times ($P \geq 0.29$; Table 2.3). In agreement, other studies reported no difference or improvement in cow BW with postpartum supplementation of RUP or Rumensin (Lalman et al., 1993; Anderson et al., 2001). In contrast, Wiley et al. (1991) reported greater BW gains during the postpartum period with supplementation of RUP. Marston et al. (1995) reported that BW gains during the breeding season tended to be greater for energy fed cows and gained 10 kg more than high protein fed cows. Patterson et al. (2003) reported that RUP supplementation to 2-yr-old cows in the Sandhills increased postpartum BW change, however these cows were consuming meadow hay and calved in the spring. Body weight nadir represents the magnitude of postpartum cow BW loss caused by negative energy balance (Waterman et al., 2006). In dairy cattle, body weight nadir represents the transition from negative to positive energy balance and is considered a measurement for the resumption of reproductive competence (Beam and Butler, 1997). Days to BW nadir were similar among treatment groups ($P = 0.60$; 54, 58, 60, and 54 for MIN, RUM, RUP, and DDG, respectively) and did not interact with year ($P = 0.27$).

Body condition score can be used as an indirect indicator of nutritional status as it estimates the amount of fat that an animal contains (Herd and Sprott, 1968). Body condition score was similar ($P = 0.45$; Table 2.4) at calving among supplemental groups and remained similar ($P \geq 0.37$) BCS throughout the rest of the study. In agreement, other studies have seen no difference in BCS throughout the postpartum supplementation

period with cows consuming RUP, energy, or ionophores (Wiley et al., 1991; Marston et al., 1995; Strauch et al., 2003).

Calf BW at birth, 60-d, and 205-d did not differ ($P \geq 0.19$; Table 2.5) among supplement groups. Wiley et al. (1991) also reported that postpartum supplementation with high RUP did not influence calf growth at birth, 60-d, or 205-d of age. Strauch et al. (2003) also reported that postpartum supplementation with ionophores did not influence calf growth.

The key to increase pregnancy rates in young range cows is to decrease the postpartum interval (Wiltbank et al., 1961), which allows a young cow more opportunities to conceive in a defined breeding season. Artificial insemination (AI) rates were also similar among supplement groups ($P = 0.77$; Table 2.6). Pregnancy rates were 82, 83, 92, and 89% for MIN, RUM, RUP, and DDG fed cows, respectively ($P = 0.76$). Lalman et al. (1993) and Marston et al. (1995) also reported similar results regarding pregnancy rates when young cows were fed supplements containing a high RUP source, energy, or rumensin.

Twenty-four-hour milk production did not differ ($P = 0.62$; Table 2.7) between all supplemental treatments. Concentrations of milk butterfat, protein, lactose, solids-non-fat, and milk urea nitrogen also were not different ($P \geq 0.11$) between supplemental treatments. In agreement, studies have shown similar results or no differences in milk production from supplementation strategies of RUP, energy or rumensin (Wiley et al., 1991; Patterson et al., 2003; Marston et al., 1995; Lemenager et al., 1978). Studies have suggested that RUP supplementation to postpartum cattle may increase milk production, but a high amount of RUP supplementation may stimulate BW gain at the

expense of milk production (Hersom et al., 2011). For example, Triplett et al. (1995) demonstrated that excessive RUP (75.6% RUP) in first-calf heifers decreased milk production while maintaining BW compared to moderate (56.3%) and low RUP supplementation (38.1%).

Circulating concentrations of serum glucose were greatest ($P = 0.05$; Table 2.8) in cows fed DDG and lowest in cows fed MIN. Addition of protein supplements increase serum glucose concentrations, indicating that addition of dietary protein enhances gluconeogenesis (Sawyer et al., 2012). Circulating concentrations of serum non-esterified fatty acids were similar among supplement groups ($P = 0.13$). There was a supplement \times cow age interaction ($P = 0.03$; Table 2.9) for circulating concentrations of serum urea nitrogen (SUN) with 2-yr-old cows having greater concentrations compared to the 3-yr-olds. Concentrations of SUN provide an index of Nitrogen (N) released due to deamination of dietary protein and endogenous protein or losses of N from the rumen (Roseler et al., 1993). Two-yr-old cows fed the RUP and DDG supplements had greater concentrations of SUN than other supplement-cow age combinations. However, 3-yr-old cows fed the RUM supplement had the lowest concentrations of SUN compared to other supplement-cow age combinations. Concentrations of SUN less than 7 mg/dL would indicate a deficiency of dietary protein relative to the intake of digestible energy (Hammond, 1997). Cows that received any of the four supplements were ≤ 7 mg/dL, indicating that a protein deficiency may have still been present.

