EVALUATION OF A STARTER RATION ON GROWTH AND PERFORMANCE OF WHITE-TAILED DEER FAWNS

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Matlin Ann Sain

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DEDICATION

I dedicate this thesis to those that I love, value and appreciate most in this world. Also, I dedicate my work to science, a field that I care so much about. In addition, I would like to dedicate this work to my parents, Lonny Sain and Teri Corwin and my sisters, Ashton and McCall for their support and encouragement. Furthermore, I would like to dedicate this work to my two best friends, Hanna Potts and Casey Ling, thank you for believing in me. Lastly, I would like to dedicate this thesis to my mentor Kimberly P. Wellmann, you have made such an influential impact on my life and I am forever grateful for that. Thank you to each one of you for playing such an important role in this process.

ABSTRACT

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Until recently, there was not a ration available to the Texas white-tailed deer (*Odocoileus virginianus*) industry that was designed specifically for fawns. Common practice for pen-raised white-tailed deer breeders is to provide fawns with a ration that is formulated for mature deer. The objective of this study was to evaluate growth and performance of fawns on a new starter ration and to evaluate a dietary supplement designed to enhance the immune system of young fawns. To achieve this, 44 white-tailed deer fawns (26 female, 18 male; 14 d of age) from an established herd (3-S Ranch, Bedias, TX) were randomly assigned to one of two diets. Twenty-two fawns received the control diet (16% CP, 71.6 % TDN, 2.12 % Ca, 0.96 % P, and 0.47 % Mg), which was a pelleted feed formulated for mature deer when limited forbs and browse are available, and 22 fawns received the treatment diet (22% CP, 79.5 % TDN, 1.90 % Ca, 0.63 % P, and 0.31 % Mg), which was also a pelleted feed, but one specifically formulated for young, growing fawns. The treatment diet also contained a proprietary supplement designed to enhance immunity. All fawns in the study were removed from their dams shortly after birth and were bottle-fed using a milk replacer for white-tailed deer according to ranch protocol. Feed was first offered when fawns were 14 d of age and feed intake was recorded daily through 140 d of age. Growth measurements including cannon length, leg length, body length, heart girth circumference, and BW were recorded every 2 wk from d 0 to 140. Data were analyzed using the PROC MIXED procedure of SAS for the effects of diet and day and the diet x day interaction. Male fawns consuming

the treatment ration had a greater ADG ($P<0.05$) than male fawns on the control diet. However, there was no effect of diet on cannon length, leg length, body length, heart girth circumference, or body weight for female or male fawns. Additionally, there was no difference in morbidity, mortality, or the number of days treated for illness between the fawns on the different diets. These data reveal that there is an inconsequential difference in growth and performance of fawns consuming the two different rations; however, fawns required a greater daily intake of the less nutrient dense ration formulated for mature deer to achieve the same level of performance observed in the fawns consuming the starter ration. In addition, these data indicate that white-tailed deer fawns may rely on metabolic signals to regulate feed intake.

KEY WORDS: White-tailed deer (*Odocoileus virginianus*), Fawns, Growth, Performance, Starter ration

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PREFACE

The basis for this research project was to provide today's modern farmer or rancher with the information to manage their herd. After all, the industry that they are involved in and the animals they produce are their livelihood. I have so much respect for people in this industry. They work day in and day out, rain or sunshine, hurricane or icy weather for their animals that they truly do care about.

With that being said, this experience has taught me so much about myself that I did not know before. More specifically, I learned that research is a constant battle of thinking quick and acting fast. Research was never meant to be perfect and I have learned that the hard way. There were several times that my colleagues and I had to come up with a plan-b,c,d,etc. solution to solve the problems we ran into throughout the project. In addition to this, I have learned that it is perfectly normal to not know what you are doing. I would like to attribute that to Dr. Mark J. Anderson, whom reminded me several times that it is perfectly normal to be where I was, lost and confused about what I was doing and where I was going to go. In conclusion, this experience has made me a better scientist and a better person.

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CHAPTER I

Introduction

Background

The white-tailed deer (*Odocoileus virginianus*) is found to be the most wide-spread ungulate in the United States (Holter et al., 1979; DeNicola et al., 2000). Consequently, deer farming has increased throughout the nation, and as a producer, their goal is breed and sell high quality bucks, does, and fawns. For that reason, a producer's priority is to provide the proper environment and nutrition to these animals to enhance their growth and overall health. In addition to this, the offspring or fawns of high value bucks and does can impact the overall population and sales of a producer's white-tailed deer herd. Therefore, if the producer can enhance the nutrition of the fawn, then they can improve and increase survival rates, therefore expanding the quality and quantity of animals within the herd. By doing so, the producer improves their breeding and hunting operation.

Subsequently, a notable challenge of growing concern for producers is improving the health and survivability of newborn fawns and young, growing deer in a penned environment. This can be accomplished by providing animals with appropriate amounts of nutrients in order to strengthen the immune system and prevent infection or disease from occurring. More specifically, Scrimshaw and Talyor (1968) concluded that there is a relationship between malnutrition and infection, implying that there is an increased possibility of becoming sick if one is deficient in essential nutrients. The lack of nutrients such as protein, vitamins and minerals in the diet is one of the underlying causes of this synergistic relationship between malnutrition and infection. Furthermore, protein

is an essential component of the diet and has the greatest impact on the immune system, because protein is a foundation for which cells rely on. Cell replication and the production of antibodies within the immune system have heavy reliance on amino acids in the diet. Overall, the deficiency of essential nutrients, or malnutrition can negatively affect growth and development of young children and can decrease productivity in adults (Scrimshaw and SanGiovanni, 1997). We can infer that the deficiencies of nutrients in the diet have the same effect on young and mature animals in captivity. Therefore, the purpose of this study is to evaluate the fawns' productivity between a feed formulated for mature deer and a starter ration with a dietary supplement that is specifically designed to enhance the immune system of young fawns. We hypothesize that the difference between these two diets will be evidenced through increased growth rates.

CHAPTER II

Literature Review

The White-Tailed Deer

The white-tailed deer (*Odocoileus virginianus*) is under the order Artiodactyla, characterized by the term, even-toed ungulate, or hooved mammal of which moose, caribou and wapiti share the same order (Taylor, 1961; Baker, 1984). In addition to this, the deer is a cervid and belongs to the family *Cervidae* that is made of four subfamilies, Moschinae, Cervulinae, Cervinae, and Odocoileinae. The white-tailed deer fall under the subfamily Odocoileinae with the genus of *Odocoileus* (Baker, 1984). Cervids are ruminants with the typical four-chambered stomach made of the rumen, reticulum, omasum, and abomasum. While white-tailed deer are ruminants, they are considered to be concentrate selectors because they cannot digest plants that are highly lignified; and instead have adapted to digesting forage that is rich in plant cell contents (Hofmann, 1989). Furthermore, cervids have long, thin legs and are admired for their graceful appearance when running and jumping. Also, they are the only animals that can grow antlers with the exception of the musk deer and Chinese water-deer. Antlers are grown only by males, though female *Rangifer* or reindeer have antlers. The size of antlers are determined by genetics, hormones, maturity, and nutrition HILLER. Typically, a buck located in the northern U.S. states will have a larger set of antlers with more tines, than bucks living farther south. This is due to the colder climate, suggesting that deer are larger in order to withstand harsh winters, because it reduces surface area to mass, and therefore heat loss (Taylor, 1961; Baker, 1984; Hiller, 1996). Antlers are made of solid bone that grow from pedicels on top of the male deer or buck's skull and are shed each

year after the breeding season followed by a new set grown in the spring of the next year. The process of shedding is unique in that there is a possibility that the buck can replace his previous set of antlers with a larger set the following year. This is typically seen in bucks that are fully grown as they need less nutrients for growing, therefore nutrients can be diverted towards growing antlers (Hiller, 1996).

The white-tailed deer inhabits almost all 50 states, with the exception of Utah, California, and Nevada and can be found from southern Canada all the way to the northern part of South America (Smith, 1991). They are quite a ubiquitous species that dwell in swamp lands of Georgia and Florida, grasslands of the Gulf Coast, hardwood forests in Canada and the United States, and woodlands of the Rocky Mountains (Taylor, 1961). According to Taylor (1961), deer support the theory of Bergmann's Rule in that animals of the same species that are widely distributed in areas with colder climates have larger bodies than animals from areas that are warmer. This theory is due to the need to supply more fat on the body for animals in colder climates so that they can survive through the winter months.

Management of White-Tailed Deer

Formulating a diet that meets growth and reproductive needs for young deer has been an issue seen throughout the cervid industry in the past (French et al., 1955; Silver and Colovos, 1957). The diet of white-tailed deer is complex in that it varies depending on where the deer is located. Hiller (1996) states that there are over six hundred different plant species that white-tailed deer will consume, however the deer will only consume the plant species that are growing in their habitat that are palatable. Furthermore, wild deer in colder climates typically consume browse because it is the only food source available,

whereas deer living near the Coastal Bend area of Texas will consume forbs that grow almost year-round (Hiller, 1996). This complexity of the diet is further compounded by maturity in that as an animal grows older or enters a different phase of life, their nutritional requirements will change, which makes understanding their nutrient requirements that much more difficult (Ullrey et al., 1969, 1970). This theory is also used by authors Joyce (1993) and Fulbright (1996), in the aspect that a certain management program may work for one habitat, climate, or region, but may not work for another, and each region, climate, or habitat should have their own respective management protocols. Moreover, Fulbright and Ortega-Santos (2013) summarized adequate habitat management into three concepts: 1) A good habitat must begin with adequate vegetation and forage, 2) A habitat that has a greater diversity of vegetation is better suited for animals than one that is not diverse in vegetation, and 3) A good habitat for deer should prevent animals from being in a negative state of energy, and should also provide shelter from the elements. Considering these concepts, French et al. (1956) placed emphasis on the quality of management practices and their effect on white-tailed deer, highlighting the importance on nutritional needs. Similarly, Thompson et al. (1973) recounts that the most productive method for producing high quality deer and creating a good deer management program is through the understanding of range carrying capacity, with emphasis on food preferences, herd nutrition and food quality. As a manager of this species, regardless of what sector of the industry one is in, it is imperative that through experience, both failure and success, one continues to constantly better their management protocols to provide the best nutrition and environment possible for these animals.

