IMPROVING THE CATTLE INDUSTRY IN GEORGIA: EVALUATING FEED ADDITIVES TO IMPROVE STOCKER CATTLE PERFORMANCE & MEASURING THE IMPACT OF EXTENSION PROGRAMMING

by

MARRISSA JEAN BLACKWELL

(Under the Direction of Robert Lawton Stewart, Jr. and Alexa J. Lamm)

ABSTRACT

Two experiments were conducted to improve stocker cattle performance and examine the impact of extension programming in Georgia. Experiment 1 studied the impact of sodium butyrate supplementation on stocker cattle performance in response to stress associated with long-distance transportation. Supplementation of exogenous sodium butyrate did not have an effect on average daily gain (ADG) after transportation in any treatment group. No treatment effect on the volatile fatty acid (VFA) profiles was observed between groups. Experiment 2 measured the impact of the Northeast Georgia Beef Cattle Short Course through a survey. Respondents indicated that the course has added $1,545,316.64 in value to the state beef industry since its inception in 2012. Continuing to offer the course allows for further improvement of beef cattle production in Georgia.

INDEX WORDS: Beef Cattle, Butyrate, Stress, Transportation, Extension

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DEDICATION

I have been extremely lucky to have a huge support system behind me in all that I do, and this I dedicate this work to the village it took to raise me. Special thanks to my parents, Becky, and Glen, you continue to support me in every way imaginable and it means the world to me. Thank you for being my rock, my voice of reason, and for always pushing me to be the best version of myself. I love you more than you know. To my papa, you inspire me to be the hardest worker in the room. I can always count on you to teach me to cook, help with barn chores, and make me smile. To my siblings - Dominick, Rosemarie, and Parker, your love and support pushes me to be a better person every single day.

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CHAPTER 1

INTRODUCTION

Beef cattle production is a large part of the agricultural industry throughout the United States (U.S.) and plays a significant role the economy of the Southeast. The U.S beef production system is a global leader and is present in all 50 states with 58,622,213 beef cattle spread across 29,046 farms throughout the country ("USDA," 2017). Within the state of Georgia, beef cattle are raised in all 159 counties and are mainly focused on cow-calf and stockering. In 2020, beef was the number four overall agricultural commodity in Georgia, valued at $633.2 million in farm gate value, representing 4.6% of the total $76 billion that agricultural products contribute to the state economy (University of Georgia, 2021). Cow-calf operations make up 71% of Georgia's cattle, 21% are purebred, and the other 8% of cattle are stockers (Georgia Cattlemen's Association, 2019). The segmented and cyclical nature of the beef cattle industry creates challenges for Georgia producers to maximize profit. However, consumer demand ultimately drives prices. Therefore, cow-calf and stocker producers' focus remain on producing healthy and efficient cattle.

2020 brought the COVID-19 pandemic, and with that came a unique set of challenges for all sectors that could negatively impact cattle cycles and beef price cycles. Processing facilities operating under capacity limitations reduced beef product output to consumers while stifling movement of cattle through the production chain. Feedlots were forced to retain cattle that were ready for market while stocker and backgrounding operations were either selling cattle at reduced prices or retaining them and incurring additional production costs in hopes of prices increasing in the future (Marchant-Forde et al., 2020). Cow-calf producers will also continue to face similar obstacles in the coming year, as challenges in these other sectors will ultimately lead to similar, perhaps more prolonged effects. As a result of these issues, increased beef supply is expected over the next nine years, which has potential to translate to improved per capita consumption (Martinez et al., 2020). The beef cattle industry's projected future growth, along with the unique set of challenges every sector faces, proves it crucial for producers to begin exploring options for increasing their operation's efficiency.

Proper nutrition and management are critical to a profitable operation, especially as calves transition to post-weaning. Providing adequate balance of nutrition early on is necessary to ensure that ruminal development occurs. Establishing microbial diversity is critical during this period in order to allow the animal to establish a foundation for productivity throughout its lifetime. After transitioning from Milk Replacer (MR) to a solid diet, fermentation of feed and roughage is what stimulates ruminal development (Bentley et al., 2015). The carbohydrates broken down by the microbial population in the rumen leads to the production of volatile fatty acids which provides a majority of energy requirements for the animal (Bergman, 1990). During post-weaning, calves are slowly transitioned into a starter grain diet with a gradual increase in Dry Matter Intake. These diets are usually easy to ferment and promote ruminal and intestinal development (Berends et al., 2012). Because butyrate is the VFA metabolized the most by rumen epithelium, therefore it preserves the concentration gradient between the cytosol and lumen, allowing for optimal absorption by the epithelial cells. This facilitation and optimization of nutrients makes butyrate a viable supplement option. (Penner et al., 2011) The cell growth associated with this improvement in absorption provides a mechanism of defense against cell damage and inflammatory response as a result of heat, transportation, or other aspects of production (Pohl et al., 1995). By maintaining the integrity of the epithelium, nutrient absorption is improved, resulting in post-weaning improvements in growth rate and feed efficiency. Like that in pre-weaning calves, some studies suggest an increase in intestinal integrity post weaning as a result of exogenous butyrate supplementation (Yohe et al., 2019). A study by McCurdy et al. (2019) suggested that dairy calves had improved weaning performance when placed on a starter diet supplemented with rumen-protected butyrate. These data indicated the positive effects of exogenous butyrate supplementation has in dairy calves; however, no research exists evaluating the impact of supplemented butyrate on animal performance in beef cattle. Specifically, in weaned calves that have experienced stress.

Stocker cattle are an integral part of Georgia's cattle industry. Stocker operations focus on buying calves and adding weight to increase their value and performance once they are transitioned to the feedlot. The Southeast is primarily a cow-calf producing region, which provides southeastern stocker operations the opportunity to purchase calves with a reduced transport cost and minimal stress placed on the animal. The diverse selection of forage species available paired with the almost year-round growing season allows for a cost-effective feed source for stocker development (Hancock et al., 2014). Once the cattle are prepared for the feedlot, they are typically shipped to feedlots in the Midwest and Great Plains. Stress of long-distance travel can cause significant liveweight loss, commonly referred to as shrink, due to the lack of food and water for this period of time. Many factors of transportation such as distance, handling, temperature as well as feed and water deprivation elicit physiological responses and has been shown to lead to approximately.75% weight loss per head per day (Parish et al., 2017).

Maintaining gut integrity through proper diet and management allows for added protection from cell damage and inflammation that can ultimately lead to weight loss. These potential issues have presented a need for methods of mitigating transportation stress in stocker cattle.

The field of animal science, and the research involved, is heavily focused on improving livestock production and management to address the needs of the industry. Extension education exists to bring the evidence-based science conducted by land grant institutions to farmers, consumers, and families. Extension programming plays a crucial role in these developments along with their faculty, agents and program evaluators that work to educate the industry on how to apply these findings to their everyday operations, therefore it is essential for extension professionals to utilize reliable evaluation tools to recognize trends and needs of the industry over time (Lamm, et al., 2013). Surveying the economic, production, and social impact of the research and how it is distributed to agricultural producers is important for assessing the value of research conclusions and allows for improvement, economic impact statements, and assessment of utility in a true production setting (Franz, et al., 2010). Program evaluation allows researchers and agricultural leaders to assess and meet the needs of the livestock industry by connecting directly with producers. Dillman's Tailored Design Method sits at the forefront of the field of evaluation theory and provides a means for which researchers can create and distribute surveys in order to receive a representative set of feedback data (Dillman et al., 2014). In addition to this, utilizing the Social Exchange Theory allows extension professionals to maximize the benefit of the data collected while minimizing the cost of producers and industry members conducting this assessment (Homans, 1958). Education programs ultimately provide a channel for which to assess the needs of the industry as well as how effectively research responds to these issues.

The research for this thesis was divided into two experiments. The first experiment evaluates the use of sodium butyrate as a feed additive for stocker cattle prior to and after exposure to transportation stress. Cattle were fed on treatment diets for fourteen days prior to being transported to another research station via a shipping route that amounted to 12 hours of travel to induce shipping stress. Ruminal fluid was collected at 5 days prior to shipping, D14, and D28 in order to examine any changes in volatile fatty acid production in response to sodium butyrate and the levels at which it was fed. Weight data was on D-19, D0, D2, D14, D28, D57, and D89 to see if there were any benefits to preventing weight loss after exposure to transport stress. Results from this study will help us determine if sodium butyrate has an effect on mitigating effects of stress in stocker cattle and provide direction for future studies.

The second experiment analyzed the impact of the Northeast Georgia Beef Cattle Short Course program hosted by University of Georgia's beef extension team. Previous activity attendees were surveyed to assess quality of the program and delivery of information as well as how it was utilized by producers both short and long term. Results from this questionnaire and analysis aimed to provide insight into the impact of the Northeast Georgia Beef Cattle Short Course on the industry at a state level as well as give direction for how the program will be conducted in the future.

Addressing some of the obstacles to maximizing profitability of a stocker operation through nutritional research and collecting information about how producers are able to utilize findings is critical to advancing the cattle industry in Georgia. These experiments are relevant to the agriculture industry as they will investigate both the nutritional and practical production aspects of the industry and aim to improve both animal performance and producer education.

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CHAPTER 2

THE REVIEW OF LITERATURE

Animal Stress

Collier et al. (2017) defines stress as an “external event or condition that poses a threat to homeostasis, increasing the maintenance requirements of an animal.” Net energy for production is compromised when the nutrient requirement for maintenance is increased due to stress. Prolonged exposure to stress factors such as climate changes and confinement can alter cattle production significantly (Brody, 1956). Stress triggers physiological and immune responses that lead to weakened immune system, lower reproductive success and in most cases, cattle shrink (Stott, 1981). Basic management practices of feeder cattle expose the animal to multiple stressors (Cernicchiaro et al., 2012). Adverse stimuli from weaning, handling, and transporting lead to elevated cortisol concentrations.

Prolonged periods of exposure to adverse stimuli can result in immunosuppression that increases risk of poor health. (Minton, 1994). As much as 10.5% of liveweight loss has been reported when cattle are exposed to stress factors. This variability creates a challenge for buyers and sellers to negotiate price of calves – as dietary differences can affect how these cattle regain weight and improve performance after extended stress events (Phillips et al., 1985; Phillips et al., 1991)

Physiological Effects of Stress

Endocrine system activity is commonly evaluated to assess stress levels in livestock. (Mormède et al., 2007). When cattle are exposed to stressors, the central nervous system elicits physiological responses which activate the hypothalamic-pituitary-adrenocortical (HPA) axis and the sympathoadrenal axis. As a result, corticotropin releasing hormone (CRH) and vasopressin (VP) are released. From there, the pituitary gland is signaled to release adrenocorticotropic hormone (ACTH) and glucocorticoids are released (Minton, 1994). The primary corticoid that is released is cortisol, which is the commonly used biomarker for stress (Blecha, 2000). Cortisol is predominantly used when measuring stress responses from short-term stress events such as transportation or handling. Historical research indicates that mean baseline cortisol levels across breed and sex range from 0.5-9 ng/mL during handling events. (Henricks et al., 1984; Tennessen et al., 1984; Alam and Dobson, 1986; Mitchell et al., 1988). These data are highly variable depending on individual animal types and what stress factors they are exposed to, therefore direct comparisons between studies should not be made (Grandin, 1995).