Cow age. A cow age \times year interaction ($P < 0.05$; Table 2.10) was observed for cow BW at beginning of supplementation, BW nadir, beginning of breeding, end of supplementation and breeding, and at weaning. For beginning of supplementation, BW

nadir and beginning of breeding measurement times, 2- and 3-yr-old cows had different weights between 2020 and 2021. In 2021, 2-yr-old cows were heavier at all measurement times than the previous year. However, 3-yr-old cows were all lighter in year 2021 compared to the previous year. In 2020, 3-yr-olds were heavier than 2-yr-olds. In 2021, BW was similar between both ages. In contrast, Mulliniks et al. (2008) reported that 2-yr-old cows were lighter compared to the 3-yr-old cows throughout the supplementation period of the study. However, cows in 2020 had lower quality forage (7.65 vs 11.9 CP% for 2020 and 2021; respectively) at the start of breeding, which may have influenced differences in cow BW.

A cow age \times year interaction ($P < 0.05$; Table 2.11) was observed for cow BCS at beginning of supplementation, beginning of breeding, and end of supplementation and breeding. In 2021, 2-yr-old cows had greater BCS at all measurement times. In 2021, 3-yr-old cows had greater BCS at beginning of supplementation, end of supplementation, and breeding than 2020. At beginning of breeding, BCS for 3-yr-old cows were similar between both years. In 2020, 3-yr-old cows had greater BCS compared to 2-yr-old cows. In 2021, BCS was similar between the age groups.

A cow age \times year interaction ($P < 0.05$; Table 2.12) occurred for pregnancy rates. In 2021, 3-yr-old cows had greater pregnancy rates in 2020 than 2021 (100 and 75.6%, respectively). However, there were no differences in pregnancy rates for 2-yr-old cows in 2020. In 2020, 3-yr-old cows had greater pregnancy rates than the 2-yr-old cows (100 and 75.6%, respectively). However, in 2021, 3-yr-olds had lower pregnancy rates compared to the 2-yr-olds (75.6 and 93.4% for 3-yr-old and 2-yr-old cows, respectively). The

difference in pregnancy rates each year could also be related to the different body weights measured each year.

Cow age influenced calf BW at birth, 60-d, and 205-d time measurements ($P \leq 0.01$; Table 2.13). Three-yr-old cows had heavier calves at birth, 60-d, and 205-d than 2-yr-old cows. Two- and three-yr-old cows produced similar amounts of milk, with a similar response to age for buttermilk, protein, lactose, solids-non-fat, and milk urea nitrogen. In agreement, Mulliniks et al. (2008) reported that 2- and 3-yr-old cows produced similar amounts of milk, with a similar response for milk components however, both age groups weaned similar sized calves.

A cow age \times days postpartum interaction ($P < 0.02$; Figure 2.1 and 2.2) was observed for concentrations of serum SUN and glucose. As the forage is expected to decrease in quality throughout the course of the study (Mulliniks and Adams, 2019), concentrations of SUN decreased for both age groups while concentrations of glucose fluctuated. Sawyer et al. (2012) observed that steers with greater SUN concentrations reflects ruminal NH_3 values and may indicate some degree of N loss from the rumen. Wiley et al. (1991) observed that greater concentrations of SUN may be indicative of excess protein fed, resulting in deamination of the amino acids and the carbon skeleton used for oxidation metabolism. However, these results were not observed in this study, indicating that there was not a surplus of protein supplied or N loss from the rumen. Waterman et al. (2006) reported that as concentrations of SUN and NEFA declined over the course of their study, forage quality and nutrient status improved however, this was observed in late May when forage quality was increasing. These authors suggested that these trends are consistent with increasing glucose pool size, resulting in reduced

deamination of proteins for glucose synthesis, reduced rates of adipose catabolism, and increased efficiency of fatty acid metabolism as time postpartum progressed.

Cow age ($P < 0.01$; Figure 2.3) and days postpartum ($P < 0.01$; Figure 2.4) also influenced circulating concentrations of NEFA. Concentrations of NEFA were greater for 3-yr-old cows compared to the 2-yr-old cows. Greater concentrations of NEFA in cows indicate mobilization of body fat from reserves for additional energy, which corresponds with the reduction in BCS (Radunz et al., 2010). The greater concentrations of NEFA in 3-yr-old cows could also explain their lower BW in year 2021. Concentrations of NEFA increased until d 55 postpartum and then decreased to d 125 as illustrated in Figure 2.4. During early lactation, cows are more likely to enter a negative energy balance (Bell, 1995), due to the net effect of less energy available leading to an increase in mobilization of adipose tissue and having greater levels of circulating NEFA concentrations (Hess et al, 2005). Suggesting that at the start of supplementation cows were mobilizing body fat stores due to the onset of early and peak lactation. After peak lactation, concentrations of NEFA declined, indicating that their nutrient status may have been improved.

Year. Year influenced days to BW nadir ($P < 0.01$; Table 2.14). In 2020, 2- and 3-yr-old cows took more days to reach their BW nadir than in 2021. Year also influenced cow BCS at weaning time measurement ($P < 0.01$). In 2021, 2- and 3-yr-old cows had greater BCS than in 2020. Calf weight was also influenced by year for 60-d and 205-d time measurements ($P \leq 0.02$; Table 2.15). In 2021, both calf 60-d and 205-d weights were greater for 2- and 3-yr-old cows than in 2020. These results could be due to low forage quality in year 2020.