Economics of the White-Tailed Deer Industry

The economic impact of the Texas white-tailed deer breeding industry has increased rapidly in the last 15 years and represents one of the largest portions of the cervid farming industry in the United States. Adams et al. (2016) found that more than 5,555 captive white-tailed deer breeding facilities were reported in 2016 from 37 out of 50 states in the United States. Of these 37 states, Texas represented the greatest number of breeding facilities with approximately 1,332 facilities containing over 100,000 white-tailed deer. Moreover, an analysis called IMPLAN® (Impact Analysis for Planning) was used in 2015 to evaluate the economic impact of the deer breeding industry on the Texas economy. This model was originally developed by the U.S. Forest Service and is now managed by the Minnesota IMPLAN group, and uses an input-out design (Lindall and Olson, 1996). The input-out design is driven by sales and purchases of goods and services in all sectors of an industry for a specific economy, also this design has been used for several different industries and economies in the United States (Lindall and Olson, 1996; Outlaw et al., 2017). Using this model, the results showed that the breeding and hunting operations in Texas generate $1.6 billion of economic activity while supporting 16,892 jobs within the industry in Texas (Outlaw et al., 2017). For a comparison, the 2012 Census of Agriculture estimated that the sales of cattle and calves in the United States totaled $76.4 billion (National Agricultural Statistics Service, 2012).

The leading cervid in the deer breeding industry in Texas are white-tailed deer, where breeding and hunting make up the industry (Anderson et al., 2007). The deer breeding industry is composed of two sectors, production and consumption that fuels the operations. The production sector consists of breeding operations and the consumption

sector of the industry comprises several different methods of hunting. Individually, trophy hunting makes up a large portion of the consumption sector of the white-tailed deer industry, where deer are specifically bred to obtain the greatest phenotypical traits that separate trophy deer from non-trophy deer. Altogether, the Texas deer breeding industry makes a huge impact on the National Cervid Farming Industry (Anderson et al., 2007). Therefore, the Texas white-tailed deer industry has a great impact on the economy of the cervid industry in the United States.

Nutrition of White-Tailed Deer

It is to be noted that nutritional studies are limited due to the intensive labor, expense of research and equipment, and time commitment to performing this research (French et al., 1956). In addition to this, French et al. (1956) noted the lack of information available to determine requirements of essential minerals, vitamins and overall nutrients for cervids, therefore presenting a large gap in this field of study. While the information published by French et al. (1956) is from over 50 years ago, we can still speculate that more research is needed to understand the nutritional requirements of white-tailed deer in a captive setting. Due to this gap in valuable information, one can infer that the nutrient requirements for white-tailed deer are not completely understood. Therefore, when providing essential nutrients such as vitamins, minerals, and energy, producers will occasionally base the quantity and quality of these nutrients on the requirements for goats, sheep, and cattle in other production settings.

According to Dietz (1965), protein is a crucial component of the diet and not only influences growth, reproduction and lactation, but also aids the digestive and metabolic state of an animal. In reference to crude protein (CP), Ullrey et al. (1971) found a

suitable stock diet for white-tailed deer of all ages to contain 17% CP. In addition to this, Ullrey et al. (1971) stated that a diet for ruminants should contain these nutrients: energy, protein, essential fatty acids, minerals, vitamins A, D, and E, and fiber. Furthermore, this stock diet can be used during times of growth, maintenance, and reproduction for white-tailed deer. However, this stock diet may not be suitable for neonates, especially those that are about to experience their first winter, as Ullrey et al. (1967) states that the nutritional status of the fawn determines its success or failure to endure its first winter. Furthermore, Ullrey et al. (1967) noted that food consumption decreased during the winter months of November through January, where the mean temperature ranged from -2 to -6 C °, stating that the decrease in intake could potentially be due to the low temperature. Therefore, during the winter months, fawns may rely on fat storage to survive; consequently, it is important to feed them high quality nutrients so that they can store fat and survive the winter months.

Smith et al. (1975) reported that 3.05 g of digestible nitrogen per kg of metabolic weight, or 25% CP is needed for fawns to achieve their greatest growth rate. In opposition, Ullrey et al. (1967) described that male fawns require a greater amount of CP than female fawns for ideal growth, a difference of around 8% CP, with male fawns requiring 20.2% CP and female fawns requiring 12.7% CP. Also, Ullrey et al. (1967) noted a difference in average daily gain (ADG) in males versus females of 0.05 kg and 0.03 kg, respectively. Whereas, French et al. (1956) suggests that 13 to 16% CP is needed for male fawns to achieve peak growth. Altogether, this suggests that young growing fawns require a CP content of at least 13% in the diet and male fawns may require more CP than female fawns.

According to Atasoglu et. al (1998) ruminants have the ability to produce essential and non-essential amino acids (AA) via the microbes in the rumen. However, if the animal is not consuming adequate carbon skeletons and nitrogen from non-protein sources, it can prevent the rumen from synthesizing AA (Atasoglu et al., 1998). Moreover, the carbon skeleton is crucial for AA digestion, because the amine group (NH_2) has to have a carbon skeleton in order to be an AA (Fig. 1).

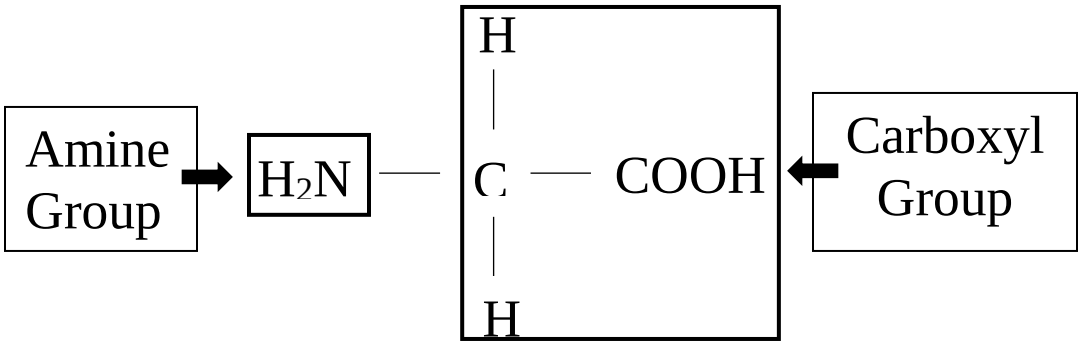

Figure 1. Basic structure of the amino acid, glycine. The amine group (NH_2) is attached to the carboxyl group, thus making a complete amino acid.

For the majority of macro and micro minerals there is not substantial information about the requirements for cervids due to the lack of research in this field of study. Therefore, the National Research Council (2007) suggests to use requirements for goats and sheep for some of the essential nutrients needed in the diet. The overall calcium and phosphorus requirements for growing white-tailed deer are 0.4 to 1.2% of calcium and 0.3 to 0.6% of phosphorus (National Research Council, 2007). Calcium requirements at a maintenance level are suggested as a daily intake of 73 mg/kg of BW, and for antler growth, a calcium requirement of 0.5 to 1.0 g/d is recommended (National Research

Council, 2007). Phosphorus requirements for antler growth are about 26 g on a dry matter (DM) basis per kg of metabolic BW. The authors suggest the phosphorus requirements for growth of white-tailed deer based on growth requirements of goats which is 6.5 g of phosphorus per kg of BW (National Research Council, 2007).

Small ruminants require vitamins A, D, E and K in their diet. However, vitamins A and E need to be supplemented in the diet, as vitamin D is synthesized by sunlight on the skin and vitamin K is synthesized in the rumen after carbohydrate breakdown (Moran, 2005; National Research Council, 2007). The vitamin A requirements for young, growing small ruminants is 100 retinol equivalents per kg of BW. The vitamin D requirements for maintenance and early pregnancy are 5.6 IU per kg of BW, and the vitamin E daily requirement for cervids is based on lamb production at 15 IU per kg of DM (National Research Council, 2007).

Energy requirements of white-tailed deer are met through feedstuffs and roughages and vary among different stages of life (National Research Council, 2007). For deer that are suckling or pre-weaned and live in a penned environment, the energy requirements are 116 kcal per kg of metabolic BW. For growing deer in the winter seasons and summer months, the energy requirements are 125 to 131 kcal per kg of metabolic weight and 192 kcal per kg of metabolic BW, respectively. For mature deer, energy requirements in the winter seasons and summer months are 135 kcal per kg of metabolic weight and 173 kcal per kg of metabolic weight, respectively (Ullrey et al., 1969, 1970; Thompson et al., 1973; National Research Council, 2007).

In summary, white-tailed deer fawns have a CP requirement of at least 13% in the diet. In addition to this, small ruminants need adequate nitrogen and carbon in their diet

to synthesize amino acids. The National Research Council (2007) recommends to use the nutrient requirements for goats and sheep when feeding cervids for some macro-and micro-minerals, vitamins, and energy. The overall calcium and phosphorus requirements for growing white-tailed deer are 0.4 to 1.2% and 0.3 to 0.6%, respectively. Small ruminants require vitamins A and E to be supplemented in the diet. The vitamin A requirement for growing, small ruminants is 100 RE/kg of BW and the vitamin E requirement is 15 IU/kg of DM. The energy requirements for white-tailed deer vary depending on their stage of life. In general, the energy requirements for growing deer in the summer months is 192 kcal/kg of BW.

Growth of White-Tailed Deer

Expected growth rate of pen-raised white-tailed deer fawns has garnered little attention. However, in past studies, Thompson et al. (1973) established growth rates using hand-reared fawns fed a single diet. The authors reported that normal fawns gained an average of 0.21 kg per d during the first 125 d of life. Murphy and Coates (1966) recounted an ADG for fawns fed 7%, 11%, and 13% CP diets. The fawns fed the 13% CP diet had an ADG of 0.24 kg for the first 150 d. In addition, Murphy (1960) found that fawns fed the 7% and 11% CP diets had slower growth rates and weighed less overall. Along with this, Murphy (1960) reported an ADG of 0.22 kg over a 107-d period. On the contrary, Ullrey et al. (1971) noted an average daily growth rate of 0.18 kg over a 120-d period beginning at birth. Atti et al. (2004) noted that greater amounts of CP lead to greater growth rates in goats, specifically observing that goats fed a CP content of 160 g/kg DM had greater muscling and less fat than goats on 130 g/kg DM protein content. This suggests that a diet containing 160 g/kg DM of CP is an adequate quantity for small

ruminants. However, more research is needed to determine if this CP content is sufficient for white-tailed deer. Therefore, we have a basal estimated ADG of 0.18 to 0.22 kg for healthy fawns. These studies demonstrate growth rates of healthy deer in captivity that can be used as benchmarks for the proposed research.