Dehydroepiandrosterone (DHEA), the precursor to cortisol, has been used in some research as a biomarker of stress. DHEA possesses anti-inflammatory properties that react in response to the inflammatory response brought on by increases in cortisol levels (Kalimi et al., 1994). increased In addition to the increased ratio of cortisol, Sporer et al. (2008) linked this to expression of neutrophil genes that can be detected after a stress event. These more recent findings have created a profile for multiple parameters that can be used to quantify levels of stress in cattle. Plasma cortisol was increased at 4.5 hours after transportation, confirming this was a significant stress event It was discovered that decreases in plasma DHEA correlated with increases in plasma cortisol. The ratio of cortisol to DHEA had significantly increased by 4.5 hours after transportation (*P* = 0.001. Neutrophil gene expression, leukocyte counts, and neutrophil counts were also correlated to increased cortisol (*P* < 0.05).

Leme et. al (2012) conducted a study on lambs to examine the effects of different transportation methods on stress and performance. Eighty-six crossbred Dorper lambs were divided into four groups and transported in either an open or closed container. Blood samples were collected via jugular venipuncture before and after transportation to a slaughterhouse. Findings showed that those transported in a in closed cages presented lower (28.97 ng/ml^{-1}) concentrations (*P* <0.01) as compared to animals transported in open cages (35.49 ng/ml^{-1}). It was concluded that visual access to external stimuli contributed to elevated stress. Crookshank et al. (1979) reported that the blood chemistry of eight heifers who were transported from the tropical region of Mexico to a northeastern US feedlot indicated increased cortisol concentrations in cattle at 0 days post arrival, while cortisol returned to pre-transportation levels by D25.

Similar parameters were measured in response to transportation and handling of a group of weaned crossbred calves. Calves for this study were transported for 43 hours on gravel and asphalt roads and spent a total of 63 hours in the trailer. Cortisol levels were significantly higher (*P* < 0.05) at the time cattle were loaded onto a trailer (1.5±0.4 μg/dl). After unloading, cortisol levels dropped to 1.0±0.4 μg/dl. Another study looked at a group of 16 heifers considered "high-risk" due to lack of feed and water access during transportation. Eight heifers were loaded onto a trailer for a 40-hr road trip. The remaining eight heifers had been placed on a feedlot for 25 days at the time of data collection. Cortisol concentrations were higher in the 0 days post-arrival (DPA) heifers than the 25 DPA group (*P* = 0.051; (Avila-Jaime et al., 2021). When cortisol concentration was determined in Pirenaica and Parda de Montaña calves after being weaned, baseline levels were determined to be below 8 ng/ml in all animals. Six hours after weaning, cortisol levels increased significantly in the early weaned (P = 0.02) and traditionally weaned (P = 0.01) calves. Cortisol levels were monitored until 7 days post-weaning and baseline cortisol levels were not recovered in either group. Age at weaning and breed were determined to have no effect on the physiological response (Blanco et al., 2009). Upon review of the literature, results show variation in cortisol levels, both baseline and in response to stress. Breed, sex, and temperament have interacted in a complex manner, creating high variability in results. Therefore, it is difficult to draw conclusions about an animal's response to exposure to a specific stressor based on an invasive technique such as blood collection to monitor cortisol concentrations.

Impact of Stress on Animal Performance

Cattle transportation can be one of the most stressful stimuli feeder cattle endure. During the time between departure from one location to their arrival at their destination, cattle commonly experience weight loss referred to as "shrink" (Hersom et al., 2015). Cattle shrink is used a measure for performance of cattle when exposes to stressors. The food and water deprivation associated with transportation has been linked to this bodyweight loss. The physiological response to this stress incites liveweight loss and diminished meat quality (Smith et al., 2004). Tennessen et al. (1984) found that cattle saw a mean 2.2% weight loss after a 2-hour transportation event, while those that traveled for 10 minutes experienced a mean 1.6% weight loss. Further correlations have been made between shrink and animal health. Cernicchiaro et al. (2012) examined the associations between shrink and operational data from various feedlots through negative binomial mixed models. Animals transported during the spring saw significantly ($P < 0.05$) greater HCW and ADG values than those transported in the summer, fall and winter in cattle that experience 2.5% shrink or less. Comparing cattle shrink data with other cattle performance data allows provides insight needed to help reduce economic losses associated with transportation.

Ribble et al. (1995) conducted a field study that examined risk of fatal fibrinous pneumonia or "shipping fever" in cattle transported to a feedlot. The study found that instances of shipping fever were similar regardless of transportation distance. Though there is variability in findings, cattle shrink can be linked to data on diminished performance (Marques et al., 2012). Developing a nutritional solution could allow for the gastrointestinal (GI) environment in cattle to combat any liveweight loss and create more consistent average daily gain before and after exposure to transportation stress.

Economic Impact of Cattle Nutrition

On average, 55-75% of an operation's total cost is feed costs (Berger, 2017). A 5% improvement in feed efficiency of cattle can lead to a 20% increase in average daily gain and improving profitability by up to 18% (Gibb and Mcallister, 1999). Additionally, it was noted that a 43% increase in profits resulted from a 10% improvement in herd feed efficiency (Fox et al., 2001). Therefore, improving feed utilization and efficiency is crucial to the bottom line of beef cattle producers' operations. Making this improvement creates potential to lower the cost of raising cattle while increasing their weight, quality, and overall value through enhanced nutrition. Lowering input costs on feed can ultimately affect the price at which they can profitably sell beef products as well as what consumers are willing to pay, which effects the economy on a larger scale.

The Ruminant Animal

All cattle are defined as ruminant animals. Ruminants are hoofed mammals that are defined by the presence of a large fermentation compartment in their G.I. tract, known as the rumen, alongside the reticulum, omasum, and abomasum (Van Soest, 1994). The structure of the ruminant system enables cattle to turn fiber-based byproducts from agricultural production into high quality meat, milk, and fiber (Oltjen and Beckett, 1996). This is accomplished by the populations of bacteria, fungi, protozoa, and bacteriophage that exist within the ruminant digestive system, known as the microbiome. As this microbial population breaks down feedstuffs, the Volatile Fatty Acids (VFAs) acetate, proprionate and butyrate are produced, which provide greater than 70% of cattle's energy supply (Bowen). Volatile Fatty Acids are utilized by the epithelium of the GI tract, where they are transported through tissues for host animal energy (Hungate, 1966).

The microbial population within the rumen closely interacts with the ruminant animal host. The ability to absorb feedstuffs and acquire energy for maintenance and production suggests a close correlation with overall animal performance. The rumen itself is considered a "black box" due to its immense diversity and gene content that can have a wide variety of effects on host health and feed utilization (Huttenhower et al., 2012).

Gastrointestinal Development of the Calf

When a calf's GIT makes the transition from a functional monogastric to a ruminant, development of the reticulorumen and its associated microbial population is required for efficient utilization and minimal growth loss. Proper calf-rearing is crucial for cattle operations, as management decisions made before weaning help to minimize risk of disease and optimize performance (Heinrichs, 2005). The newborn calf does not function as a ruminant at birth and in the early weeks of life. The rumen, reticulum, and abomasum make up approximately 41% of the GIT and cattle are considered functionally monogastric in the early weeks of life (Malmuthuge et al., 2019). During this period when the diet consists of milk, development of the rumen papillae occurs; increasing absorptive capacity for fibrous feedstuffs. Young calves' GIT can also be characterized by the esophageal groove, which is engaged to block passage of milk into the reticulorumen as calves suckle and milk passes down the esophagus (Church, 1988). During this time, the reticulorumen can be characterized as smooth tissue, with no developed papillae. The absence of the papillae and smaller surface area in the reticulorumen during this period inhibits absorptive capacity (Aschenbach et al., 2019).

When the calf matures and is transitioned to a solid diet, the fully developed reticulorumen comprises of approximately 70-80% of the GIT (Church, 1988). This period of growth has been studied to examine how diet can affect GIT development in the calf. A study found that calves transitioned to a solid diet at five weeks presented larger and more developed papillae than those transitioned at six weeks, suggesting an advanced stage of development, and improved absorptive capacity (Schäff et al., 2018). Reticulorumen development has also been shown to be influenced by starter feeds and their nutrient composition. Some studies indicated that ruminal fluid VFA content of calves fed concentrated feed rations that are rich in protein and energy were higher than in those fed milk replacer. Calves fed concentrates in this study had low ruminal pH (4.9-5.2). Total VFA content was affected by dietary treatment ($P < 0.001$) with a mean of 110.2 mmol/L compared to the milk replacer treatment at 36 mmol/L (Suárez et al., 2006).

Though the reticulorumen is not active during the early weeks of life, Jami et al. (2013) concluded that some ruminal bacteria populations were present as early as one day post-birth. The most notable change in bacterial populations occurred between the first and third day of life ($P < 0.0001$). One study concluded that from birth to weaning, the reticulorumen environment is populated with bacteria in rapid sequence. *Proteobacteria* populations decrease and are replaced with *Bacteroidetes* (Rey et al., 2012). Bryant et al. (1958) also found that at six weeks of age, bacteria similar to that which is present in mature cattle begin to populate in small concentrations, while at 9-13 weeks of age; bacteria present in the reticulorumen of calves is largely similar to that which can be found in a mature animal. It was also shown that after day 15, diet did not seem to have an impact on bacterial populations present (Rey et al., 2012)Appropriate diet changes early in life are critical to proper GIT development in calves prior to and in the early days after weaning, allowing them to continue to utilize energy for performance when exposed to external stressors.