Implications

Postpartum supplementation strategies did not influence cow BW, BW change, or BCS. Supplementation strategies also did not influence milk production, calf performance, or reproductive performance. Supplementation of energy and protein resulted in an increase in concentrations of serum glucose and serum urea nitrogen. Cow age did influence results with 2-yr-olds having improved concentrations of circulating metabolites compared to 3-yr-olds. Year also influenced results, the year correlated with higher forage quality resulted in greater cow BW, BCS, and calf performance. More research is warranted to determine supplementation effects due to limitations in this study, such as number of animals used and years evaluated.

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Table 2.1. Supplementation costs for young May-calving range cows receiving postpartum supplements.

| Item | Supplements ¹ | | | |
|--------------------|--------------------------|------|------|------|
| | MIN | RUM | RUP | DDG |
| Feed cost, \$/hd/d | 0.08 | 0.11 | 0.43 | 0.24 |

¹ MIN = 113 g/d of mineral; RUM = 200mg Rumensin per 113g/d of MIN; RUP = 113 g/d blood meal + 113 g/d feather meal + MIN; DDG = 907 g/d dried distiller grains

Table 2.2. Feed analysis for range quality 2020-2021 (DM Basis).

| Item | Range Quality | | | |
|------------------|------------------------|-------------------------|-----------|------------|
| | 2020 | | 2021 | |
| | Pre-Breed ¹ | Post-Breed ² | Pre-Breed | Post-Breed |
| Dry matter, % | 95.1 | 95.0 | 95.5 | 96.6 |
| NDF, % | 42.9 | 58.8 | 63.5 | 53.6 |
| Crude Protein, % | 7.65 | 6.95 | 11.9 | 7.7 |
| TDN, % | 65.6 | 56.9 | 56.0 | 55.8 |

¹ Early July

² Late September

Table 2.3 Effects of postpartum supplementation to young May-calving range cows on cow body weight (BW) and BW change.

| Item | Supplement ¹ | | | | SEM | P-value |
|------------------------------|-------------------------|-------|-------|-------|------|---------|
| | MIN | RUM | RUP | DDG | | |
| Cow weight, kg | | | | | | |
| Begin supplementation | 427.2 | 439.4 | 424.2 | 423.8 | 23.1 | 0.54 |
| BW Nadir | 418.3 | 433.2 | 420.2 | 412.6 | 21.7 | 0.29 |
| Begin breeding | 416.8 | 436.0 | 425.0 | 417.5 | 24.6 | 0.42 |
| End supplementation/breeding | 437.1 | 450.8 | 444.9 | 437.9 | 25.5 | 0.71 |
| Weaning | 401.4 | 416.3 | 410.9 | 409.4 | 23.9 | 0.74 |
| Weight change interval, kg | | | | | | |
| Begin supp – BW nadir | -8.9 | -6.2 | -4.0 | -11.3 | 8.1 | 0.38 |
| Begin supp – begin breed | -10.4 | -3.4 | 0.8 | -6.3 | 27.7 | 0.92 |
| BW nadir – end supp/breed | 18.8 | 17.6 | 24.8 | 25.3 | 24.5 | 0.90 |
| Begin supp – end supp/breed | 9.9 | 11.4 | 20.8 | 14.1 | 26.0 | 0.91 |
| Begin supp – wean | -25.8 | -23.1 | -13.2 | -14.5 | 26.0 | 0.78 |
| Days to BW nadir | 54 | 58 | 60 | 54 | 4.06 | 0.60 |

¹ MIN = 113 g/d of mineral; RUM = 200mg Rumensin per 113g/d of MIN; RUP = 113 g/d blood meal +113 g/d feather meal + MIN; DDG = 907 g/d dried distiller grains

Table 2.4. Effects of postpartum supplementation to young May-calving range cows on body condition score (BCS).

| Measurement time | Supplement ¹ | | | | SEM | <i>P</i> -value |
|----------------------------------|-------------------------|------|------|------|------|-----------------|
| | MIN | RUM | RUP | DDG | | |
| Begin supplementation BCS | 5.45 | 5.53 | 5.37 | 5.41 | 0.08 | 0.45 |
| Begin breeding BCS | 5.57 | 5.57 | 5.48 | 5.43 | 0.09 | 0.37 |
| End supplementation/breeding BCS | 5.36 | 5.28 | 5.22 | 5.38 | 0.09 | 0.43 |
| Wean BCS | 5.13 | 5.08 | 5.05 | 5.19 | 0.11 | 0.71 |

¹MIN = 113 g/d of mineral; RUM = 200mg Rumensin per 113g/d of MIN; RUP = 113 g/d blood meal + 113 g/d feather meal + MIN; DDG = 907 g/d dried distiller grains

Table 2.5. Effects of postpartum supplementation in young May-calving range cows on calf body weight.

| Item | Supplement ¹ | | | | SEM | <i>P</i> -value |
|----------------------------|-------------------------|-------|-------|-------|------|-----------------|
| | MIN | RUM | RUP | DDG | | |
| Calf BW, kg | | | | | | |
| Birth weight | 29.4 | 29.2 | 31.7 | 29.9 | 2.11 | 0.19 |
| 60-d Calf BW ² | 97.1 | 95.3 | 107.7 | 97.6 | 24.6 | 0.83 |
| 205-d Calf BW ³ | 197.8 | 199.1 | 203.5 | 205.3 | 17.3 | 0.82 |