Mortality of White-Tailed Deer Fawns

Cook et al. (1971) determined mortality rates of wild fawns on the Welder Wildlife Refuge. Thirty-four radio collared fawns were used in 1965 and 47 fawns were used in 1966. Seventy-two percent of the fawns died during the project, with 93% dying in the first month of life and 7% in the last month of the project. The major cause of death was due to predators, approximately 53% primarily due to coyotes. Several factors influence mortality rate in neonatal fawns, such as predators, lack of nutrients, weak immune system, and disease. Past studies in captive deer populations have shown that early mortality in neonates is influenced by low birth-mass, depressed immunocompetence, inability to nurse, and maternal rejection (Verme, 1962; Langenau and Lerg, 1976; Sams et al., 1996a; Sams et al., 1996b; Ditchkoff et al., 2001). More specifically, if nutritional requirements of the dam are not met during pregnancy, this could have a drastic effect on the health of the fawn, such as preventing the dam from carrying the fetus to full term if her nutritional needs are not met (Murphy and Coates, 1966). Murphy and Coates (1966) concluded that lower protein levels fed to pregnant does led to the highest mortality rate in their herd. This is primarily due to the reduced ability of the dam to produce milk after giving birth, thus affecting the fawn by preventing colostrum and quality antibodies from being received. Another cause of mortality is the high population density of captive deer causing fawns to have decreased

immunocompetence due to animals that may become sick in close quarters (Sams et al., 1996b). Further, the risk of death for newborn fawns is greatest during their first year of life (DelGiudice et al., 2006). This is partly due to their limited fat reserves which puts them at a higher risk for starvation as well as having limited energy reserves to mount an immune response. Providing pen-raised fawns with a supplemental feed may provide them with the additional energy needed in order to mount an appropriate immune response to pathogens. Therefore, investigating nutritional supplements in populations of high stocking rates could have a positive impact on the white-tailed deer industry through reducing mortality rates of fawns.

CHAPTER III

Materials and Methods

IACUC Statement

All care, handling, and sampling of deer were approved by the Sam Houston State University Institutional Animal Care and Use Committee (Protocol number: 16-10-13-1019-3-01).

Standard Operating Procedure at Birth

White-tailed deer fawns (n = 44; 26 female, 18 male; 14 d of age) from an established herd (3-S Ranch, Bedias, TX) were used to evaluate the efficacy of two diets in regards to growth, performance, and health status. All fawns used in the trial were born between the months of May and July of 2016. The fawns were offspring of does that were mated using laparoscopic insemination and later placed with bucks for natural breeding purposes to maximize pregnancy rate. Breeding occured in November through December of 2015 with an expected due date of May through August of 2016. During the fawning season, pens were checked twice daily for newborn fawns at 12-h intervals. At the time of discovery, fawns were identified with a panel ear tag, a hair sample was collected for DNA analysis to determine parentage, and other procedures were performed according to standard ranch protocol. Once animals were identified, physical measurements including cannon length, leg length, body length, heart girth circumference and BW were obtained. Cannon length was measured from the point of the hock to the pastern, leg length was measured from the point of the hock to the point of the hoof, body length was measured from the point of the shoulder to the point of the hip, and heart girth circumference was measured immediately caudal to the shoulder. All measurements

were recorded in centimeters using a soft tape measure and BW, measured in kilograms, was determined by using a mesh basket and a portable, digital scale (Berkley, Columbia, SC). Blood was collected via jugular venipuncture 12 to 24 h after birth using a 23-gauge butterfly needle and 12 inch extension kit into three 2 mL sterile vacutainer tubes, one containing 15% K_2EDTA and two non-additive tubes (Monoject, VWR, Radnor, PA).

Shortly after blood was collected, whole blood was utilized to determine the values for Brix score, total protein concentration, and IgG concentration using a digital refractometer (Misco, Solon, OH). Brix score or brix concentration is a test on the refractometer that can measure sucrose concentration (Hernandez et al., 2016). In addition to this, Brix can also be used to evaluate the total solids percentage, or a supplemental measurement of IgG concentration in liquids that do not contain sucrose (Deelen et al., 2014; Hernandez et al., 2016). However, for this study, Brix was used to estimate the IgG concentration of the blood. In addition to this, blood from the non-additive tube was centrifuged after collection at 2000 rpm for 20 min (ThermoFisher Scientific, Waltham, MA). Thereafter, serum was also used to determine the values for Brix, total protein concentration, and IgG concentration with the same refractometer. Twenty-four to 48 h later, fawns were removed from their dams and were bottle raised due to low birth weight (less than 2.27 kilograms), health status, or high value. All fawns were selected to be removed from the dam by the owner of the animals in an attempt to increase chances of survivability by hand-rearing them. After the fawns were removed from their dams, they were moved to separate pens that were 1.2 x 3 m in size, containing two fawns per pen. The fawns were paired based on similar birth weight. Fawns were

offered a milk replacer (Superior Milk Replacer, Waterloo, IL) for approximately 3 mo or until weaning, depending on the health status and age of the fawn.

On d 14, fawns were randomly allocated to a treatment (n=22) or control (n=22) diet with *ad libitum* access to feed, hay, and water. The control diet was a pelleted feed formulated for mature deer when limited forbs and browse are available. The treatment diet was also a pelleted feed, and contained a dietary supplement that was an all-natural fermentation-based feed additive composed of metabolites such as proteins, peptides, antioxidants, phytosterols, organic acids, and nucleotides. The dietary supplement also contained betaglucans and mannans to support animal health and performance. Furthermore, the treatment diet was designed to enhance immunity and increase response to medical treatment of disease and is specifically formulated for young, growing fawns. Nutrient compositions of the control and treatment diets are displayed in Table 1. The hay offered was a summer alfalfa hay (17% CP, 58% TDN).

Table 1

Nutrient composition of treatment and control diets fed to growing fawns over a 140-d period

Nutrient	Control Diet	Treatment Diet
Crude Protein	16.0 %	22.0 %
Total Digestible Nutrients	71.6 %	79.5 %
Calcium	2.12 %	1.90 %
Phosphorus	0.96 %	0.63 %
Magnesium	0.47 %	0.31 %

Feed and hay intake were recorded daily from d 14 through d 100. Growth measurements were recorded every 2 wk beginning at birth and continuing through d 140. In addition to this, blood samples were collected 24 h after birth and on d 56, 84, 112 and 140. Whole blood and serum were used to determine Brix score, total protein concentration, and IgG concentration. Whole blood was used to conduct a complete blood cell count (CBC), and serum was utilized to determine antibody titers to Bluetongue Virus and Epizootic Hemorrhagic Disease types 1, 2 and 6 (Texas A&M Veterinary Medical Diagnostic Laboratory, College Station, TX). Remaining plasma and serum were stored at -20 °C. A 9-way combination vaccine for Epizootic Hemorrhagic Disease and Bluetongue Virus (Newport Labs, Worthington MN, USA) was administered to the fawns s.c. near the shoulder on d 56 and was used to evaluate immune response to the vaccine as indicated by antibody titers to these diseases. However, this was discontinued after d 56 per herd owner's decision. Dewormer (Ivomec, Merial, Duluth, GA) was administered to the fawns s.c. near the shoulder beginning at 3 mo of age and every 6 to 8 wk thereafter.

Standard Operating Procedure per Pen

On d 30 of the trial, fawns were moved from the 1.2 x 3 m pens to pens measuring 3 x 9 m with a total of 4 fawns per pen. On d 100, fawns were removed from the 3 x 9 m pens and placed into one of two large enclosures, approximately 20 x 20 m in size based on diet. The arrangement of pens are referenced in Fig. 2. After this, feed and hay intake were no longer measured due to the inability to determine how much each experimental unit was consuming; however, fawns continued to receive *ad libitum* feed and hay.

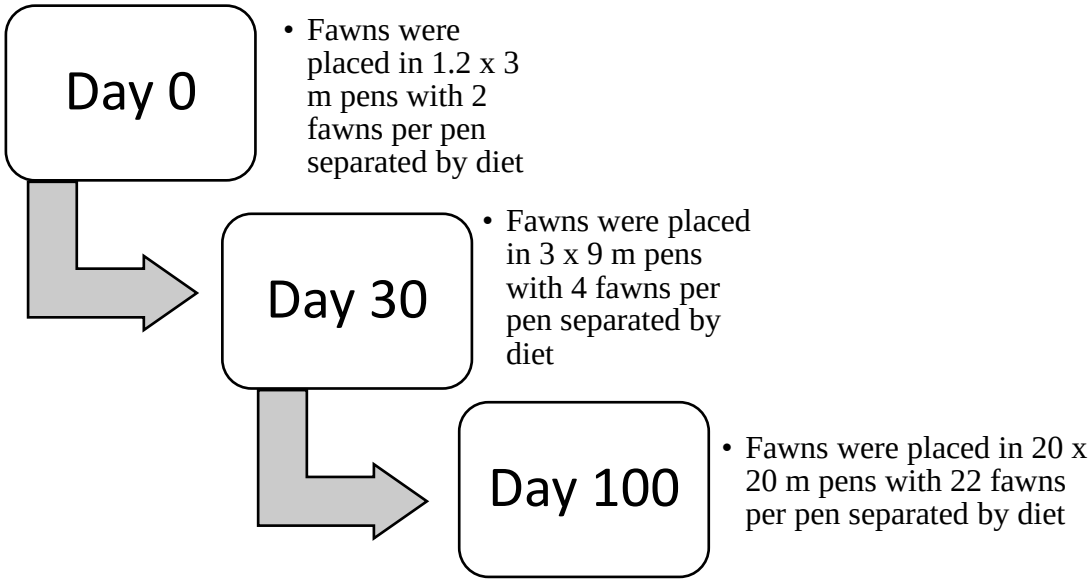

Figure 2. Diagram of pens that fawns were housed in on d 0, 30, and 100 of the trial. On d 0 fawns were placed into 1.2 x 3 m pens with 2 fawns in each pen per diet. On d 30 fawns were moved into 3 x 9 m pens with 4 fawns per pen per diet. Lastly, on d 100, fawns were moved into two 20 x 20 m pens with 22 fawns in one pen fed the treatment diet and 22 fawns in the other pen fed the control diet.