The Rumen Microbiome and Its Significance

The rumen is often referred to as a "black box," as it houses trillions of microbes with genetic content hundreds of times that of host cells (Huttenhower et al., 2012b). The microbial environment of the ruminant is a diverse ecosystem of anaerobic bacteria, fungi, archaea, and protozoa (Flint, 1997; Firkins and Yu, 2015). In terms of animal efficiency, Herd and Arthur (2009) reported that 19% of the variation in feed efficiency seen in Angus steers could be attributed to diet composition and digestibility. Tissue metabolism, protein turnover, and stress response had also shown to account for 37% of the animals' variation in efficiency. Microbes in the rumen break down feedstuffs to produce VFAs, which are used for energy by the host animal for maintenance, growth, performance, and reproduction. The microbes themselves use these end products for their own growth and reproduction as well (Moran, 2005). Given the data suggesting biological processes can affect efficiency, it is possible that the ruminal microbial environment and the VFAs that it produces can have an impact on animal performance

Since ruminally-derived VFAs account the majority of cattle's energy needs, research into improving efficiency in this area is of particular interest (Bergman, 1990). Research regarding the microbiome of cattle predominantly investigates what bacterial populations are associated with increased productivity and how this microbial environment can be altered (Kim et al., 2017). The most prevalent phyla in the microbiome have been reported as Bacteroidetes, Firmicutes, and Actinobacteria(Jami et al., 2013; Zhu et al., 2017) Findings from Krause and Russell (1996) showed that bacteria are present in the highest concentration, therefore it is concluded that they are the most metabolically active species in the rumen. Bacterial presence in large numbers further suggests they play a major role in the fermentation ability and ultimate feed efficiency of the animal (Hungate, 1966)

Volatile Fatty Acids (VFAs)

Acetate, proprionate, and butyrate are the most abundant VFAs. They are formed in the rumen and absorbed across its epithelium. Isobutyrate, isovalerate, and valerate are also present in rumen in lower concentrations. VFAs are end products of anaerobic metabolic processes that occur in the ruminant animal (van Soest, 1994b). As feedstuffs are digested, carbohydrates such as starch, cellulose, hemicellulose, and lignin are further broken down to produce VFAs. They are then transported in the blood through the portal vein and to the liver. In the liver, protein, carbohydrates, and fats provide digestible energy. This is the energy that is available for the animal to use for maintenance, growth, reproduction, and performance. (Moran, 2005)

The microbiome is what drives fermentation and produces acetate, proprionate, and butyrate as the main end products. Acetate is utilized to meet the energy needs of the host animal, while proprionate contributes to gluconeogenesis. Butyrate encourages papillae development within the rumen, which in turn increases gut motility(Wang et al., 2020). Establishing this proper epithelial development and increasing absorptive capacity is important for the future productive success of the animal. Research examining heat-related stress indicates that proper nutrition is a key element in combating negative production effects associated with animal stress (Broadway et al., 2020; St-Pierre et al., 2003). Li et al. (2019) examined the effect that transportation stress had on the microbiome. After cattle traveled for 6 hours, transportation stress increased cortisol, adrenocorticotropic hormone as well as pro-inflammatory cytokines IL-6, TNF-α, and IL-1β ($P < 0.05$). Total VFAs were also increased ($P < 0.05$).

The ratio of acetate, proprionate, and butyrate in the rumen varies depending on the diet of the animal, as the rate at which it is broken down can affect the amount of VFA present. In classical research, (Elsden et al., 1945) found that VFA content can double within the first few hours after feeding (1945). Barcroft et al. examined the variation in dry matter between organs to assess the disappearance of VFAs (1943). It was concluded that VFAs are absorbed in the organs in which they are produced, while it is possible that varying concentrations of VFAs between the organs can be attributed to differing absorption rates. Bauman et. al concluded that diets containing concentrates exhibited higher VFA concentrations over forage diets, due to lower volume and more turnover in the rumen pool (van Soest, 1994b). The highest VFA concentrations were present in the rumen, while and hindgut, while the small intestine experienced lower levels of VFA content(Bergman, 1990).

Acetate, the end-product of fiber fermentation, is the most abundant VFA found in the GIT of ruminant animals. Acetate is a major source of acetyl CoA and a precursor to lipid synthesis in the liver. The amount of acetate that is present in the reticulorumen in the highest concentrations regardless of diet composition (Hungate, 1966; Russell, 2019) Proprionate is the end-product of starch and sugar fermentation in the GIT. Proprionate is known as the glucogenic VFA and is associated with energy for weight gain and lactose production (Sheperd and Combs, 1998). Higher grain diets have been linked to increased proprionate production and reduced ruminal pH (Russell 1988). When acetate concentrations are high, proprionate is not sufficient for gluconeogenesis to occur (van Soest, 1994b). Butyrate is known as the energy source for ruminal epithelium, helping promote proper nutrient absorption.

Butyrate

Though present in lower concentrations than acetate and proprionate, butyrate is arguably the most vital to rumen development and function (Baldwin et al., 2004). Butyrate is a short-chain fatty acid (SCFA) that is produced by anaerobic fermentation in the rumen and large intestine. It serves as a major energy source for epithelial cells and stimulates their proliferation, ultimately improving nutrient absorption and overall animal performance (Ishaku, 2010). Ninety percent of butyrate will be absorbed in the rumen epithelial tissue, thus further suggesting its significant impact on ruminal function and improvement (Bergman, 1990). Utilization of nutrients in the ruminal environment is where butyrate holds the most influence. Research findings indicate that butyrate's mode of action is through production of regulatory peptides that stimulate cell proliferation, differentiation, and maturation (Guilloteau et al., 2010). Butyrate is utilized as a major energy source for epithelial development. Butyrate is mainly absorbed in the rumen; however, it can circulate in the blood supply to potentially affect the liver and lower GIT (Bergman, 1990). Butyrate that oxidizes in the gut is largely converted to B-OH butyrate or acetoacetate and is retained in epithelial cells promoting cell proliferation and growth (Church, 1988). Butyrate that is not utilized in the epithelial tissue of the rumen is converted to Butyryl-CoA as it is transported to the liver through the hepatic portal vein. From there it can readily be converted to acetyl-CoA, long-chain fatty acids, or ketones that can assist with lactation or reproduction (Bergman, 1990).

As mentioned, the rumen is lined with a stratified epithelium that undergoes a major transformation during the weaning phase. The surface area of the rumen increases, and papillae are developed to improve epithelial cells' ability to absorb nutrients. Butyrate during this critical period has been shown to influence this ruminal maturation (Sander et al., 1959; Niwińska et al., 2017). Recent research has sought to shed light on whether butyrate supplementation, and in what form or method of administration, influences animal health and performance during other transition periods such as exposure to stress.

Much research in this area is focused on butyrate's impact on ruminal development of younger animals and its long-term benefits. One study found that sodium butyrate supplementation in milk replacer had led to improved ruminal development. Reticulorumen weight was highest in calves supplemented with sodium butyrate at .3% of the milk replacer ration followed by a starter feed mixture with .6% sodium butyrate. Calves fed milk replacer and starter mixture containing butyrate tended to have higher papillae length and width within the cranial dorsal sac of the rumen (Górka et al., 2011). When a starter feed mixture was supplemented with sodium butyrate, it had a more direct effect on rumen development, stimulating epithelial growth. In another study, dairy calves' intake increased by 800 grams per day after supplementation with a ruminal-protected butyrate during their two-week weaning transition period that began at 16 days of age. The calves also experienced higher total VFA concentrations when butyrate was added to the diet. Moreover, findings from another study examined the potential of butyrate supplementation paired with NSAID administration to reduce inflammation and improve dairy cow performance during the calving transition period. Eighty-three pregnant dairy cows were randomly assigned to treatments during the calving transition period, defined as 28 days before calving to 24 days after calving in this study. Animals were fed either a diet with coated calcium butyrate (1.0% butyrate, .24% calcium, and .18% fatty acids) or a control diet (1.04% fat supplement). Diets were formulated to meet the nutrient requirements of a 650-kg cow producing at least 31 kg/day of milk. In the postpartum period, butyrate supplementation and non-steroidal anti-inflammatory drug (NSAID) administration did not affect plasma fatty acid or β-Hydroxybutyrate. Neither butyrate nor NSAID administration had an effect on dry matter intake, body weight, or body condition score (Engelking et al., 2022). Kowalski et. al. shared similar results after evaluating the effects of butyrate supplementation in Holsteins during the close-up period (2015). These findings suggest that when animals are supplemented with butyrate prior to full ruminal development, it can influence the development of the rumen environment, leading to improved animal performance over the course of their life.

Additional research focused on determining if butyrate can have these positive effects and mitigate damage that can occur from transition periods or periods of stress. Abdelqader and

Al-Fataftah (2015) supplemented heat-stressed broilers with butyrate and found that epithelial damage from stress was repaired. These broilers supplemented with butyrate saw an increase in villus height, surface area and overall intestinal weight. A group of adult male sheep were administered sodium butyrate intra-ruminally at 2 g/kg body weight in either one immediate dose, or a gradual release over a 20–24-hour period. Biopsies of the rumen were taken just before each sodium butyrate dosing as well as 24 hours after the final administration. These tissue samples shows that the sheep dosed rapidly had an increase ($P < 0.01$) in mitotic indices and saw more proliferation of epithelial cells. (Sakata and Tamate, 1978). Moolchand et al. (2013) examined this concept further in a study supplementing young goats (2013). Butyrate was administered through rumen cannulas at 0.3 g/kg each day for 28 days. Rumen samples were taken just before infusion as well as 0.5, 1.0, 1.5, 2.5, and 3.5 hours after administration. It was found that butyrate concentrations remained elevated up to 3.5 hours after initial infusion. Overall papillae height and density increased ($P < .05$). Rumen weight was 89.09% of total GIT weight in the sodium butyrate supplemented goats, whereas it was 86.71% for the control. Butyrate administered directly into the rumen environment has positive effects on GIT development and performance in both young and mature animals. The *in vivo* and *in vitro* experiments conducted by Blottiere et al. (2003) concluded that larger surface area of papillae within the rumen has been linked to improved nutrient utilization by animals (2003). This previous research has outlined the benefits of SB supplementation in ruminants, specifically cattle, before and during the weaning period. However, the benefits in post-weaned animals have not been explored.

Extension

Extension was established in 1914 by the Smith Lever Act in 1914, partnering the USDA with land grant universities with the intention of addressing rural agricultural issues. The creation of extension services led to increased productivity, allowing fewer producers to feed the entire United States (NIFA USDA, n.d.). University of Georgia Extension started as a service to bring agricultural research to producers and for over 100 years has provided free and easy to digest information on best-management practices. Extension offers a wide variety of services from workshops, consultations, certifications to field days. UGA extension has personnel in all 159 counties to meet the needs of farmers, families, educators, and industry professionals around the state (University of Georgia Extension, n.d.) Proper reporting of impacts made by extension programs and activities are crucial to the success of extension, as it allows faculty and staff to showcase how the industry has been changed as a result of extension efforts.

Northeast Georgia Beef Cattle Short Course

A group of extension faculty at UGA specialize in topics related to beef production and management, ranging from reproduction, nutrition, to forages. The team is committed to herd innovation, producer education, as well as stockmanship and stewardship as it relates to beef cattle producers in the state of Georgia. The team hosts a wide range of events, including a series of short courses that focus on covering pertinent issues in the beef cattle industry, as determined by team members. The courses combine seminars, live-animal demonstrations, and other hands-on learning experiences to deliver best-management practices and research findings to producers in an easily understood manner (UGA Beef Team, n.d.) The team is focused on assessing the needs of producers and industry members in an effort to present relevant, engaging program. The development of a sustainable, standardized evaluation tool will allow extension faculty and staff to assess and develop extension efforts to effectively bring evidence-based science and best-management practices to producers and industry members across the state.