¹ MIN = 113 g/d of mineral; RUM = 200mg Rumensin per 113g/d of MIN; RUP = 113 g/d blood meal + 113 g/d feather meal + 113 g/d MIN; DDG = 907 g/d dried distiller grains

² Calf BW was adjusted to a common 60-d BW

³ Calf weaning BW was adjusted to a common 205-d BW

Table 2.6. Effects of postpartum supplementation on reproduction performance in young May-calving range cows.

| Item | Supplement ¹ | | | | SEM | <i>P</i> -value |
|--------------------|-------------------------|-----|-----|-----|------|-----------------|
| | MIN | RUM | RUP | DDG | | |
| AI rates, % | 48 | 44 | 60 | 49 | 0.12 | 0.77 |
| Pregnancy rates, % | 82 | 83 | 92 | 89 | 0.08 | 0.76 |

¹ MIN = 113 g/d of mineral; RUM = 200mg Rumensin per 113g/d of MIN; RUP = 113 g/d blood meal + 113 g/d feather meal + 113 g/d MIN; DDG = 907 g/d dried distiller grains

Table 2.7. Effects of postpartum supplementation on milk production in young May-calving range cows.

| Item | Supplement ¹ | | | | SEM | <i>P</i> -value |
|-----------------------|-------------------------|------|------|------|------|-----------------|
| | MIN | RUM | RUP | DDG | | |
| 24 hr milk yield, kg | 8.68 | 6.54 | 6.85 | 5.91 | 4.5 | 0.62 |
| Butterfat, % | 2.93 | 3.32 | 4.51 | 3.75 | 0.46 | 0.11 |
| Protein, % | 2.81 | 2.89 | 2.93 | 2.96 | 0.12 | 0.61 |
| Lactose, % | 5.26 | 4.97 | 5.03 | 5.12 | 0.19 | 0.49 |
| Solids-non-fat, % | 9.05 | 8.74 | 8.87 | 9.01 | 0.34 | 0.75 |
| Milk urea nitrogen, % | 16.0 | 16.7 | 14.9 | 16.2 | 1.45 | 0.82 |

¹ MIN = 113 g/d of mineral; RUM = 200mg Rumensin per 113g/d of MIN; RUP = 113 g/d blood meal + 113 g/d feather meal + 113 g/d MIN; DDG = 907 g/d dried distiller grains

Table 2.8. Effects of postpartum supplementation in young May-calving range cows on concentrations of circulating serum metabolites.

| Item | Supplement ¹ | | | | SEM | <i>P</i> -value |
|----------------------------|-------------------------|-------------------|-------------------|-------------------|------|-----------------|
| | MIN | RUM | RUP | DDG | | |
| Glucose, mg/dL | 57.7 ^a | 60.7 | 60.2 | 61.7 ^b | 1.4 | 0.05 |
| SUN ² , mg/dL | 6.22 ^a | 5.92 ^a | 6.55 ^b | 6.76 ^b | 0.24 | 0.01 |
| NEFA ³ , μmol/L | 300 | 330 | 290 | 280 | 0.02 | 0.13 |

¹ MIN = 113 g/d of mineral; RUM = 200mg Rumensin per 113g/d of MIN; RUP = 113 g/d blood meal + 113 g/d feather meal + 113 g/d MIN; DDG = 907 g/d dried distiller grains

² SUN = Serum urea nitrogen

³ NEFA = Non-esterified fatty acids

^{a,b} Means within a row with different superscripts differ ($P < 0.05$)

Table 2.9. Treatment × cow age interaction for circulating serum urea nitrogen concentrations on young May-calving range cows receiving postpartum supplements.

| Item | Cow age | Supplement ¹ | | | | SEM |
|--------------------------|---------|-------------------------|-------------------|--------------------|--------------------|------|
| | | MIN | RUM | RUP | DDG | |
| SUN ² , mg/dL | 2 | 6.33 ^a | 6.24 ^a | 7.31 ^{bx} | 7.53 ^{bx} | 0.37 |
| | 3 | 6.10 | 5.60 | 5.78 ^y | 5.99 ^y | 0.33 |

¹ MIN = 113 g/d of mineral; RUM = 200mg Rumensin per 113g/d of MIN; RUP = 113 g/d blood meal + 113 g/d feather meal + 113 g/d MIN; DDG = 907 g/d dried distiller grains

² SUN = Serum urea nitrogen

^{a,b} For each interaction, means in rows with different superscripts differ ($P < 0.05$)

^{x,y} For each interaction, means in columns with different superscripts differ ($P < 0.05$)

Table 2.10. Cow age × year interaction for body weights at different measurement times on young May-calving range cows receiving postpartum supplements.