Statistical Analysis

All data were analyzed using the PROC MIXED procedure of SAS Enterprise Guide (SAS Institute Inc., Cary, NC, USA) to determine the differences in ADG, intake, growth, and blood cell count between the treatment and control diets. Pen was used as the experimental unit and fixed effects were day and diet and repeated measures were day, pen, and diet.

CHAPTER IV

Results and Discussion

Nutrient Intake of White-Tailed Deer Fawns

There was a day effect for feed ($P<0.001$), forage ($P=0.002$), and milk replacer ($P<0.001$: Table 2). This effect represents a steady increase in protein intake due to the fawns consuming a greater amount of feed, forage, and milk replacer on a daily basis. Furthermore, there was no effect of diet or a diet x day interaction in intake for feed (P=0.30, $P=0.13$, respectively) or forage (P=0.93, $P=0.82$, respectively), or milk replacer (P=0.59, $P=0.59$, respectively).

McEwen et al. (1957) established that 17% CP was optimal to achieve maximum skeletal and antler growth in white-tailed deer. Additionally, French et al. (1956) conducted similar research where male deer were fed varying levels of protein and concluded that young deer require a CP content in the diet of 13-16% fed *ad libitum*. French et al. (1956) determined that deer weighing 22.7 to 27.2 kg require a daily intake of 0.91 kg or 3600 calories of premium quality deer food fed *ad libitum*. Nevertheless, while these two studies present different values of crude protein needed in the diet, one could speculate that young fawns need between 13-25% of dietary CP. Consequently, in the present study, the authors assume that both diets met the fawns CP requirements.

Table 2

Mean (lower 95% CI, upper 95% CI) CP intake of fawns that were consuming either a 16% crude protein (control) diet or 22% crude protein (treatment) diet in addition to milk replacer and forage by day.

Diet	Day of Trial								*P* - value		
	1	14	28	42	56	70	84	98	Diet	Day	Diet*Day
					Feed intake, g/d						
Control	0.22 (0.05, 0.81)	0.86 (0.25, 3.05)	1.36 (0.21, 8.72)	5.22 (1.34, 20.36)	18.48 (6.15, 55.51)	74.1 (25.08, 218.78)	88.78 (30.64, 257.16)	143.15 (50.45,406.07)			
Treatment	1.04 (0.28, 3.84)	1.55 (0.44, 5.46)	3.28 (0.58, 18.54)	11.53 (3.00, 44.95)	19.02 (6.33, 57.11)	57.12 (19.34, 168.69)	63.31 (21.86, 183.44)	140.25 (49.44, 397.83)	0.30	<0.001	0.13
Overall Mean	0.48[a] (0.16, 1.44)	1.16[a] (0.39, 3.42)	2.11[ab] (0.53, 8.35)	7.76[bc] (2.51, 24.00)	18.75[c] (6.73, 52.20)	65.06[d] (21.66, 195.39)	74.97[d] (27.04, 207.87)	141.68[e] (49.22, 407.94)			
					Forage intake, g/d						
Control	1.87 (1.12, 3.13)	2.32 (1.29, 4.19)	3.42 (0.69, 16.95)	3.10 (1.29, 7.48)	3.82 (1.90, 7.70)	5.71 (3.90, 8.35)	6.25 (1.96, 19.90)	---			
Treatment	2.03 (1.21, 3.41)	2.39 (1.32, 4.31)	1.78 (0.36, 8.83)	2.79 (1.16, 6.72)	2.90 (1.44, 5.84)	6.93 (4.71, 10.20)	15.14 (4.04, 56.75)	---	0.93	0.002	0.82
Overall Mean	1.94[a] (1.35, 2.81)	2.35[a] (1.55, 3.57)	2.47[abc] (0.80, 7.66)	2.94[abc] (1.58, 5.48)	3.33[abc] (2.03, 5.46)	6.29[bc] (4.80, 8.25)	9.73[c] (4.04, 23.42)	---			

(continued)

Diet	Day of Trial								*P* - value		
	1	14	28	42	56	70	84	98	Diet	Day	Diet*Day
	Milk Replacer intake, g/d										
Control	11.55 (9.00, 14.80)	37.31 (29.11, 47.83)	49.37 (38.51, 63.30)	55.55 (43.33, 71.22)	39.68 (30.96, 50.87)	28.41 (20.96, 38.49)	23.52 (15.30, 36.16)	---			
Treatment	12.91 (10.07, 16.55)	39.81 (31.05, 51.04)	41.95 (32.72, 53.78)	45.96 (35.85, 58.93)	42.31 (33.00, 58.93)	37.34 (28.45, 49.02)	27.79 (15.13, 51.04)	---	0.59	<0.001	0.59
Overall Mean	12.21[a] (10.24, 14.55)	38.54[bc] (32.33, 45.94)	45.51[bc] (38.18, 54.25)	50.54[b] (42.39, 60.24)	40.97[bc] (34.37, 48.84)	32.57[c] (26.56, 39.94)	25.57[c] (17.62, 37.10)	---			

[a, b, c] Means within growth parameters without common superscripts differ (*P*<0.05)

There was a day effect for TDN for feed and forage ($P<0.01$) for fawns on both diets (Table 3). This was due to the steady increase in TDN intake as the fawns consumed more feed throughout the trial. As a comparison, Thompson et al. (1973) recounted that when fawns were fed a concentrate diet with 16.8% CP at 125 d of age they had a daily overall TDN intake of 667.8 g. Comparing this information provided by Thompson et al. (1973) with the results from the present study, we see that the fawns at 98 d of age had an overall TDN intake of 1261 g. Therefore, the fawns in the present study had a greater TDN intake at a younger age than the fawns used in the study by Thompson et al. (1973). Furthermore, Thompson et al. (1973) noted that as the fawns consumed more feed, the TDN intake increased. This was also observed in the present study. Additionally, comparing BW of fawns between these two studies, fawns in the present study had an overall BW of 13.47 kg at 126 d of age and fawns from the study conducted by Thompson et al. (1973) had an overall BW of 29.0 kg at 125 d of age. The greater BW published by Thompson et al. (1973) could be due to the location and climate where the fawns were raised. Typically, deer that are located in the northern U.S. are larger than fawns located farther south, and the study conducted by Thompson et al. (1973) was located in New Hampshire. Overall, the fawns from the present study had a lower BW, even though they were consuming more TDN. This could indicate that the diet fed to the fawns in the current study was more nutrient dense than the diets fed to the fawns in the study conducted by Thompson et al. (1973), however this is only a speculation. Altogether, there is a lack of information published about the TDN requirements of white-tailed deer fawns (Ullrey et al., 1969, 1970).

Table 3

Mean (lower 95% CI, upper 95% CI) TDN intake of fawns that were consuming either a 16% CP (control) diet or 22% CP (treatment) diet in addition to milk replacer and forage.

Diet	Day of Trial								*P* - value		
	1	14	28	42	56	70	84	98	Diet	Day	Diet*Day
						Feed g/d					
Control	2.0 (5.0, 7.0)	8.0 (2.0, 27.0)	12.0 (2.0, 78.0)	47.0 (12.0, 181.0)	164.0 (55.0, 494.0)	659.0 (223.0, 1947.0)	790.0 (273.0, 2289.0)	1274.0 (449.0, 3614.0)			
Treatment	9.0 (2.0, 34.0)	14.0 (4.0, 49.0)	29.0 (5.0, 165.0)	103.0 (26.0, 400.0)	169.0 (56.0, 508.0)	508.0 (172.0, 1501.0)	564.0 (195.0, 1632.0)	1248.0 (440.0, 3541.0)	0.30	<0.001	0.13
Overall Mean	0.004[a] (0.001, 0.013)	10.0[ab] (3.0, 30.0)	19.0[bc] (5.0, 74.0)	69.0[cd] (22.0, 213.0)	167.0[d] (60.0, 465.0)	579.0[e] (193.0, 1739.0)	667.0[e] (240.0, 1850.0)	1261.0[e] (438.0, 3630.0)			
						Forage g/d					
Control	14.0 (8.0, 24.0)	17.0 (10.0, 32.0)	27.0 (5.0, 132.0)	23.0 (10.0, 56.0)	29.0 (14.0, 58.0)	42.0 (28.0, 65.0)	47.0 (15.0, 148.0)	---			
Treatment	0.015 (0.009, 0.026)	18.0 (10.0, 33.0)	14.0 (3.0, 68.0)	21.0 (9.0, 49.0)	20.0 (10.0, 41.0)	50.0 (32.0, 77.0)	106.0 (28.0, 398.0)	---	0.99	0.004	0.82
Overall Mean	15.0[a] (10.0, 21.0)	18.0[a] (12.0, 27.0)	19.0[abc] (6.0, 59.0)	22.0[abc] (12.0, 40.0)	24.0[abc] (15.0, 40.0)	46.0[bc] (34.0, 62.0)	70.0[c] (29.0, 169.0)	---			

[a, b, c, d, e, f, g, h] Means within growth parameters without common superscripts differ ($P<0.05$)

Growth Parameters of White-Tailed Deer Fawns

During the course of the trial there was an interaction between treatment and sex of the fawns for ADG (P=0.03; Fig. 3). Specifically, there was a tendency (P=0.06) for the male fawns on the treatment diet to have a greater ADG (0.14 ± 0.01) than males on the control diet (0.11 ± 0.01). We speculate that the cause of the greater daily gain for the male fawns on the treatment diet was due to the higher CP content of the diet. In addition to this, Ullrey et al. (1967) had similar results with male fawns gaining a greater amount of weight on a 20.2% CP diet compared to male fawns consuming either a 12.7% or 7.8% CP diet. This can further suggest that CP content impacts ADG in male fawns and that a diet containing at least 20.2% CP will increase rate of gain compared to lower CP formulations. The same cannot be said for female fawns on this trial as there was no difference between treatments (P>0.10). In prior research, female fawns fed a diet of 12.7% CP had a greater rate of gain than females fed a diet of 7.8% or 20.2% CP (Ullrey et al., 1967). Both diets in the current study had CP concentrations greater than 12.7%. It is possible that these diets exceeded the female fawns' protein requirements, which could cause more energy to be expended digesting and excreting excess nitrogen resulting in reduced ADG. This could possibly be the reason why female fawns on this trial had a lower ADG than the male fawns. Our results suggest that the reason behind this is growing male fawns require more protein than females. This is similarly noted in calves by Morrison (1936) where normal growth rates of bull and heifer dairy calves showed that bulls grew faster in both weight and height than heifers. Additionally, if producers see similar results between their male and female fawns, it might be necessary

to provide males with a diet containing a greater CP concentration, however this is only a speculation. Further research should investigate sex differences in protein requirements of captive raised white-tailed deer fawns.