Common Measures

Extension professionals are challenged to evaluate the effectiveness and overall impact of statewide and regional programs. Specifically in the field of animal science, these programs are all created with unique content and formatting but ultimately are created to provide educational opportunities for producers and add value to their livestock operation (Payne and McDonald, 2012). Common Measures assessment was created as a tool in 2012 for the national 4-H program to evaluate the impact of all programs. California 4-H utilized Common Measures to collect descriptive statistics about 721 4-H youth members across the state. It was concluded that the tool was useful for evaluating existing programs by using the attitudes, skills, and application subscales. The study made further recommendations were made to develop subscales further and improve the range and validity of the tool (Lewis et al., 2015). Feedback such as this led to the release of Common Measures 2.0, which utilizes the online Qualtrics platform to help identify a common core of indicators that can be used to improve extension or 4-H programs (Georgia 4-H). Common Measures was developed as a tool to evaluate across programs but can be utilized in many ways by extension personnel. The tool is useful for evaluation of a specific program, as a cross-sectional tool, or as an assessment of needs (Hawley, 2017).

Payne and McDonald (2012) found in a pilot study that the development and utilization of a common measures tool allow extension personnel to attain feedback that can be used to make recommendations for improving quality, attaining funding as well as increase the accountability for participants and funders (2012). One study identified a need for standardized measures for assessing positive youth development in Iowa 4-H programs (Kavanaugh & Allen, 2020). It was concluded that utilizing the Common Measures 2.0 captured reliable and valid measures that allowed for effective evaluation of program quality. In a study conducted for University of Georgia Cooperative Extension, faculty expressed that they found it difficult to assess the public value that programs have on agriculture in the state. A common measure was developed to analyze self-reported knowledge gain, intent to change behavior, and self-reported economic value based on producers' personal experience with an extension program or activity. A particular challenge that extension faculty addressed was developing a method to capture economic impact, without asking producers about their personal financial information. The tool prompts producers to estimate their value with interval response options asked on a per acre or per head basis (Lamm et al., 2020)

Maximizing Survey Feedback

In the past, researchers and extension personnel relied on mail, telephone, or in-person methods for collecting data to evaluate programs. As technology has improved, online surveys have become the most popular method of collecting data. Benefits include low-cost, easy distribution and organized management of data. However, a challenge that has been faced across survey-distribution methods has been acquiring a good response rate that is representative of the population. One article reports that expected response rates for extension evaluations of meetings, conferences, or overall impact are around 57% or less on average (Archer, 2008). Social Exchange Theory emphasizes the idea that participants are more likely to comply with a request if they perceive that the reward for doing so exceeds the cost. (Dillman et al., 2014).

Monroe and Adams (2012) concluded that utilizing Qualtrics for survey distribution is a viable option for maximizing response rate. The program allows for easy distribution of personalized messages and reminders to respondents or potential respondents, allowing evaluators to increase the perceived reward of conducting the survey, by conveying to potential respondents the value of their feedback and the research they agree to be a part of. It is vital that the beef Extension team at the University of Georgia uses these survey design and distribution practices to create a method to examine the perceived knowledge and economic impact of programs. Feedback collected in an accurate manner will allow for extension personnel to examine how respondents feel about programs while having more insight into how the opportunities presented are in making improvements in the state’s cattle industry, ultimately paving the path for future extension efforts.

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CHAPTER 3

UTILIZATION OF EXOGENOUS BUTYRATE TO IMPROVE GROWTH RATE AND FEED EFFICIENCY IN RESPONSE TO STRESS IN STOCKER CATTLE [1]

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[1]Blackwell, M.B. J. Lourenco, C. Welch, T. Callaway, J. Tucker, D. Davis, S. Hernandez, and R.L. Stewart Jr. to be submitted to *Journal of National Association of County Agricultural Agents*

Abstract

The effect of two different levels of sodium butyrate (SB) supplementation on stress responses in feeder calves were analyzed before and after exposure to long distance transportation between two University of Georgia research facilities: the Eatonton Beef Research Unit and the Georgia Mountain Research and Education Center in Blairsville. Calves were stratified by weight and divided into nine groups with nine animals each. Each of the groups was assigned to one of three treatments: SB (9g/hd), SBx2 (18g/hd) and control group (no SB). At 16 days prior to the start of the trial (d -16), animals were sorted into their treatment groups and weights were recorded. Three randomly selected feeder calves from each pen were selected for rumen fluid collection, in order to analyze volatile fatty acid (VFA) profiles. After the 16 day feeding period (d0), weights were recorded, and animals were loaded onto a trailer where they traveled for twelve continuous hours ending at the Blairsville unit. Twelve hours post transportation, cattle were weighed and separated into treatment groups and rumen fluid was collected (d1). Two weeks after transportation (d14), weights and rumen fluid was collected again. Weights were monitored through the remainder of their stockering period (d84). Animal performance was not affected by treatment across any of the time points. Analysis of the VFA profiles were not affected by treatment, however, a time effect was noticed in that butyrate values decreased by d1 and d14 post transportation ($P < 0.01$). An *in vitro* test was conducted for a sample of each diet, with no treatment effect. While not statistically significant, butyrate levels were numerically lower in the two supplemented treatment groups twelve hours post transportation.

KEYWORDS: *Cattle, Butyrate, Diet, Rumen, Transportation, Supplement*

Introduction

Calves are exposed to a variety of stressors such as weaning, transportation, vaccinations, and dietary changes. These exposures to stressors can potentially lead to reduction in the animals' future productivity and ultimately the profitability of the producer (Amin, et al. 2021). Proper nutrition and management are crucial to ensuring healthy, productive calves during this period, as their digestive system and immunity are underdeveloped (Meléndez et al.,2021).

During the first two months of a calf's life, their digestive system function changes significantly from birth to weaning. When the calf is nursing, the esophageal groove allows milk to bypass the rumen and feed directly into the abomasum. At this point, the abomasum is the largest portion of the GIT (gastrointestinal tract), and the animal is considered functionally a monogastric. As calves reach 6-8 weeks of age and transition to incorporating roughage and other feedstuffs into the diet, the rumen experiences rapid growth and an increase in absorptive capacity (Amin and Seifert, 2021). During this transition, the rumen becomes inoculated with bacterial populations that play a primary role in the fermentation and utilization of feedstuffs, ultimately driving the productivity of cattle long-term (Cammack et al., 2018). The microbial community that populates a mature rumen play a critical role in stress abatement (Heinrichs, 2005).

As this microbial community within the rumen breaks down feedstuffs, they produce volatile fatty acids (VFA) such as acetate, proprionate and butyrate. These are absorbed across the rumen wall and serve as precursors for gluconeogenesis and lipid biosynthesis, thus providing the majority of energy required by the animal. One study concluded that butyrate promoted ruminal papillae growth, leading to improved animal performance (Liu et al., 2021). This, in turn, provides a mechanism of defense against inflammation or any other response to stressors as a result of heat, transportation, or other aspects of production (Bedford and Gong, 2018). Rice et al. (2019) investigated the effects of sodium butyrate on growth and health performance of post-weaned dairy heifers and found that animals tended to have a greater final BW as supplementation increased from 0 to 0.75g/ kg. Guilloteau et al. (2010) concluded that when milk-fed dairy calves were administered oral butyrate supplementation at a low dose (0.3% of DM intake), it increased digestibility of those animals ($P < 0.05$). This could in turn provide post-weaning improvements in growth rate and feed efficiency (Bedford and Gong, 2018).

To this date, there is no research that examines the effects on sodium butyrate on beef cattle during the pre and post-weaning periods. Additionally, research in this field has not examined butyrate's potential effect on improving performance in response to transportation related stressors. Therefore, the objective of this research was to evaluate sodium butyrate supplementation as a way to mitigate transportation stress in beef cattle. Additionally, an in-vitro assay was performed to determine the digestibility and viability of the sodium butyrate supplement as it relates to feed efficiency.

Materials and Methods

Experiment 1

Design and Treatments

All practices and procedures used in this study were approved by the University of Georgia Animal Care and Use Committee prior to the beginning of the study (A2019 10-015-Y3-

A0). A feeding trial was conducted from October to February in 2019. The experiment was conducted at two University of Georgia research farm locations: The Eatonton Beef Research Unit (Eatonton, Georgia) and The Georgia Mountain Research and Education Center (Blairsville, Georgia).

Prior to the experimental period, animals were preconditioned for 42d at the Eatonton Beef Research Unit. In late October, 72 steers and 9 heifers (n = 81) with a mean weight of 287 ± 35.2 kg (mean ± SD) were selected from the Eatonton herd and stratified by weight and sex into 9 groups (9 animals per group). Each group was randomly assigned to one of three treatments, totaling 3 pens (27 animals) per treatment. Treatments evaluated were: 9 g/hd of sodium butyrate (SB); 18 g/hd of sodium butyrate (SBx2) and control with no sodium butyrate (CON).

Animal Management

At d -12, all animals were penned in small pasture facilities and began receiving their experimental diets in Eatonton for a 12-day pre-shipping period. During this period, the experimental diet (Table 3.1) was mixed by hand and delivered daily per pen. The diet was offered at 2% of BW to ensure complete intake of the dietary treatments. Additionally, all animals had ad-libitum access to bermudagrass hay (55% TDN, 10% CP), fresh water, and shade throughout the pre-shipping period. After a 12-day period, animals were loaded onto a livestock trailer and hauled to the Georgia Mountain Research Center in Blairsville, GA for no less than 12 hours without receiving food or water in order to induce transportation stress. Upon arrival, all cattle were comingled for 24 h with access to ad-libitum hay and water. Cattle were then sorted into their original treatment groups and penned by treatment for the remainder of the post-shipping period. For the post-shipping period, the three experimental diets that included butyrate, dried distillers grains, trace mineral and limestone were mixed in bulk at a commercial operation (Godfrey's Feed, Madison, GA), delivered to the station and stored in bulk containers. The experimental diet was weighed daily to deliver 1.8 kg/hd. Corn silage was fed on a per-pen basis at approximately 2% (DM basis) of pen BW and delivered daily at 0830. The remainder of the diet was weighed daily and top-dressed on the silage in the bunk.

In both locations, feed was placed in concrete bunks that were covered to allowed for protection from precipitation. Animals had free access to water. At both locations, Samples from the experimental diets were collected at the beginning and end of each period, submitted to Cumberland Valley Analytical Services (Waynesboro, PA) for chemical analysis (Table 3.2).

Animal Performance

Animal weight data was collected 6 times throughout the study, 3d prior to the initiation of the feeding trial, just prior to shipping (d0), 12 hours after arrival to Blairsville (d1) as well as on d28, 56, and 84. Average daily gain (ADG) and weight loss during shipping were calculated as differences in weight over time in order to determine whether treatment with exogenous butyrate had an effect on animal performance in response to transportation stress.