| Item | Cow age | Year | | SEM |
|----------------------------------|---------|---------------------|--------------------|------|
| | | 2020 | 2021 | |
| Begin supplementation, kg | 2 | 392.4 ^{ax} | 429.5 ^b | 18.5 |
| | 3 | 470.9 ^{ay} | 421.7 ^b | 24.6 |
| BW nadir, kg | 2 | 386.3 ^{ax} | 419.1 ^b | 17.4 |
| | 3 | 467.1 ^{ay} | 411.7 ^b | 23.0 |
| Begin breed, kg | 2 | 388.0 ^{ax} | 423.1 ^b | 19.7 |
| | 3 | 458.0 ^{ay} | 426.3 ^b | 26.1 |
| End supplementation/breeding, kg | 2 | 415.9 ^x | 436.2 | 20.4 |
| | 3 | 488.2 ^{ay} | 430.8 ^b | 27.0 |
| Weaning, kg | 2 | 371.5 ^{ax} | 414.2 ^b | 19.2 |
| | 3 | 437.1 ^y | 415.2 | 25.4 |

^{a,b} For each interaction, means in rows with different superscripts differ ($P < 0.05$)

^{x,y} For each interaction, means in columns with different superscripts differ ($P < 0.05$)

Table 2.11. Cow age × year interaction for body condition scores on young May-calving range cows receiving postpartum supplements.

| Item | Cow age | Year | | SEM |
|--|---------|--------------------|-------------------|------|
| | | 2020 | 2021 | |
| Begin supplementation BCS ¹ | 2 | 4.98 ^{ax} | 5.64 ^b | 0.07 |
| | 3 | 5.45 ^{ay} | 5.69 ^b | 0.09 |
| Begin breeding BCS | 2 | 5.09 ^{ax} | 5.69 ^b | 0.07 |
| | 3 | 5.58 ^y | 5.69 | 0.09 |
| End supplementation/breeding BCS | 2 | 4.97 ^{ax} | 5.58 ^b | 0.07 |
| | 3 | 5.22 ^{ay} | 5.47 ^b | 0.09 |

¹Body Condition Score

^{a,b} For each interaction, means in rows with different superscripts differ ($P < 0.05$)

^{x,y} For each interaction, means in columns with different superscripts differ ($P < 0.05$)

Table 2.12. Cow age × year interaction on cow pregnancy rates on young May-calving range cows receiving postpartum supplements.

| Item | Cow age | Year | | SEM |
|--------------------|---------|-------------------|-------------------|------|
| | | 2020 | 2021 | |
| Pregnancy rates, % | 2 | 75.6 ^x | 93.4 | 0.07 |
| | 3 | 100 ^{ay} | 75.6 ^b | 0.09 |

^{a,b} For each interaction, means in rows with different superscripts differ ($P < 0.05$)

^{x,y} For each interaction, means in columns with different superscripts differ ($P < 0.05$)

Table 2.13. Effect of cow age on calf weight. Cows were young May-calving range cows receiving postpartum supplements.

| Item | Cow age | | SEM | <i>P</i> -value |
|---------------------------------|---------|-------|------|-----------------|
| | 2 | 3 | | |
| Birth weight, kg | 28.4 | 31.8 | 1.4 | < 0.01 |
| 60-d Calf BW ¹ , kg | 87.55 | 111.3 | 15.6 | 0.01 |
| 205-d Calf BW ² , kg | 190.3 | 212.5 | 11.6 | < 0.01 |

¹ Calf BW was adjusted to a common 60-d BW

² Calf weaning BW was adjusted to a common 205-d BW

Figure 2.1. Cow age \times sample time interaction on circulating serum urea nitrogen concentrations from young May-calving range cows receiving postpartum supplements ($P < 0.02$; SEM = 2.5).