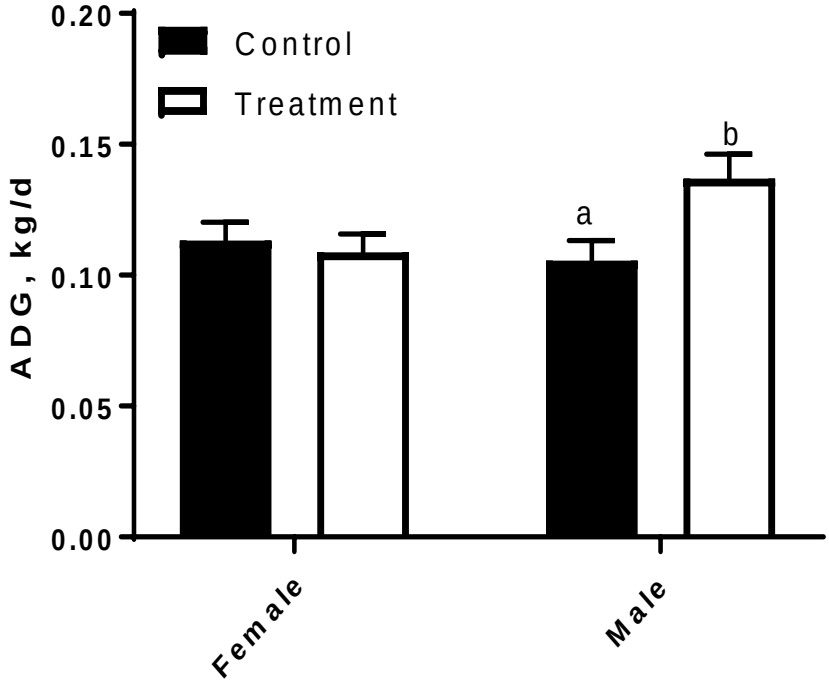

Figure 3. Mean ADG (kg/d) of fawns that were consuming either a 16% crude protein (control) diet or 22% crude protein (treatment) diet in addition to milk replacer and forage by sex. [a, b] Means within sex without common subscripts differ ($P<0.05$)

There was a day effect ($P<0.01$) for cannon, leg, and body length, where all values increased over time due to normal growth for animals on both diets (Table 4). No differences were detected ($P>0.10$) for the diet or diet x day interaction for cannon length, leg length, or body length. From this we can infer that while the diets were different in nutrient density, there was not a difference in growth rates ($P>0.10$). This could also potentially mean that the physical characteristics measured were not an accurate indicator of growth differences between fawns on the two different diets. Further research is needed to define the most appropriate measurement of growth for fawns. Additionally, while there were no differences seen in the growth parameters, it is possible that both diets are adequate in achieving a normal growth rate for fawns in this study. However, there is little to no information on the growth curve for white-tailed deer in a captive setting, therefore, we cannot accurately state that the growth measurements obtained from this study are normal. This subject should be studied further to establish an ideal growth curve for fawns and provide producers with a standard for comparison to determine if fawns in their herd are achieving adequate growth rates.

A study conducted by Bartlett et al. (2006) using a 2 x 4 factorial design evaluated growth parameters of calves fed differing levels of CP (14%, 18%, 22%, and 26%) content in a milk replacer fed at varying levels of BW (1.25% and 1.75%). The authors reported that the calves fed the milk replacers at 1.75% BW had overall greater ADG, BW, and heart girth circumferences (Bartlett et al., 2006). In addition, there was a linear increase in the overall body length of the calves fed at 1.75% BW as DM and CP increased (Bartlett et al., 2006). Based on these results, we can infer that the growth of

young ruminants may be more dependent on CP and increasing the CP content of the diet could result in an increased growth rate. While the present study used that same concept of providing a group of fawns with a greater CP content, the results of this trial were not similar to those of Bartlett et al. (2006).

Table 4

Mean (lower 95% CI, upper 95% CI) of growth parameters measured of fawns that were consuming either a 16% crude protein (control) diet or 22% crude protein (treatment) diet in addition to milk replacer and forage by day.

Diet	Day of Trial								*P* - value		
	0	14	28	42	56	70	84	98	Diet	Day	Diet*Day
					Cannon Length, cm						
Control	18.13 (17.22, 19.04)	19.11 (18.21, 20.02)	19.80 (18.89, 20.71)	20.77 (19.86, 21.68)	21.47 (20.55, 22.38)	21.72 (20.81, 22.64)	22.45 (21.53, 23.36)	22.95 (22.03, 23.86)			
Treatment	18.18 (17.24, 19.12)	18.95 (18.01, 19.89)	19.82 (18.87, 20.76)	20.82 (19.87, 21.76)	21.54 (20.60, 22.49)	21.76 (20.82, 22.71)	22.69 (21.74, 23.63)	23.21 (22.27, 24.16)	0.73	<0.001	0.69
Overall Mean	18.15[a] (17.29, 19.01)	19.03[b] (18.17, 19.89)	19.81[c] (18.94, 20.67)	20.79[d] (19.93, 21.66)	21.50[e] (20.64, 22.37)	21.74[e] (20.88, 22.61)	22.57[f] (21.70, 23.43)	23.08[g] (22.22, 23.94)			
					Leg Length, cm						
Control	22.33 (21.04, 23.62)	24.01 (22.72, 25.30)	25.45 (24.16, 26.75)	27.04 (25.75, 28.34)	27.84 (26.54, 29.13)	28.43 (27.13, 29.73)	29.43 (28.13, 30.73)	30.48 (29.18, 31.78)			
Treatment	22.57 (21.23, 23.91)	23.82 (22.48, 25.16)	25.30 (23.96, 26.64)	26.71 (25.37, 28.05)	27.83 (26.48, 29.17)	28.64 (27.30, 29.99)	29.79 (28.45, 31.14)	30.64 (29.30, 31.99)	0.79	<0.001	0.12
Overall Mean	22.45[a] (21.23, 23.68)	23.92[b] (22.69, 25.14)	25.38[c] (24.15, 26.60)	26.88[d] (25.65, 28.10)	27.83[e] (26.60, 29.06)	28.54[f] (27.31, 29.77)	29.61[g] (28.38, 30.84)	30.56[h] (29.33, 31.79)			

(continued)

Diet	Day of Trial								*P* - value		
	0	14	28	42	56	70	84	98	Diet	Day	Diet*Day
					Body Length, cm						
Control	26.28 (23.84, 28.71)	28.56 (26.12, 31.00)	32.62 (30.15, 35.08)	35.55 (33.10, 38.00)	37.79 (35.32, 40.26)	39.79 (37.30, 42.28)	43.19 (40.70, 45.68)	45.09 (42.60, 47.58)			
Treatment	25.96 (23.43, 28.48)	28.91 (26.39, 31.44)	32.82 (30.30, 35.35)	35.09 (32.57, 37.62)	37.98 (35.44, 40.51)	39.11 (36.56, 41.65)	43.26 (40.71, 45.80)	45.91 (43.36, 48.45)	0.88	<0.001	0.96
Overall Mean	26.12[a] (23.85, 28.38)	28.74[b] (26.47, 31.00)	32.72[c] (30.45, 35.00)	35.32[d] (33.06, 37.59)	37.88[e] (35.60, 40.16)	39.45[e] (37.16, 41.73)	43.22[f] (40.94, 45.51)	45.50[g] (43.21, 47.78)			

[a, b, c, d, e, f, g] Means within growth parameters without common superscripts differ ($P<0.05$)

There was a day effect for body weight ($P<0.01$), but there was no diet effect or diet x day interaction ($P>0.10$; Fig. 4). The significance of day suggests that the fawns on both diets had a constant increase in BW throughout the trial as they were consuming more feed. While the two diets had different levels of CP, it is possible that fawns on both diets were able to achieve maximum BW in this trial; this could suggest that both diets were adequate in providing nutrients to achieve a normal BW. Thompson et al. (1973) recounted a mean BW of 3.9 kg for hand-reared fawns at 3 d of age. When comparing the results from Thompson et al. (1973) to the results of the current study, we noticed that on d 0 of the trial (14 d of age), fawns on the treatment diet (22% CP) weighed an average of 3.9 kg and the fawns on the control diet (16% CP) weighed an average of 3.8 kg. Furthermore, Ullrey et al. (1971) observed an ADG of 0.18 kg per d for a 120-d period for fawns and Murphy (1960) observed an ADG of 0.22 kg for a 107-d period. This information suggests that at 14 d of age, fawns from the project conducted by Ullrey et al. (1971) weighed approximately 2.5 kg and fawns from the project conducted by Murphy (1960) weighed approximately 3.0 kg. While there are obvious differences between the BW published by Thompson et al. (1973), Ullrey et al. (1971), and Murphy (1960), the authors can conclude that our results for BW are similar to those reported previously. More research is needed to determine the normal range for BW of captive white-tailed deer fawns.

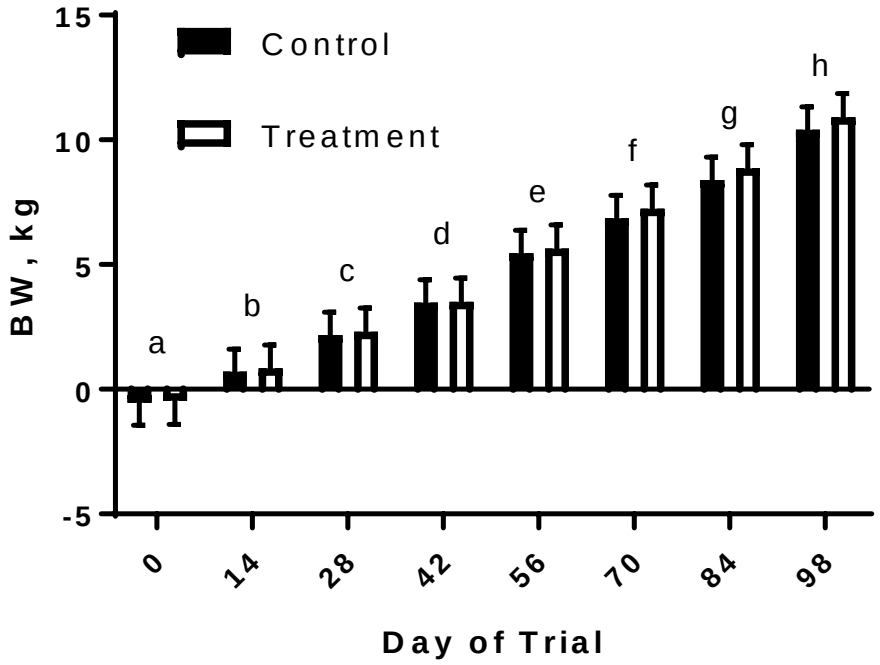

Figure 4. Least squares means of BW (kg) measured in fawns that were consuming either a 16% crude protein (control) diet or a 22% crude protein (treatment) diet in addition to milk replacer and forage by day. [a, b, c, d, e, f, g, h] Means within BW without a common superscript differ ($P < 0.05$).