Volatile Fatty Acid Analysis

Rumen fluid was collected via esophageal tubing from three randomly selected animals in each pen (9 in each treatment group; 27 total) on d-16 in Eatonton as well as d1 and d14 in Blairsville. Rumen fluid was collected into 50 mL conical tubes and stored on ice at 0°C for transportation to the lab. Samples were stored prior to analysis in a -80°C freezer. Samples analysis was performed according to the procedure described in Lourenço et al. (2020). Five mL of rumen fluid was thawed and centrifuged for 10 min at 10,000 x g at 4°C. From the supernatant, 2.5 mL was then transferred to another centrifuge tube. These samples were vortexed to homogenize the sample and frozen overnight at -18°C. The following day, samples were thawed and centrifuged for 10 min at 10,000 x g at 4°C. One mL of the thawed supernatant was mixed with 2 mL of ethyl acetate in a vial, vortexed, and left to separate for 5 minutes. One half of a mL of the top ethyl acetate portion was placed in screw-cap vial for analysis by gas chromatography. VFA analysis was performed using a Shimadzu GC-2010 Plus gas chromatograph (Shimadzu Corporation, Kyoto, Japan) utilizing a flame ionization detector and capillary column (Zebron ZB-FFAP; 30 m x 0.32 mm x 0.25 µm; Phenomenex Inx., Torrance, CA, USA). Sample injection volume was set to 1.0 µL, using helium as a carrier gas. Column temperature started at 110°C and increased to 200°C gradually. The injector temperature was set to 250°C, and the detector temperature was set to 350°C.

Statistical Analysis

Statistical analysis was performed using the software Minitab (v21.2.0). Volatile fatty acid concentrations were analyzed using a mixed effects model ANOVA. The experimental unit was pens (n=3) that animals were housed in. Pen was used as the random factor for animal performance and VFA concentration analysis. Fixed factors for these analyses were treatment and time. The treatment x time interaction was also analyzed. Tukey's pairwise comparison test was utilized to analyze differences between treatment groups. Animal performance data was analyzed using a one-way ANOVA, with time point as the response and treatment as a random effect. Results were considered significant at $P \leq 0.05$ and trends were considered at $P > 0.05$ and $P \leq 0.10$.

Experiment 2

Substrate Preparation

Corn silage and dried distillers' grains were selected as substrates to represent the diet animals were given in experiment 1 during the post-shipping period. Both substrates were dried for 48 h at 60°C and ground to passed through a 2 mm screen using a Model 4 Wiley Mill (Thomas Scientific, Swedesboro, NJ) to allow for more efficient absorption by ruminal contents. Approximately 500mg of substrate was placed in ANKOM F57 bags (ANKOM Technologies, Macedon, NY) and sealed (American International Electric; South El Monte, CA). Twenty (n = 20) bottles (Fisher Scientific; Hampton, NH) were randomly assigned to one of three treatment groups, 9 g/hd of sodium butyrate (SB); 18 g/hd of sodium butyrate (SBx2) and control with no sodium butyrate (CON), with two bottles being utilized for blank bags. Three bags from each treatment were placed at the bottom of each bottle. Ten bottles were analyzed at each time point, 24 h and 48 h. Original weight of each bag as well as weight of substrate was recorded.

Ruminal Fluid Collection and Bottle Preparation

All practices and procedures used in this experiment were approved by the University of Georgia Animal Care and Use Committee prior to the beginning of the study (A20121 11-008-Y1-A0). Ruminal fluid was collected from 3 ruminally cannulated steers housed at the University of Georgia's J. Phil Campbell, Sr. Research Station in Watkinsville, GA. Ruminal contents were collected directly from the rumen. Ruminal contents were agitated by hand in order to obtain a representative sample from multiple locations in the rumen. Ruminal contents were strained through paint strainers (Trimaco, Morrisville, NC), to remove large particles and placed into three

1L thermos that had been previously filled with warm water (39°C) to heat the container and preserve bacterial populations and transported back to the laboratory. Ruminal fluid from all animals was pooled and added (33% v/v) to a buffer media as described by McDougall (1948). Media composition was: 29.4 g $NaHCO_3$, 11.12 g Na_2HPO_4 $7H_2O$, 1.71g KCl, 1.41g of NaCl, 0.36 g $MgSO_4$ $7H_2O$, 0.12g $CaCl_2$. The mixture was equilibrated with O_2-free, CO_2 prior to anaerobic transfer (240 mL) to O_2-free, CO_2 flushed bottles. The mixture was placed into 250 mL bottles and then sealed with caps vented for gas expulsion and incubated in an oscillating incubator (Sheldon Manufacturing, Inc., Cornelius, OR). The bottles were incubated for their designated times (24h and 48h) at 39°C and 127 revolutions per minute.

Bottles were removed after 24hr and 48hr of fermentation, respectively. pH was immediately recorded (Oakton Basic pH 11 Series, Cole-Parmer® Scientific; Vernon Hills, IL) and 30 mL of each fermentation were collected and immediately frozen at -80°C until further analysis. Bags were removed from each bottle, gently rinsed with cold deionized water until rinse water was clear and placed in an oven to dry at 60°C for 24 h. Once dry, bags were weighed, and *in vitro* dry matter disappearance (IVDMD) was calculated as a percent using the following formula. Blank bags and bottles were utilized as a correction factor.

$$\frac{\text{Final DM of feed sample} - \text{Initial DM of feed sample}}{\text{Initial DM of feed sample}} \text{ x } 100$$

Statistical Analysis

Statistical analysis was performed using the software Minitab (v18.1). Volatile fatty acid concentrations were analyzed using a mixed effects model ANOVA. Bottle was used as the random factor. Fixed factors utilized were treatment and time. The treatment x time interaction was also analyzed. Tukey's pairwise comparison test was utilized to analyze any contrasts. Results were considered significant at $P \leq 0.05$ and trends were considered at $P > 0.05$ and $P \leq 0.10$. In vitro dry matter disappearance was analyzed using a general linear model ANOVA. Data was calculated as a percentage based on initial bag weight and contents as well as the final weight.

Results and Discussion

Experiment 1

Animal Performance

Performance data are presented in Table 3.3. There was no effect across treatment groups ($P > 0.100$). Though not statistically significant, we did notice that post-shipping average daily gain (ADG) tended to be numerically highest in SB supplemented group compared to CON. These findings differ from that found by Nazari et al. (2012) that concluded that butyrate had a positive effect on ADG of milk-fed dairy calves at d48 ($P < 0.05$). It is important to recognize that these authors utilized calcium encapsulated butyrate supplementation. In a study that utilized microencapsulated form of sodium butyrate, Liu et al. (2021) found that dairy calves supplemented with sodium butyrate prior to weaning showed enhanced growth, as ADG increased with increasing supplementation (15, 30 and 45 g/day/hd). It is important to note that under the conditions of this study, calves were not challenged with exposure to external stress stimuli. Calves in this study also received higher doses of sodium butyrate per day, at a rate of 15, 30, or 45g/d. Additionally, chemical compositions of our study diet compared to the starter feeds utilized in these studies were largely different. Similarly, Rice et al (2019) reported increased growth in weaned heifers. It was concluded that heifers fed the highest level of sodium butyrate had 4.4% greater average BW and 3.9% greater final BW compared with the CON group. However, Wanat et al (2015) reported that supplementation at 0.3%, 0.6%, or even 0.9% of DM lead to linear decreases in ADG of weaned calves. Though butyrate promotes epithelial cell proliferation, it may also lead to keratinization of rumen papillae, thus stifling absorption of short chain fatty acids in the rumen, possibly explaining this ADG decrease (McGavin et al., 1976).

Volatile Fatty Acids

Volatile Fatty Acid concentrations are reported in Table 3.4. There was no treatment effect on individual VFA concentration, total VFA, or A:P ($P > 0.190$). However, there was time effect ($P < 0.01$) on all VFA concentrations, total VFA, and A:P with all being greatest at D-16. This is likely due to the fact that animals did not receive any feed during the transportation period and fermentation decreased. This time effect is due to the weight changes seen over time. Individual animals also respond differently to treatments and may account for the differences seen (Smith et al., 2004**)**. Interestingly, treatment x time interaction for total VFA (P =0 .099) tended to be higher. The concentrations of butyrate were lowest at D1, 12 hrs after transportation ($P = 0.071$). These results suggest that sodium butyrate supplementation does not influence VFA production in the rumen when exposed to transportation stress. Liu et al. (2021) reported no significant effect on individual or total VFAs were found during the experiment despite animal performance differences being present between treatment groups. Górka et al. (2011) demonstrated that without differences in VFA profiles, sodium butyrate when supplemented in a starter feed rather than a milk replacer had direct effect on rumen development. There was no change in VFA profiles noticed, but reticulorumen weight and papillae size increased in the sodium butyrate treated groups. An additional study by Górka et al

(2014) concluded that a protected form of sodium butyrate, similar to the one used in our study, supplemented at a low level (0.3%) DM enhanced GIT development and animal performance during the pre-weaning period.

Experiment 2

Volatile Fatty Acids

Similar to the data found in experiment 1, *in vitro* butyrate concentrations were not affected by treatment, time, or treatment x time interaction at both 24hr and 48hr time points (Table 3.5). These findings are different from that of McCurdy et al. (2019), which concluded that VFA concentrations overall tended to be lower (P = 0.090) and acetate to proprionate ratios were lower ($P = 0.020$) in animals supplemented with butyrate during the postweaning period. In another *in vitro* experiment, *Clostridium saccharobutylicum* was isolated and identified as a butyrate-producing bacterial species within the rumen that enhances use of butyrate supplementation, and supplementation of butyrate lead to an increase in the population of this bacteria. (Miguel et al., 2019). Li et al. (2006) also concluded that high fiber diets can increase butyrate-producing bacterial populations. It should also be noted that there was a time effect on acetate to proprionate ratio ($P < 0.01$), which can be expected as a result of longer fermentation time.

pH

There was no treatment effect on pH, however, there was a time effect ($P < 0.01$), which can be expected due to increased fermentation over time (Table 3.5). These findings coincide with Liu et al. (2021) who concluded that there was no significant effect on pH when calves were supplemented with SB. However, it is important to note that due to the monogastric nature of pre-weaned calves, butyrate may have bypassed the rumen. Conversely, Khan et al. (2008) found that pH is often lower in pre-weaned cows than those that are mature. McCurdy et al. (2019) also found that butyric acid could lower pH and promote GI colonization of beneficial bacteria. Additionally, differences in diet can possibly account for variation in findings amongst studies. Research suggests that buffering effects are present when forage is added to the diet, allowing for the rumen to maintain pH (Laarman et al., 2012)

In Vitro Dry Matter Disappearance

Dry matter disappearance did not have a treatment (P = 0.784) or time (P = 0.166) effect (Figure 3.1). Hallada et al. (2008) reported that lower levels of dry matter disappearance and digestibility could be attributed to the amount of time that the corn silage was ensiled. Increased amount of time in a low pH environment may have led to an increase in nutrient digestibility when silage enters the GIT. Conversely, Tiwari et al. (2022) found that feedstuffs rich in starch, such as silage, have a higher in-vitro digestibility.