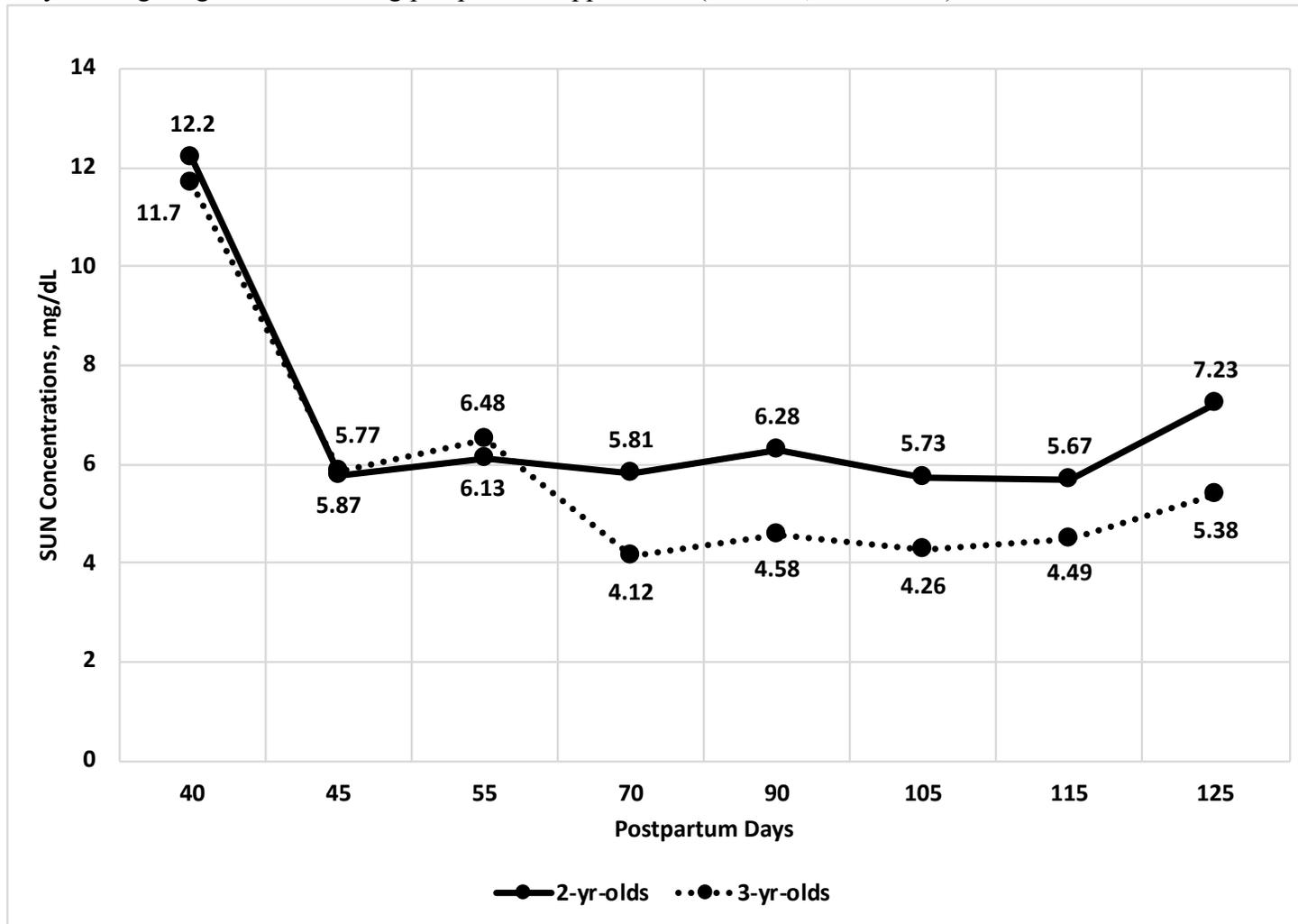


Figure 2.2. Cow age \times sample time interaction on circulating serum glucose concentrations from young May-calving range cows receiving postpartum supplements ($P < 0.01$; SEM = 2.4).