There was a diet x day interaction (P = 0.056) for heart girth circumference. This is indicated by treatment mean differences beginning on d 70, when the treatment group had a mean heart girth circumference of 42.83 cm and the control group had a mean heart girth circumference of 41.06 cm (Fig. 5). However, there was not a treatment effect of diet (P = 0.31). A study conducted by Stamey et al. (2012) evaluated the effects of feeding three different treatments to calves at 3 d of age. The treatments were 1) low milk replacer (20% CP) and a conventional calf starter (19.6% CP), 2) high milk replacer (28.5% CP) and a conventional calf starter (19.6% CP), and 3) high milk replacer (28.5% CP) and high calf starter (25.5 % CP). The results established that the calves fed the high milk replacer had greater pre-weaning and final BW, withers height, body length, and heart girth circumfrence than the calves fed the low milk replacer (Stamey et al., 2012).

In addition to this, the calves fed the high milk replacer and high calf starter had greater final BW and heart girth circumferences than the calves fed the high milk replacer and conventional calf starter. In a similar study conducted by Blome et al. (2003), the authors experimented with calves that were less than a wk old and fed them four different treatments fed as milk replacers. The milk replacers were fed at 12% of BW (as fed) with 12.5% solids and contained 16.1%, 18.5%, 22.95%, or 25.8% CP on a DM basis. The results indicated a linear increase in BW as the calves consumed more CP. Also, ADG and heart girth circumference increased linearly as CP increased (Blome et al., 2003). The results from the present study did not result in a linear increase in heart girth circumference as CP increased; however there was a linear increase in heart girth circumference by d (Fig. 5).

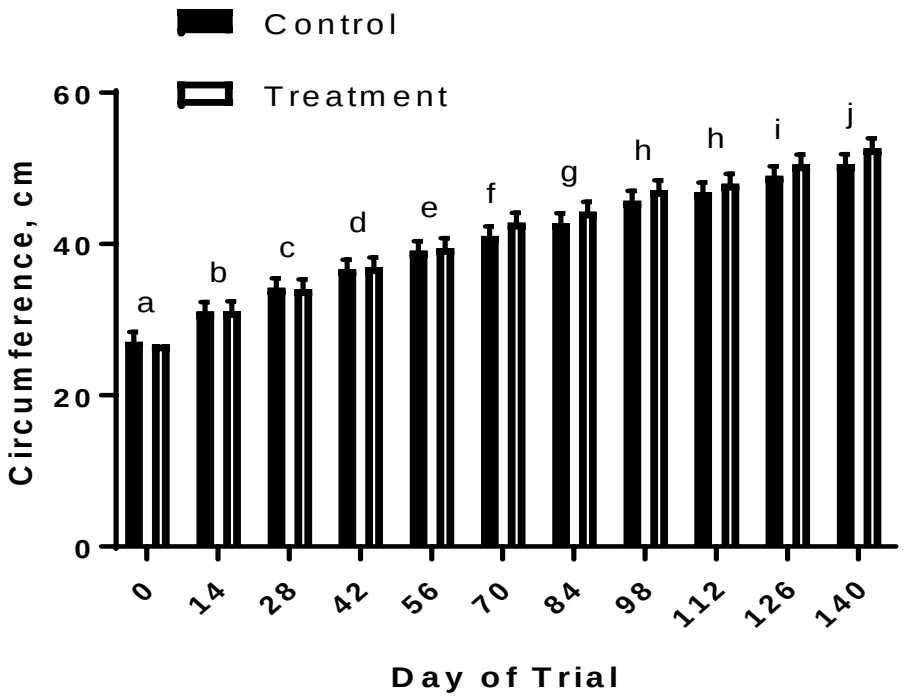

Figure 5. Mean heart girth circumference (cm) measured in fawns that were consuming either a 16% crude protein (control) diet or 22% crude protein (treatment) diet in addition to milk replacer and forage by day. [a, b, c, d, e, f, g, h, i, j] Means without a common subscript differ ($P<0.05$)

Serum Chemistry of White-Tailed Deer Fawns

There was a diet effect for serum total protein concentration, as fawns on the treatment diet had a greater serum total protein concentration than fawns on the control diet ($P<0.05$; Table 5). In addition to this, there was a main effect of day for serum Brix value, total protein, and IgG ($P<0.01$), indicating that over time Brix, total protein and IgG increased. Brix is a measurement used to determine the amount of sucrose concentration in the blood (Hernandez et al., 2016). Additionally, Brix can also be used to determine the amount of total solids as a percentage and an estimate of IgG concentration in liquids that do not contain sucrose (Deelen et al., 2014; Hernandez et al., 2016). Serum total protein indicates the amount of proteins in the blood, particularly albumin and globulin. According to Alberghina et al. (2010) albumin is an important protein in the blood as it can be a carrier for other substances and has the ability to move freely across membranes. Furthermore, Alberghina et al. (2010) states that there is a diversity of globulins that range from antibodies, lipid carriers, vitamins, and hormones. IgG is an antibody that young animals, such as calves and fawns receive from their dams via colostrum (Jezek et al., 2012). Also, studies suggest that young animals that do not receive high quality colostrum or no colostrum have a greater chance of dying or contracting a disease (Nocek et al., 1984; Quigley, 2004).

Unfortunately, there is not any published information to compare our results in regards to Brix, serum IgG, and total protein of white-tailed deer. However, in the dairy industry it is not uncommon for producers to use a refractometer to analyze IgG concentration of colostrum and serum of calves (Deelen et al., 2014). Additionally, the difference between bovine blood and cervid blood is also another topic with limited

information. Yet, we can use this information to understand if a refractometer has the capacity to provide producers with an accurate estimate of serum IgG concentration. Deelen et al. (2014) used a digital refractometer (Misco, Cleveland, OH) similar to the refractometer used in the present study to assess passive transfer of maternal immunoglobulins measured via radial immunodiffusion assay when compared to serum total protein and percent Brix measured by a refractometer in calves that were between 3 and 6 d old. The results show that there was a mean Brix of 9.2%, a mean serum total protein of 6.0 g/dL and a mean serum IgG of 24.1 g/L (Deelen et al., 2014). Comparing the Brix results from Deelen et al. (2014) to the current study, on d 0 of life there was an overall Brix value of 8.31 for fawns on both diets combined. Additionally, on d 0, all fawns combined had an overall mean serum total protein concentration of 5.16 g/dL, along with a mean overall serum IgG concentration of 6.40 g/L. This could suggest that while young calves possibly have different blood parameters, it is somewhat comparable to blood parameters of young white-tailed deer. More research in the field of hematology should be conducted, especially when comparing to cattle. In summary, both methods indicated that fawns had successful passive transfer.

Table 5

Mean (lower 95% CI, upper 95% CI) serum degrees brix, total protein concentration, and IgG concentration measured by a refractometer in fawns that were consuming either a 16% crude protein (control) diet or 22% crude protein (treatment) diet in addition to milk replacer and forage

Diet	Age, d					*P* - value		
	0	56	84	112	140	Diet	Day	Diet*Day
			Brix, °Bx					
Control	8.17 (7.32, 9.03)	8.22 (7.81, 8.63)	9.04 (8.57, 9.52)	9.04 (8.62, 9.46)	8.83 (8.41, 9.24)			
Treatment	8.44 (7.67, 9.22)	8.55 (8.15, 8.94)	9.02 (8.56, 9.48)	9.44 (9.03, 9.85)	9.34 (8.93, 9.75)	0.12	<0.001	0.28
Overall Means	8.31[ac] (7.70, 8.92)	8.39[a] (8.03, 8.74)	9.03[b] (8.64, 9.42)	9.24[b] (8.87, 9.60)	9.09[bc] (8.72, 9.45)			
			Total Protein, g/dL					
Control	5.04 (4.34, 5.74)	5.08 (4.74, 5.42)	5.81 (5.41, 6.21)	5.80 (5.43, 6.17)	5.61 (5.20, 6.02)			
Treatment	5.27 (4.64, 5.91)	5.36 (5.03, 5.69)	5.75 (5.36, 6.14)	6.14 (5.78, 6.49)	6.24 (5.84, 6.64)	0.05	<0.001	0.18
Overall Means	5.16[a] (4.65, 5.66)	5.22[a] (4.92, 5.53)	5.78[b] (5.44, 6.12)	5.97[b] (5.65, 6.29)	5.92[b] (5.58, 6.27)			

(continued)

Diet	Age, d					*P*-value		
	0	56	84	112	140	Diet	Day	Diet*Day
			IgG, g/L					
Control	6.29 (2.33, 10.24)	5.70 (3.61, 7.79)	9.98 (7.66, 12.30)	9.89 (7.74, 12.03)	8.79 (6.70, 10.88)			
Treatment	6.52 (2.91, 10.12)	7.35 (5.32, 9.38)	9.76 (7.52, 12.01)	11.75 (9.67, 13.84)	11.33 (9.28, 13.37)	0.19	<0.001	0.22
Overall Means	6.40[a] (3.55, 9.25)	6.53[a] (4.71, 8.34)	9.87[b] (7.93, 11.81)	10.82[b] (8.97, 12.67)	10.06[b] (8.23, 11.89)			

[a, b, c] Means within growth parameters without common superscripts differ ($P<0.05$)

Table 6 references the red blood cell count, hemoglobin and hematocrit concentrations that were determined via a complete blood cell count (CBC) conducted at Texas A&M Veterinary Medical Diagnostic Laboratory (TVMDL; Texas A&M University, College Station, TX). There was a main effect of day in red blood cell count ($P<0.01$), but no diet or diet x day interaction. This suggests that the red blood cells increased over time. Hemoglobin had a main effect of diet ($P<0.01$) due to the greater hemoglobin concentration of fawns on the treatment diet. Additionally, hemoglobin had a main effect of day ($P<0.01$), signifying that the concentration increased over time. Additionally, hematocrit had similar results, as there was a main effect of diet and day ($P<0.01$). The fawns on the treatment diet had a greater hematocrit concentration. Additionally, as the fawns became older their hematocrit concentration increased. Red blood cells are created by the bone marrow and a red blood cell count contains the total number of hematocrit, hemoglobin, and erythrocytes (Roland et al., 2014). Hemoglobin is an iron-containing protein and is an essential part of the red blood cell as it represents the amount of the oxygen in the red blood cell and hematocrit represents the volume of blood within the red blood cell (Jones and Allison, 2007).