Conclusions and Implications

Strategies for mitigating negative performance effects associated with exposure to transportation stress is important for the profitability of operations. Findings from this study showed that exogenous butyrate supplementation of 9 or 18 g/hd/d prior to and after shipping did not alter the VFA profiles or improve overall animal performance. Results are inconclusive as to what mechanisms within the rumen encourage proper utilization of exogenous butyrate. The animal performance and VFA profiles could indicate that there is potential volatilization or evaporation of the exogenous butyrate. Further research is warranted to examine the viability and stability of sodium butyrate supplementation. Additionally, it is important to examine comparisons between pre and post weaned cattle exposed to stress stimuli as well as the potential effects of higher levels of supplementation. Additionally, no current research examines butyrate supplementation in a primarily corn silage diet. Future research should examine how butyrate interacts with a higher starch diet.

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Table 3.1. Composition of supplemental diet fed for pre and post-shipping periods to stocker steers and heifers. Diet fed with either no sodium butyrate (CON), 9 g/hd of sodium butyrate (SB), or 18g/hd of sodium butyrate (SB x 2) fed on a per-pen basis.

Ingredient, % of DM	Pre-Shipping Period[a]	Post-Shipping Period[b]
Cracked Corn	12.0	
Distiller's grain	6.00	88.0
Soy hulls	3.00	
Molasses	2.00	
Calcium Carbonate	1.50	4.40
Corn Gluten Feed	37.5	
Soybean Meal	37.5	
Trace Mineral[c]	0.14	6.60
Sodium Bicarbonate	1.00	
Ammonium Chloride	0.20	

[a]Composition of supplementary diet for the pre-shipping period fed at 2% BW on a per-pen basis with free choice hay at the Eatonton Beef Research Unit.

[b]Composition of supplementary diet for the post-shipping period fed with corn silage on a per-pen basis at 1.8 kg. Fed at the Blairsville Mountain Research Unit.

[c]Trace mineral composition: Calcium, Phosphorous, Salt, Magnesium, Vitamin A, Vitamin E, Copper, Zinc, Magnesium, Selenium, Manganese, Selenium Yeast

Table 3.2. Chemical composition report from Cumberland Valley Analytical Services (Waynesboro, PA) of corn silage and dried distiller's grain fed to stocker steers and heifers[1]

	Feedstuff	
Chemical Composition, % of DM	Dried Distiller's Grain	Corn Silage
Crude Protein	29.6	8.4
Acid Detergent Fiber	11.7	27.0
Neutral Detergent Fiber	28.0	42.7
Calcium	4.97	0.24
Phosphorous	1.51	0.23
Magnesium	0.42	0.14
Potassium	1.16	1.07

[1]Fed as the main diet components throughout the study at both locations.

Table 3.3. Animal performance of stocker steers and heifers during the pre-shipping and post-shipping periods. Treatments included: 1) no sodium butyrate (CON), 2) 9 g/hd of sodium butyrate (SB), 3)18 g/hd of sodium butyrate (SB x 2) prior to and after a 12 hr transportation period.

Time	Treatment				
	CON	SB	SBx2	SEM	P-Value
d-16 Weight, kg	287	289	285	15.1	0.964
d0 Weight, kg	290	291	292	15.8	0.993
d1 Weight, kg	288	288	289	15.9	0.872
d14 Weight, kg	291	298	294	16.4	0.807
d28 Weight, kg	312	314	315	16.9	0.960
d56 Weight, kg	340	345	345	18.7	0.895
d84 Weight, kg	376	380	378	20.6	0.940
Preship ADG, kg/d[a]	1.95	4.85	5.35	5.19	0.555
Postship ADG, kg/d[b]	3.34	9.94	8.81	18.3	0.825
Ship Shrink, kg/d[c]	-2.52	-2.92	-2.24	2.04	0.870
Wean to Arrival, kg/d[d]	-0.57	1.93	3.13	5.47	0.563

[a]Average daily gain calculated between d-16 and d0

[b]Average daily gain calculated between d1 and d14

[c]Shrink calculated between d1 and D0

[b]Wean to arrival weight difference calculated between d-16 and d1

Table 3.4. Volatile fatty acid (VFA) concentration (m*M*) of rumen fluid. Samples were collected four days prior (d-4) to animals being placed on treatment diets. Treatments included: 1) sodium butyrate (CON), 2) 9 g/hd of sodium butyrate (SB), 3) 18g/hd of sodium butyrate (SB x 2) fed on a per-pen basis, twenty-four hours after transportation (D13) 48h, and one week after transportation (d27).

VFA	Treatment												
	CON			SB			SB x 2				P- Value		
	D-16	D1	D14	D-16	D1	D14	D-16	D1	D14	SEM	TRT	TIME	TRT x TIME
Acetate	61.9	44.3	47.7	76.4	41.2	45.3	57.7	38.8	40.7	5.3	0.291	< 0.01	0.132
Proprionate	12.8^{a}	9.8^{b}	13^{ab}	18.7^{a}	9.9^{b}	10.5^{ab}	10.9^{ab}	8.0^{b}	11.3^{ab}	2.2	0.468	0.005	0.110
Butyrate	7.07^{xy}	3.94^{y}	6.79^{xy}	10.9^{x}	3.61^{y}	6.41^{xy}	5.76^{y}	3.0^{y}	6.92^{xy}	1.15	0.310	< 0.01	0.071
Isobutyrate	0.55^{ab}	0.485^{b}	0.714^{a}	0.668^{ab}	0.524^{ab}	0.659^{ab}	0.531^{ab}	0.443^{b}	0.661^{ab}	0.063	0.603	< 0.01	0.570
Valerate	0.476	0.194	0.439	0.647	0.197	0.321	0.304	0.163	0.433	0.113	0.645	0.003	0.253
Isovalerate	0.761^{ab}	0.534^{b}	1.07^{a}	1.07^{ab}	$.607^{ab}$	1.07^{ab}	0.692^{ab}	0.533^{b}	1.12^{a}	0.138	0.565	< 0.01	0.499
Caproate	0.147	0.011	0.107	0.135	0	0.094	0.109	0	0.137	0.033	0.888	< 0.01	0.735
Total VFA	83.7^{xy}	59.3^{y}	69.9^{y}	108^{x}	55.7^{y}	64.4^{y}	76^{xy}	50.9^{y}	61.3^{y}	8.43	0.193	< 0.01	0.099
A:P	4.98^{a}	4.54^{ab}	3.68^{b}	4.69^{ab}	4.19^{ab}	4.42^{ab}	5.32^{a}	5.01^{a}	3.72^{b}	0.296	0.604	< 0.01	0.043

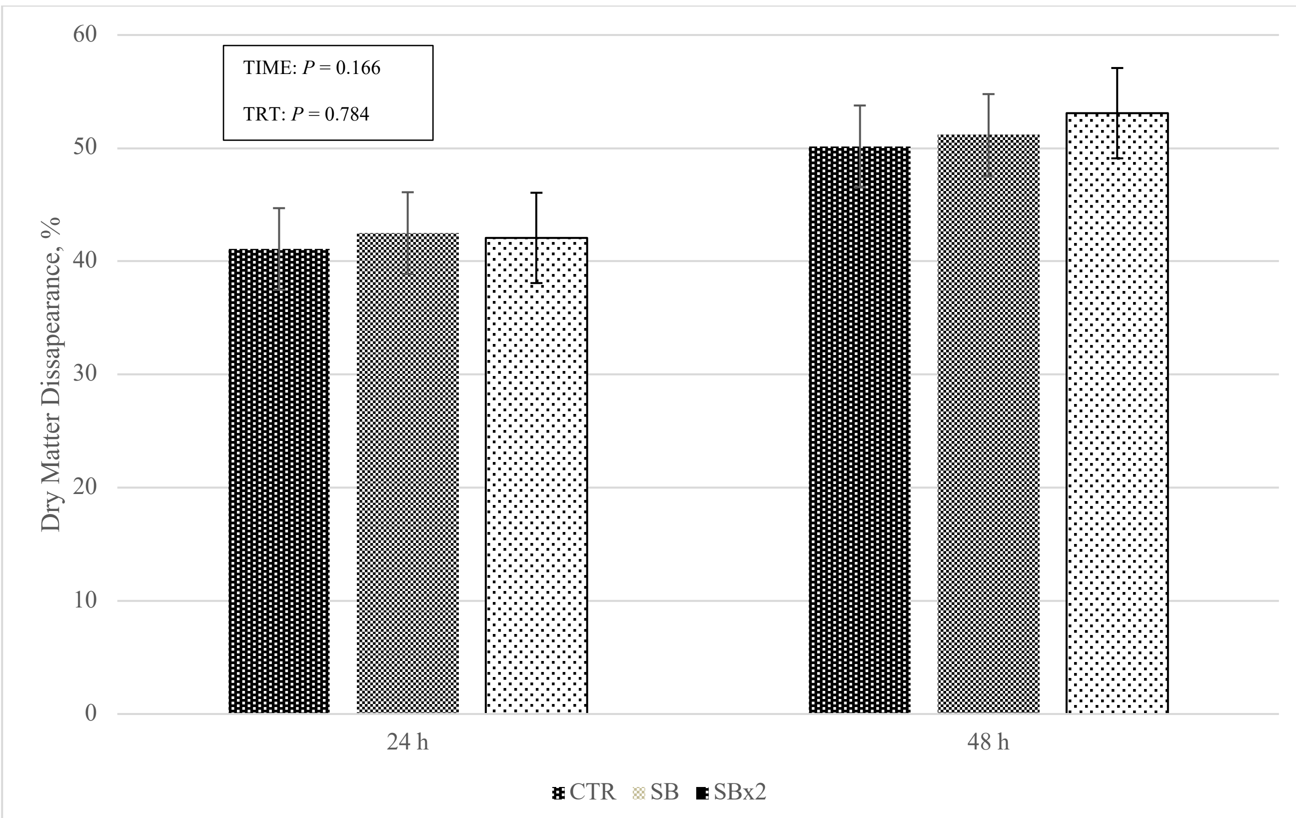
^{ab} Means within row differ at $P < 0.05$

^{xy} Means within row differ at $P < 0.10$.

Table 3.5. Volatile fatty acid (VFA) concentration (m*M*) and pH from in-vitro rumen fluid samples. Concentrations are presented by treatment and time. Rumen fluid was collected from bottles at 24hrs and 48hrs. Treatments included: 1) no sodium butyrate added (CON), 2) 9g/hd of sodium butyrate (SB), 3) 18g/hd of sodium butyrate (SB x 2).