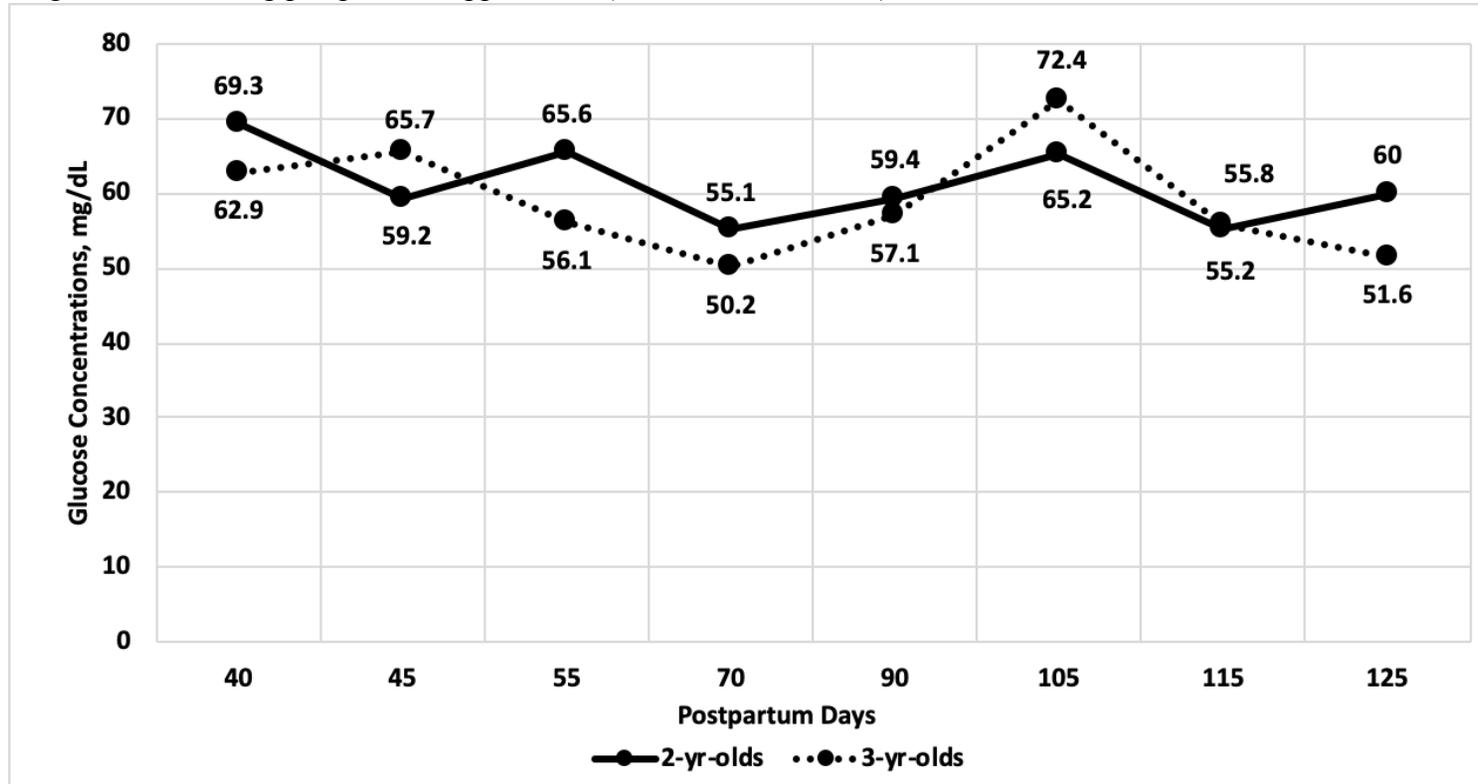


Figure 2.3. Effect of cow age on circulating serum non-esterified fatty acid concentrations from young May-calving range cows receiving postpartum supplements ($P < 0.01$; SEM = 0.01).

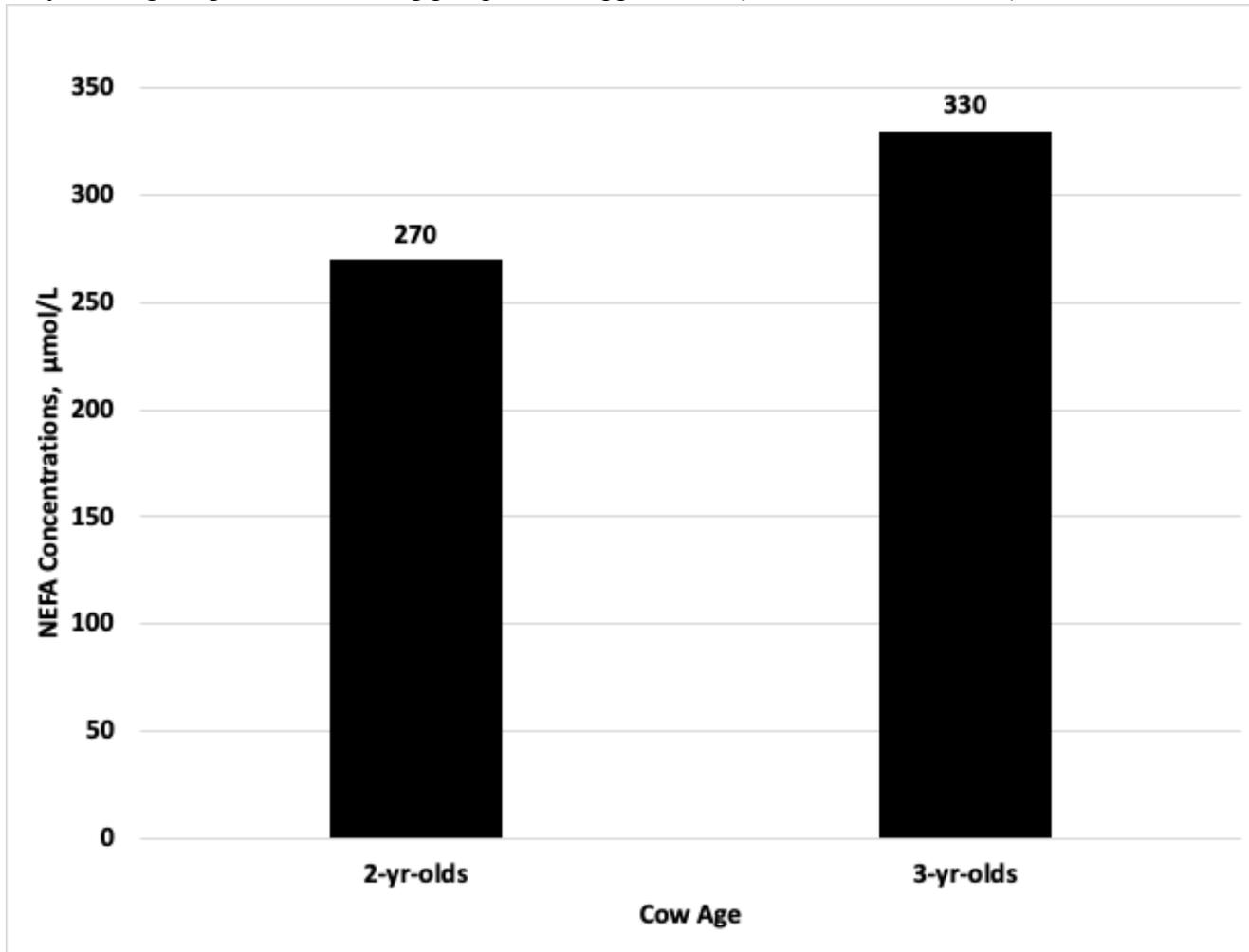


Figure 2.4. Effect of sample time on circulating serum non-esterified fatty acid concentrations from young May-calving range cows receiving postpartum supplements ($P < 0.01$; SEM = 0.02).