Unfortunately, there is minimal information published to compare our results to as far as a complete blood cell count for red blood cells, hemoglobin, and hematocrit in white-tailed deer. However, there are many studies that evaluate the complete blood cell count of other small ruminants such as cattle and sheep. Kramer (2000) evaluated the hematology of cattle, sheep,and goats and gave estimates for each. These are overall estimates of normal blood parameters from a complete blood cell count for young and mature ruminants. The normal red blood cell count of cattle is 5.0 to 10.0 x 10^6/µL, 9.0

to 15.0 x 10^6 /µL for sheep, and 8.0 to 18.0 x 10^6 /µL for goats (Kramer, 2000). Fawns in the current study had a red blood cell count that ranged from 7.27 to 16.80 x 10^6 /µL. In addition to this, Kramer (2000) states that the normal hemoglobin concentration for cattle is 8.0 to 15.0 g/dL, 9.0 to 15.0 g/dL for sheep, and 8.0 to 12.0 g/dL for goats. Comparing the results from this study to Kramer (2000), we found an overall hemoglobin concentration for fawns of 6.81 to 14.11 g/dL. Furthermore, White and Cook (1974) studied the blood characteristics of white-tailed deer fawns and found the average hematocrit concentration of 30 newborn fawns between 1 to 14 d of age to be 29.1%. Comparing these results, the fawns in the present study had an overall mean of 22.5% hematocrit on d 0. Therefore, we can speculate that when comparing the red blood cell count, hemoglobin, and hematocrit concentrations to that of other ruminants the parameters are within a normal range.

Table 6

Mean (lower 95% CI, upper 95% CI) red blood cell count, hemoglobin concentration, and hematocrit in fawns that were consuming either a 16% crude protein (control) diet or 22% crude protein (treatment) diet in addition to milk replacer and forage.

Diet	Age, d					*P*-value		
	0	56	84	112	140	Diet	Day	Diet*Day
				Red Blood Cells, 10^6/µL				
Control	7.21 (5.94, 8.47)	16.17 (14.84, 17.49)	16.26 (14.99, 17.54)	16.35 (15.02, 17.68)	14.56 (12.98, 16.13)			
Treatment	7.33 (6.11, 8.56)	17.32 (16.01, 18.63)	17.34 (16.10, 18.59)	16.79 (15.49, 18.08)	15.20 (13.67, 16.73)	0.11	<0.001	0.23
Overall Means	7.27[a] (6.11, 8.43)	16.74[b] (15.57, 17.92)	16.80[b] (15.66, 17.94)	16.57[b] (15.40, 17.74)	14.88[c] (13.58, 16.18)			
				Hemoglobin, g/dL				
Control	6.81 (5.65, 7.96)	13.33 (12.26, 14.40)	13.61 (12.54, 14.67)	13.32 (12.25, 14.38)	12.42 (11.33, 13.51)			
Treatment	6.82 (5.73, 7.92)	14.18 (13.11, 15.25)	14.61 (13.57, 15.65)	13.94 (12.89, 14.98)	13.36 (12.29, 14.43)	0.04	<0.001	0.47
Overall Means	6.81[a] (5.81, 7.82)	13.76[b] (12.80, 14.72)	14.11[b] (13.16, 15.06)	13.63[b] (12.68, 14.58)	12.89[c] (11.93, 13.85)			

(continued)

Diet	Age, d					*P*-value		
	0	56	84	112	140	Diet	Day	Diet*Day
			Hematocrit, %					
Control	22.23 (18.77, 25.68)	37.55 (34.42, 40.69)	37.93 (34.81, 41.06)	37.03 (33.91, 40.15)	34.20 (31.00, 37.39)			
Treatment	22.88 (19.65, 26.10)	41.23 (38.08, 44.37)	41.38 (38.34, 44.42)	37.28 (34.24, 40.32)	36.35 (33.19, 39.52)	0.03	<0.001	0.25
Overall Means	22.55[a] (19.62, 25.48)	39.39[bc] (36.60, 42.18)	39.66[b] (36.92, 42.40)	37.15[c] (34.41, 39.89)	35.27[c] (32.48, 38.06)			

[a, b, c] Means within growth parameters without common superscripts differ ($P<0.05$)

Table 7 contains the platelet count, fibrinogen concentration, and plasma protein concentrations that were measured via a CBC. For the platelet count, there were main effects of diet and day ($P<0.01$). This indicates that the fawns on the control diet had a greater platelet count and as the fawns matured, their platelet count increased. Additionally, there was a main effect of day ($P<0.01$) for plasma protein concentration, suggesting that as the fawns became older their plasma protein concentration increased. Jones and Allison (2007) evaluated the blood chemistry of ruminants to determine the normal range of several parameters. Cattle had a normal platelet range of 100 to 800 x 10^3/µL, sheep had the same normal range of platelets as cattle, and goats had a normal range of 300 to 600 x 10^3/µL (Jones and Allison, 2007). For the current study, the fawns had an overall range of 691 to 916 x 10^3/µL throughout the study. In addition to this, Jones and Allison (2007) found the normal range of fibrinogen concentration for cattle to be 300 to 700 mg/dL, sheep had a range of 100 to 500 mg/dL, and goats had a fibrinogen concentration of 100 to 400 mg/dL. Comparing the results from the present study, the fawns on both diets had a similar overall range in fibrinogen concentration of 302 to 399 mg/dL. Lastly, Jones and Allison (2007) found the range of plasma protein for cattle to be 7.0 to 8.5 g/dL, 6.0 to 7.5 g/dL for sheep, and 6.0 to 7.5 g/dL for goats. When comparing these results to the present study, the fawns had a similar overall mean of 5.9 to 6.7 g/dL for plasma protein concentration. The information presented by Jones and Allison (2007) could suggest that fawns in the present study had a normal range of platelets, fibrinogen, and plasma protein. However, more research is needed to understand if the platelet count, fibrinogen concentration, and plasma protein concentration are comparable between cattle and white-tailed deer.

Table 7

Mean (lower 95% CI, upper 95% CI) platelets, fibrinogen concentration, and plasma protein concentration of fawns that were consuming either a 16% crude protein (control) diet or 22% crude protein (treatment) diet in addition to milk replacer and forage

Diet	Age, d					*P*-value		
	0	56	84	112	140	Diet	Day	Diet*Day
			Platelets, $10^3/\mu L$					
Control	753.54 (598.80, 908.29)	761.76 (624.55, 898.97)	927.47 (784.99, 1069.95)	961.61 (825.55, 1097.66)	855.60 (715.70, 995.50)			
Treatment	628.26 (484.70, 771.82)	722.13 (585.37, 858.89)	733.29 (601.52, 865.07)	870.88 (739.00, 1002.76)	783.39 (644.80, 921.98)	0.01	0.001	0.42
Overall Means	690.90^{ad} (562.48, 819.32)	741.95^{abd} (622.57, 861.33)	830.38^{bc} (710.97, 949.79)	916.24^{c} (799.54, 1032.94)	819.49^{cd} (699.95, 939.03)			
			Fibrinogen, mg/dL					
Control	275.22 (141.17, 409.27)	324.44 (203.45, 445.43)	427.32 (307.83, 546.82)	373.57 (253.87, 493.27)	331.60 (210.32, 452.87)			
Treatment	327.88 (199.42, 456.34)	333.74 (211.57, 455.90)	369.75 (252.54, 486.97	330.58 (213.35, 447.82)	390.35 (270.71, 509.98)	0.89	0.26	0.60
Overall Means	301.55 (167.88, 435.22)	329.09 (199.98, 458.19)	398.54 (273.28, 523.79)	352.08 (226.64, 477.52)	360.97 (240.82, 481.12)			

(continued)

Diet	Age, d					*P*-value		
	0	56	84	112	140	Diet	Day	Diet*Day
			Plasma Protein, g/dL					
Control	5.88 (5.21, 6.55)	5.90 (5.53, 6.27)	6.62 (6.24, 7.00)	6.58 (6.21, 6.96)	6.37 (6.00, 6.74)			
Treatment	5.89 (5.29, 6.48)	6.10 (5.73, 6.47)	6.54 (6.17, 6.91)	6.78 (6.41, 7.14)	6.67 (6.31, 7.03)	0.40	<0.001	0.27
Overall Means	5.88[a] (5.40, 6.36)	6.00[a] (5.63, 6.37)	6.58[b] (6.22, 6.94)	6.68[b] (6.32, 7.03)	6.52[b] (6.14, 6.90)			

[a, b, c, d] Means within growth parameters without common superscripts differ ($P<0.05$)

Table 8 contains the total white blood cell (WBC) count and differentials determined via CBC. There was a main effect of day ($P<0.01$) for fawns consuming the two different diets. The main effect of day for the WBC count indicates that as the fawns matured, their WBC count increased. There was also a main effect of day ($P<0.01$) for absolute neutrophils, absolute lymphocytes, and absolute monocytes, as a result of a steady increase in the fawns' neutrophils, lymphocytes, and monocytes.