	CONTROL		SB		SB x 2		SEM	P-Value	
	24h	48h	24h	48h	24h	48h		TRT	TIME
Acetate	44.6	49.7	45.7	41.7	41.9	43.1	2.4	0.164	0.724
Proprionate	13.6	17.1	13.5	14.4	12.4	14.6	0.947	0.156	0.016
Butyrate	10.1	10.1	10.3	8.08	9.39	9.04	0.638	0.312	0.129
Isobutyrate	0.954	1.14	0.939	0.878	0.990	0.956	0.071[x]	0.204	0.630
Valerate	1.22	1.64	1.19	1.32	1.29	1.27	0.102	0.225	0.062
Isovalerate	1.77	2.2	1.74	1.71	1.76	1.84	0.112	0.100	0.105
Caproate	0.392	0.585	0.385	0.496	1.3	0.579	0.389	0.395	0.669
Total VFA	72.8	82.5	73.7	68.5	69	71.3	3.56	0.453	0.453
A:P	3.31[ab]	2.9[a]	3.39[b]	2.9[a]	3.32[ab]	2.97[ab]	0.126	0.954	0.002
pH	6.53	5.99	6.51	5.95	6.54	5.94	0.048	0.815	<0.01

Figure 3.1. In Vitro Dry Matter Digestibility (DMD) of corn silage and dried distillers' grain diet. Each feed sample was composed of 75% corn silage and 25% dried distillers' grains. Treatments included: no sodium butyrate added (CON), sodium butyrate at 0.6% of diet composition (SB), or sodium butyrate at 0.12% of diet composition (SB x 2) as the equivalent dietary treatments based on the DMI of the animals. Samples were incubated for either 24 hr or 48 hr.



CHAPTER 4

THE NORTHEAST GEORGIA BEEF CATTLE SHORT COURSE: A EIGHT-YEAR REVIEW [2]

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[2]Blackwell, M.B., A.J. Lamm, L. Ray, M. Stephens, G. Pittman, R. Fitzpatrick, and R.L. Stewart Jr. to be submitted to *The Journal of Extension*

Abstract

A study was conducted to assess the economic impact and knowledge retention of participants that attended the Northeast Georgia Beef Cattle Short Course over an eight-year period. The short course is an educational program hosted by the University of Georgia Extension Service and that brings evidence-based science, technology, and economic and management strategies to beef cattle producers throughout the state of Georgia. This program is a full day course, with guest speakers and demonstrations from University of Georgia faculty and staff, along with industry professionals. This study utilized Qualtrics to distribute a survey to past attendees of the eight short courses to gather information on participants' role in the cattle industry, knowledge application, and economic impact. The goal of the study was to quantify the long-term impact of the short course as well as develop an assessment tool for the beef Extension team to analyze and improve the course.

Introduction

With a presence in all 159 counties, the beef cattle sector is an integral part of the Georgia agricultural industry. According to 2022 values, beef is the fourth largest agricultural commodity in the state, contributing $663.4 million to the state economy (UGA Center for Agribusiness, 2022). With an impact of this magnitude, extension efforts are crucial to ensuring producers have the latest scientific knowledge from the land grant university.

The UGA Beef team is a group of extension professionals (state faculty and county staff) at the University of Georgia College of Agricultural and Environmental Science. This team serves to advance the beef industry by answering questions and providing educational opportunities to beef producers and other industry members invested in beef production throughout the state. The Northeast Georgia Beef Cattle Short Course was developed in 2012 to present best management practices to livestock and beef producers throughout the state in an interactive and easily accessible manner. The short course serves as an educational program hosted by the University of Georgia Extension and brings evidence-based science, technology, as well as economic and management strategies to beef cattle producers throughout the state of Georgia. The short course is a one-day course, with guest speakers and demonstrations from university faculty, staff, and industry professionals

The Northeast Georgia Beef Cattle Short Course is made up of a series of short courses that combine to create the beef extension program hosted by University of Georgia beef extension faculty. The educational program evaluated was offered as part of a series of short courses held annually in Athens, Tifton, and Calhoun. The program is open to beef cattle producers, industry members, and students with the intent of increasing participants' knowledge through hands on experience with beef cattle management topics such as reproduction, nutrition, herd selection, animal health and pasture management. Participants are also presented with current economic trends in the cattle market. Topics covered each year are determined by current needs or pertinent issues in the industry as identified by the Extension faculty. The short course combines seminars and hands-on learning experiences to keep attendees engaged and offers learning opportunities that are catered to specific learners' needs (UGA Beef, 2022). Since the program's inception twelve years ago, long-term impact has not been evaluated.

Purpose and Objectives

The purpose of the study was to quantify the long-term impact of the Northeast Georgia Beef Cattle Short Course as well as develop an assessment tool that can be consistently used for future events. Creating a common measures tool is crucial in establishing a standardized evaluation system that can effectively assess the impact of the extension program over time. The short course was evaluated for long-term impact on the beef industry in the state by collecting data on the demographics, attitudes, experiences, and perceptions of those who have participated in the short course since its inception. This study and the resulting evaluation tool had three major objectives:

1. Describe demographic characteristics of past participants, specifically as it relates to agricultural production.
2. Determine the level of comfort participants have utilizing the knowledge or techniques covered during the course they attended.
3. Assess participants perceived financial value of the skills and information acquired in regard to the profitability of their beef cattle operations.

Methods

A quantitative, survey-based research design was utilized to reach the study objectives. Online surveys are an affordable, accessible method of collecting information, as they often have features included to easily organize data collection and interpretation. (Dillman et al., 2009). Qualtrics is a web-based survey tool readily available for University of Georgia extension that allows users to create effective questionnaires with dynamic options without the need for coding experience, it is a point and click type software that is sustainable for long-term use (Qualtrics, LLC., Provo, UT). The Qualtrics XM online software was utilized in this study to migrate our previously paper-only survey to an online platform for distribution. Past attendees (*n = 307*) email addresses were cataloged from each short course offered and utilized to distribute the online questionnaire, gathering information on participants' role in the cattle industry, comfort with application of concepts taught and perceived economic value of the knowledge they gained.

A researcher-adapted questionnaire was designed to follow the one-shot case study format to review participants' overall experience, production methods adopted, and perceived economic impact related to their attendance at one or more short courses held since 2012. The data was collected with the intention of creating a frame of reference and making recommendations for future extension programming. This questionnaire was developed using Likert scale questions. (Likert, 1932). Personal perception of comfort utilizing the topics covered during the short course was measured through asking a series of questions grouped by major areas of interest covered during the short course. A series of items were combined into a scale for each of the areas of interest historically covered during the short course. Reproduction, marketing, herd health, nutrition, economics, as well as breeding and genomics had a series of questions asked to provide a quantitative measure of comfort and knowledge in those major areas (Boone, 2012). The question branch for each table of questions was "as a result of attending the short course, I was able to…" followed by a scale of response options that assigned a numerical score to the response for each part of the question: 1 = *strongly agree*, 2 = *agree*, 3 = *neither agree nor disagree*, 4 = *disagree*, 5 = *strongly disagree*.

Measuring economic value is of extreme value to extension programs. However, it is often a challenge to capture this impact without asking for personal financial information (Lamm et al., 2021). To accomplish this goal, this survey was constructed to ask producers the perceived cost or savings on their beef cattle operations that occurred as a result of the knowledge they gained during the short course. This survey sought to analyze the impact of the short course over it's lifetime, therefore we created a multiple-choice style question that allowed us to analyze impact during a single production season and extrapolate that data to gain insight on the overall long-term impact of the short course (Figure 1).

To ensure validity of the responses, the skip logic feature was utilized to send respondents to future questions in the survey based on which years they indicated they were attendees. This allowed respondents to only be asked questions related to the topics covered at the short course in which they attended, reducing time required to take the survey (Boyer, 2010).

Based on the principles of Social Exchange Theory (Homans, 1958), techniques from the Tailored Design Method were employed to improve respondent experience and maximize our response rate (Dillman, 1978). A pre-notice email was distributed 48 hours prior to publishing the survey to prepare respondents, explain the purpose of the survey and express appreciation for their participation. Three subsequent emails were sent including survey distribution and two reminders. Participants were incentivized with a chance to win various prizes upon survey completion. Each reminder correspondence was only sent to those respondents who had not completed the survey. The survey was open from August 20th to October 1st, 2020. The questionnaire had a response rate of 19.4% with all respondents compliant with the IRB consent.

All data was analyzed using descriptive statistics through SPSS27 (IBM Corp., Armonk, NY). Likert scale responses were reported as a valid percent to account missing data, as respondents were only prompted to answer questions related to topics covered in the years that they attended the short course.

Results

Nearly half of the respondents were retired from their primary occupation. Respondents reported that 31% were involved in either agricultural production or agriculture-related occupations. The remaining respondents reported they hold employment in a field that is unrelated to agriculture (Figure 4.1).

Respondents indicated that of the breeding and genetics topics covered during the short course, 75% agreed they were able to utilize expected progeny differences as a result of the course, 12.5% strongly agreed they developed the skills to implement this technique; while 25% neither agreed nor disagreed. When asked about their ability to utilize bull and heifer selection skills taught, 87.5% agreed, while the remaining 12.5% strongly agreed that they were able to use this on their operations. Most respondents neither agreed nor disagreed that they were able to implement genetic testing after attending the course (Table 4.1).

When prompted about their level of comfort implementing nutrition knowledge acquired at the short course, participants indicated that they were most comfortable with drought management, improving forage quality and mineral strategy, as well as utilizing body condition scoring (BCS) to assess the overall health of their herd. Only 2.9% of participants indicated that they felt uncomfortable developing a nutritional plan based on the information they were given at the short course and 5.9% reported that they were not comfortable with utilizing byproducts (Table 4.2).

When asked about comfort utilizing the economic topics covered to benefit their operations, respondents overall seemed to mostly disagree or felt neutral that they were able to implement estate planning. A higher frequency (56.8%) indicated that they felt comfortable implementing management strategies on their operations. Participant responses showed that 72.4% agreed or strongly agreed that they felt comfortable with understanding market cycles and economic outlooks for the cattle industry (Table 4.3). As a result of attending the program, most respondents reported that they agreed or strongly agreed that they were able to utilize all marketing topics covered. Only 2% of respondents reported that they felt uncomfortable utilizing Animal ID and record keeping as well as improve marketing strategies from what they learned during the short course (Table 4.4).

When asked about comfort utilizing herd health topics covered, it is interesting to note that 3.3% of respondents disagreed for each topic included. Respondents reported that they felt most comfortable (agreed or strongly agreed) with establishing a working relationship with their veterinarian, improving fly control, and utilizing dewormers (Table 4.5).

Respondents were also asked what amount of financial value they believe their operation saved or gained on a per head basis from the knowledge they obtained at the short course in a single production season. Producers were prompted for information about their operation such as head of cattle and acreage of pastureland. In total, 1,777 head of beef cattle and 6,250 acres of pasture were reported by respondents (Table 4.6). A total economic value variable was created (avg value/head x total head), resulting in a total economic value of $32,089.23 for the Northeast Georgia Beef Cattle Short Course over a single production season. On a producer basis, the total economic value was $629.20. On a per head basis, the total economic value calculated is $18.06. The data was extrapolated to the 307 total documented participants to a value of $193,164.58 in a single production season. Given the eight production seasons and course participants who attended multiple years over the life of the short course, the economic value can be further extrapolated to greater than $1.5 million.