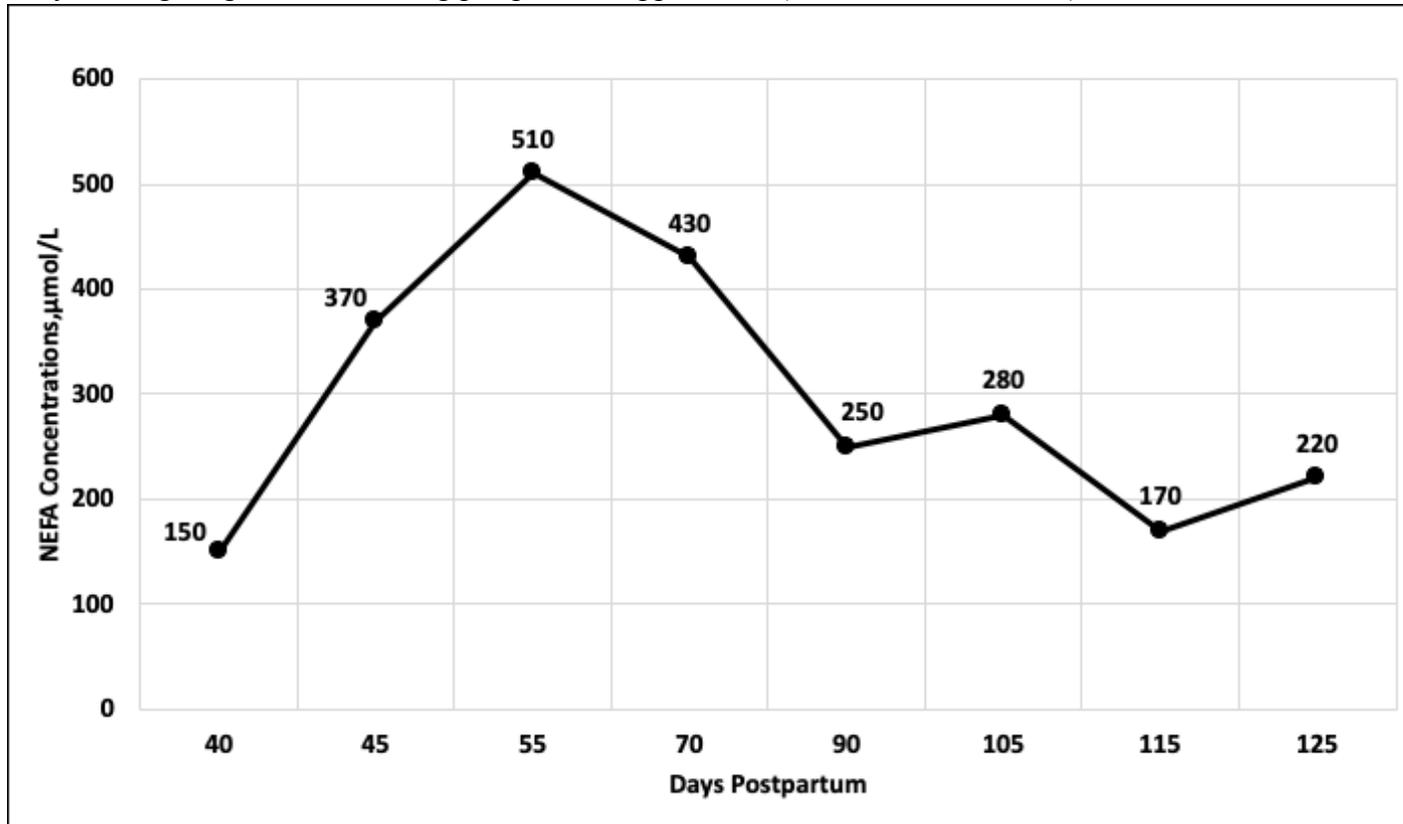


Table 2.14. Effect of year on days to BW nadir and cow BCS on young May-calving range cows receiving postpartum supplements.

| Item | Year | | SEM | <i>P</i> -value |
|------------------|------|------|------|-----------------|
| | 2020 | 2021 | | |
| Days to BW nadir | 67.1 | 45.8 | 2.7 | < 0.01 |
| Cow weaning BCS | 4.99 | 5.24 | 0.07 | < 0.01 |

Table 2.15. Effect of year on calf weight. Cows were young May-calving range cows receiving postpartum supplements.

| Item | Year | | SEM | <i>P</i> -value |
|---------------------------------|-------|-------|------|-----------------|
| | 2020 | 2021 | | |
| 60-d Calf BW ¹ , kg | 87.5 | 111.4 | 15.0 | 0.01 |
| 205-d Calf BW ² , kg | 193.5 | 209.3 | 11.5 | 0.02 |

¹ Calf BW was adjusted to a common 60-d BW

² Calf weaning BW was adjusted to a common 205-d BW