Conclusions

Respondents were found to be a representative reflection of the cattle industry in Georgia, as most producers in the state run smaller-scale (< 30 cows) operations outside of their primary occupation. The results indicated the classroom-based and hands-on learning experiences at the Northeast Georgia Beef Cattle Short Course were effective in giving producers the knowledge to confidently use best-management practices on their operation. Respondents indicated they felt most comfortable utilizing breeding and genetics, marketing, nutrition and herd health skills or knowledge that they acquired from the short course. Respondents reported the most difficulty with implementing the economics topics covered. Given the perceived economic value respondents indicated, the skills gained over the eight years the short course has been offered has contributed significantly to increasing the financial value of the beef industry in the state. Based on the average size of an operation in Georgia, this shows tremendous economic value in creating programs for smaller producers.

Continued use of a consistent long-term impact measurement scale may allow for a more comprehensive understanding of the short courses' impact and allow for data-driven decisions and development of the courses and other extension beef programs in future years. Extension faculty and staff should continue to keep track of attendees via a university-based database to continue to analyze and share impact with participants in support of beef extension programs.

Based on these results, future short courses could be improved by offering learning opportunities in areas such as cattle market cycles and estate planning and risk management to improve producers' understanding of the topics and ability to implement them to strengthen their operations. Continuing to offer the Northeast Georgia Beef Cattle Short Course is influential to agricultural industry in Georgia, as it maintains a point of contact between cattle producers, industry members and university extension and should be considered as a model for other states to emulate to further improve Extension's national impact on beef production.

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Figure 4.1. Primary Occupations of NEGA Beef Cattle Short Course Participants

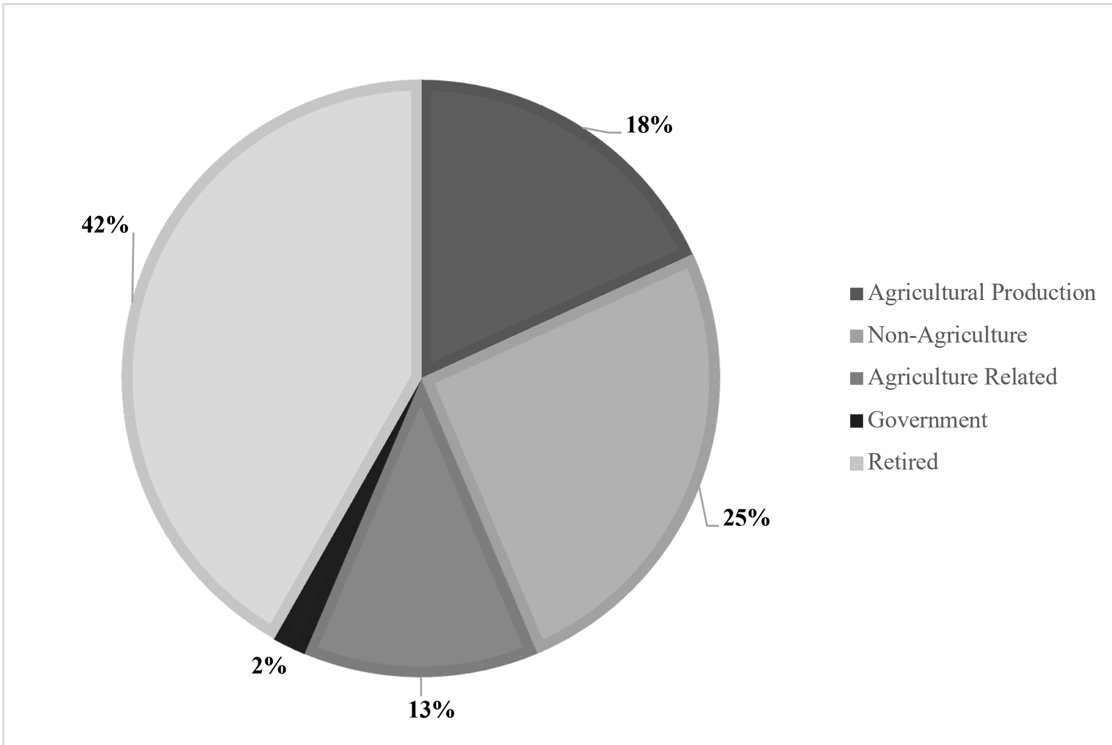

Table 4.1. Level of Comfort Utilizing Breeding and Genetics Topics Covered[1]

"As a result of attending this short course, I was able to ___."	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree
Utilize Expected Progeny Differences	12.5%	75.0%	25.0%		
Utilize Bull & Heifer Selection	12.5%	87.5%			
Utilize Genetic Testing		37.5%	62.5%		

[1]Valid percent computed as frequency that participants responded

Table 4.2. Level of Comfort Utilizing Nutrition Topics Covered[1]

"As a result of attending this short course, I was able to ___."	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree
Develop a Nutritional Plan to Meet the Requirements of Cattle	20.6%	67.6%	8.8%	2.9%	
Utilize Byproducts	8.8%	20.6%	64.7%	5.9%	
Improve Mineral Strategy	32.4%	55.9%	11.8%		
Utilize Body Condition Scoring (BCS)	38.2%	52.9%	8.8%		
Drought Management	17.6%	70.6%	11.8%		
Improve Forage Quality	44.1%	50.0%	5.9%		

[1]Valid percent computed as frequency that participants responded

Table 4.3. Level of Comfort Utilizing Economics Topics Covered[1]

"As a result of attending this short course, I was able to ___."	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree
Understand Market Cycles and Outlook	9.8%	62.7%	25.5%	2.0%	9.8%
Implement Estate Planning	5.9%	31.4%	52.9%	9.8%	5.9%
Implement Risk Management	7.8%	49%	41.2%	2.0%	7.8%

[1]Valid percent computed as frequency that participants responded

Table 4.4. Level of Comfort Utilizing Marketing Topics Covered[1]

"As a result of attending this short course, I was able to ___."	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree
Utilize Animal ID & Record Keeping	37.3%	45.1%	15.7%	2%	
Improving Marketing Strategies (graded sales, group sales, niche marketing, etc.)	27.5%	49%	21.6%	2%	
Utilize Value Added Strategies (castration, implanting, dehorning, etc.)	35.3%	51%	13.7%		
Increase Uniformity (shorter calving season, genetics, etc.)	31.4%	54.9%	13.7%		

[1]Valid percent computed as frequency that participants responded

Table 4.5. Level of Comfort Utilizing Herd Health Topics Covered[1]

"As a result of attending this short course, I was able to ___."	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree
Implement a Vaccination Protocol	33.3%	43.3%	20.0%	3.3%	
Establish a Working Relationship with a Veterinarian	16.7%	60.0%	20.0%	3.3%	
Improve Fly Control Strategy	20.0%	63.3%	13.3%	3.3%	
Start Using or Change Dewormers	23.3%	63.3%	10.0%	3.3%	
Utilize BQA Standards on Needles and Shot Administration	33.3%	46.7%	16.7%	3.3%	

[1]Valid percent computed as frequency that participants responded

Table 4.6. Economic Impact of The NEGA Beef Cattle Short Course

Total Number of Beef Cattle Represented	1777
Total Acreage (Permanent Pasture) Represented	6250
Total Economic Value	$32089.23
Total Economic Value/Producer	$629.20
Total Economic Value/Head	$18.06

CHAPTER 5

CONCLUSION

Beef cattle production plays an integral role in Georgia agriculture, as cattle are present in all 159 counties. This level of production makes a significant contribution to the Georgia economy. Such a notable impact makes it more important than ever that research efforts are made to help producers improve their operations through optimizing animal performance and management strategies.

Though Georgia is primarily a cow-calf producing state, many operations raise stocker cattle. Producers that raise stockers invest a great deal of time and money into ensuring that young cattle are properly developed and prepared for the finishing phase. When cattle are transported long-distance to feedlots, shrink occurs as a result of gut fill or tissue loss that can be attributed to exposure to external stress stimuli. This weight loss translates to an economic loss to both the producers who raise these cattle and the buyers who feed them to market weight. Much research has been conducted on the utilization of butyrate as a method for enhancing animal efficiency through fortifying the ruminal epithelium, specifically as it relates to the dairy industry. However, there is still a need for further investigation of the use of butyrate supplementation in feeder beef calves who have fully matured gastrointestinal structures. The research in this feeding trial was conducted to further understand butyrate's potential to mitigate shipping shrink by improving the environment within the rumen and in turn, enhancing feed efficiency in response to transportation stress.

Data from experiment 1 indicated that there was no overall time or treatment effect when calves were supplemented with sodium butyrate at a rate of 0 g/hd (CTR), 9 g/hd (SB), or 18g/hd (SB x 2). In terms of average daily gain and shipping shrink, there were no differences across treatment groups. Total VFA did not have a treatment or time main effect ($P < 0.01$). Butyrate concentrations also had a time main effect ($P < 0.01$). However, butyrate levels tended to be increased at D-16 and D14 across time points ($P = .071$). An in-vitro test was conducted on samples of treatment diets to further analyze how the sodium butyrate supplement interacts in the rumen environment. No main effect was noticed across treatment groups or time points. When dry matter disappearance was examined, no treatment effect was found. These combined results indicate that sodium butyrate supplementation at 9 or 18 g/hd/d prior to and after shipping did not have an impact on mitigating the negative production effects associated with transportation stress. However, this study is preliminary and further research is warranted to examine the viability of butyrate supplementation as it pertains to beef cattle production and performance. The results of this study illustrate the potential ramifications of stress on stocker cattle production. By conducting further experiments, research in this area could offer butyrate supplementation as an effective, efficient, and affordable management strategy for mitigating shipping shrink.

In addition to making developments through evidence-based science, advances in the beef cattle industry are made through ensuring that producers are presented with these findings alongside best management practices. Experiment 2 examined the long-term impact of the Northeast Georgia Beef Cattle Short Course, which is a program developed by University of Georgia faculty and staff with the intention of educating producers in a unique, impactful manner. Over the eight year lifespan of the course, respondents reflected a representative sample of the cattle industry in Georgia, with a majority reporting operations with less than 30 cattle. Most of these producers reported that cattle production was a source of income outside of their primary occupation. Respondents reported the most comfort utilizing breeding and genetics, nutrition, herd health, and marketing topics that were covered during the courses they attended. Conversely, participants reported difficulty with utilizing the economic knowledge presented during the course. When producers were asked to report the perceived value added to their operation from the knowledge they gained, a total value of $1,545,316.64 was extrapolated over the eight production seasons that took place during the life of the course. Given these results, continuing to offer this course in future years will have significant impact on increasing the productivity and profitability of the cattle industry in Georgia.

It is imperative that research efforts continue to pursue nutritional methods for improving cattle efficiency and analyzing impact of extension programming to provide producers with opportunities for education in current science and management strategies. These combined efforts can develop further success for Georgia's cattle industry.