WBC help to protect the body from infectious diseases and foreign invaders and are produced by hematopoietic stem cells in bone marrow. A total WBC differential count encompasses the total amount of leukocytes (Roland et al., 2014). Additionally, there are several types of leukocytes such as neutrophils, lymphocytes, monocytes, eosinophils, and basophils and each one of these cells play an important role in defending the body against infection (Roland et al., 2014). According to Jones and Allison (2007), cattle have a normal total WBC count of 4,000 to 12,000 cells/µL. However, Powell and DelGiudice (2005) noted that wild white-tailed deer fawns had a mean WBC count of 3,100 cells/µL that ranged from 1,000 to 6,200 cells/µL. When comparing this information to the results in the present study, the fawns consuming the control diet had a mean WBC count 2,930 cells/µL and the fawns consuming the treatment diet had a mean of 3,030 cells/µL. These results are similar to that of Powell and DelGiudice (2005). Furthermore, Jones and Allison (2007) noted that cattle had a normal banded neutrophil range of 0 to 2%. Conversely, Kraft (2005) sampled bovine hematology from healthy cows and found that their normal parameter for band neutrophils was 0 to 200 cells/µL. Comparing the results from Jones and Allison (2007) and Kraft (2005) to the present study, the fawns consuming the control diet had an overall mean of 1,520 cells/µL

absolute neutrophils and the fawns consuming the treatment diet had an overall mean of 1,480 cells/µL absolute neutrophils. These results are much greater than those reported by Kraft (2005). In addition to this, Kraft (2005) noted that cattle have a normal parameter of 2,500 to 5,500 cells/µL of lymphocytes, 0 to 300 cells/µL of monocytes, 300 to 1500 cells/µL of eosinophils and 0 to 100 cells/µL of basophils. Comparing the information presented by Kraft (2005) to the present study, the fawns consuming the control diet had an overall mean of 1,160 cells/µL absolute lymphocytes and the fawns consuming the treatment diet had an overall mean of 1,250 cells/µL absolute lymphocytes. Additionally, the fawns consuming the control diet had an overall mean for absolute monocytes of 150 cells/µL and fawns consuming the treatment diet had an overall mean of 190 cells/µL absolute monocytes. Furthermore, fawns consuming the control diet had an overall mean of 410 cells/µL and fawns consuming the treatment diet had an overall mean of 140 cells/µL for absolute eosinophils. Lastly, fawns consuming the control diet had an overall mean of 290 cells/µL and fawns consuming the treatment diet had an overall mean of 70 cells/µL for absolute basophils.

There is a general theme of blood cell parameters increasing with age in deer, cattle, sheep, and goats. Mohri et al. (2007) clarifies that that calves typically exhibit a decreased hemoglobin concentration in the first mo of life which then increases the next 3 mo of life. Likewise, this is also seen in the present study, as fawns had lower hemoglobin and red blood cell concentrations on d 0 that later increased as the fawns matured (Table 6). Additionally, Mohri et al. (2007) explains that calves display a decreased WBC count and differentials during the first mo of life followed by an increase as the as the animals mature. When comparing the results for the WBC count and

differentials from the present study to that of Mohri et al. (2007) the results are somewhat similar. Though, the authors cannot state with certainty that the results from this trial are normal for white-tailed deer fawns, and this is due to the inability to compare our results to other studies of captive white-tailed deer fawns.

Table 8

Least squares means (± SE) of WBC count and differentials in fawns that were consuming either a 16% crude protein (control) diet or 22% crude protein (treatment) diet in addition to milk replacer and forage

Day	Control	Treatment	*P* - value		
			Diet	Day	Diet*Day
	White Blood Cells, 10^3/µL				
0	2.18 ± 0.33	2.90 ± 0.29			
56	3.00 ± 0.28	2.46 ± 0.28			
84	3.16 ± 0.28	3.54 ± 0.27	0.72	0.01	0.11
112	3.10 ± 0.28	3.18 ± 0.27			
140	3.24 ± 0.30	3.05 ± 0.29			
Overall	2.93 ± 0.19	3.03 ± 0.18			
	Absolute Neutrophils, 10^3/µL				
0	1.74 ± 0.28	2.37 ± 0.24			
56	1.56 ± 0.23	1.09 ± 0.23			
84	1.60 ± 0.25	1.65 ± 0.23	0.85	0.01	0.17
112	1.32 ± 0.23	1.13 ± 0.22			
140	1.38 ± 0.25	1.18 ± 0.24			
Overall	1.52 ± 0.14	1.48 ± 0.13			
	Absolute Lymphocytes, 10^3/µL				
0	0.34 ± 0.15	0.45 ± 0.13			
56	1.21 ± 0.13	1.19 ± 0.13			
84	1.43 ± 0.13	1.61 ± 0.13	0.40	0.01	0.90
112	1.44 ± 0.13	1.60 ± 0.12			
140	1.38 ± 0.13	1.41 ± 0.13			
Overall	1.16 ± 0.08	1.25 ± 0.08			
	Absolute Monocytes, 10^3/µL				
0	0.07 ± 0.06	0.13 ± 0.05			
56	0.13 ± 0.05	0.14 ± 0.04			
84	0.16 ± 0.05	0.24 ± 0.04	0.26	0.06	0.62
112	0.13 ± 0.04	0.21 ± 0.04			
140	0.25 ± 0.05	0.22 ± 0.05			
Overall	0.15 ± 0.03	0.19 ± 0.02			

(continued)

Day	Control	Treatment	*P* - value		
			Diet	Day	Diet*Day
	Absolute Eosinophils, K/µL				
0	0.05 ± 0.55	0.06 ± 0.39	0.29	0.40	0.31
56	0.09 ± 0.37	0.09 ± 0.42			
84	0.04 ± 0.42	0.09 ± 0.39			
112	0.18 ± 0.34	0.23 ± 0.35			
140	0.23 ± 0.37	0.22 ± 0.35			
Overall	0.41 ± 0.19	0.14 ± 0.17			
	Absolute Basophils, K/µL				
0	0.00 ± 0.87	0.03 ± 0.75	0.53	0.60	0.60
56	0.04 ± 0.50	0.06 ± 0.67			
84	0.08 ± 0.43	0.08 ± 0.47			
112	0.07 ± 0.41	0.08 ± 0.40			
140	0.08 ± 0.41	0.10 ± 0.41			
Overall	0.29 ± 0.25	0.07 ± 0.25			

Table 9 contains the percentage of fawns with positive antibody titers to Bluetongue Virus (BTV) using agar gel immunodiffusion tests (AGID) to determine the presence and magnitude of functional systematic antibodies to BTV. There was a main effect of day ($P<0.01$) for the fawns consuming the two different diets due to the fact that as the fawns matured their antibody titers to BTV decreased.

Table 9

Least squares means (± SE) for the percentage of fawns with positive antibody titers to BTV in fawns that were consuming either a 16% crude protein (control) diet or 22% crude protein (treatment) diet in addition to milk replacer and forage

Day	Control	Treatment	*P* - value		
			Diet	Day	Diet*Day
	Bluetongue Virus Titer, % Positive				
56	55.00 ± 9.17	47.83 ± 8.55			
84	37.36 ± 9.40	39.19 ± 8.94			
112	13.61 ± 9.40	10.62 ± 8.94	0.85	0.01	0.87
140	1.33 ± 9.64	6.05 ± 9.60			
Overall	27.50 ± 6.0	25.90 ± 5.7			

Table 10 contains the percentage of fawns with positive antibody titers to Epizootic Hemorrhagic Disease (EHD) types 1, 2, and 6 using a virus neutralization assay. EHD type 2 had a main effect of day ($P<0.01$), indicating that as the fawns became older their antibody titer to EHD type 2 decreased. The titers for BTV and EHD were analyzed to determine the efficacy of a 9-way combination vaccine produced by

Newport Labs (Worthington MN, USA). Use of the vaccine was discontinued after d 56 of the trial per the herd owner's decision. However, on d 56, fawns did receive the vaccine; therefore, we can speculate that the antibody titers for BTV and EHD types 1, 2, and 6 should be elevated on d 84 if the vaccine was effective. Unfortunately, the results were opposite of what was expected. On d 84 the titers were lower for BTV and EHD types 1, 2, and 6.

BTV is transmitted between ruminants via midges or biting gnats with symptoms of fever, low WBC count, and excess blood in the mucous membranes within the mouth, often characterized by a swollen, purple tongue, hence the name bluetongue (Reddington et al., 1991). Additionally, BTV is communally shared between wild cervids and sheep, and cattle are considered to be a reservoir host for this virus (Reddington et al., 1991). EHD is also spread by midges. This disease wreaks havoc on the internal organs by causing hemorrhaging of the liver, heart, spleen, and lungs (Hiller, 1996). Symptoms of EHD include excessive salivation, fever, rapid heart rate, and labored breathing (Hiller, 1996). Stallknecht et al. (1995) collected blood samples from 1,369 hunter killed white-tailed deer from 1989 to 1991 to determine the distribution of EHD and BTV serotypes in several areas of Georgia. The results of the trial indicated the number of positive EHD and BTV tests from five areas and the overall positive total of all five areas combined. From 1989 to 1991, 477 out of 1,369 tests were positive with an overall positive percentage of 35% (Stallknecht et al., 1995). While this research was conducted in a different state using wild, hunter killed white-tailed deer, it is still relevant information to consider when comparing to the results of the present study. Further research should be

conducted to determine if the 9-way combination vaccine is effective in both wild and pen-raised white-tailed deer.

Table 10

Least squares means (± SE) for positive antibody titers to EHD type 1, 2, and 6 of fawns that were consuming either a 16% crude protein (control) diet or 22% crude protein (treatment) diet in addition to milk replacer and forage

Day	Control	Treatment	*P* - value		
			Diet	Day	Diet*Day
	EHD Type 1 Titer, % Positive				
56	0.0 ± 3.9	4.4 ± 3.7			
84	0.0 ± 4.0	4.6 ± 3.8			
112	0.0 ± 4.0	9.4 ± 3.8	0.14	0.84	0.84
140	0.0 ± 4.0	5.9 ± 4.0			
Overall	0.0 ± 2.9	6.1 ± 2.7			
	EHD Type 2 Titer, % Positive				
56	45.00 ± 7.38	34.78 ± 6.88			
84	11.15 ± 7.57	15.62 ± 7.19			
112	0.62 ± 7.57	10.86 ± 7.19	0.85	0.01	0.45
140	0.18 ± 7.76	0.86 ± 7.72			
Overall	14.2 ± 4.8	15.5 ± 4.6			
	EHD Type 6 Titer, % Positive				
56	5.00 ± 2.51	4.35 ± 2.34			
84	0.00 ± 2.59	0.00 ± 2.47			
112	0.00 ± 2.59	0.00 ± 2.47	0.94	0.19	0.99
140	0.00 ± 2.70	0.00 ± 2.78			
Overall	1.30 ± 1.30	1.10 ± 1.30			

Table 11 contains the mean morbidity, number of days treated for illness, and mortality rate of fawns by treatment. The morbidity percentage, mean number of days treated for illness, and mortality percentage was not different between treatments ($P > 0.10$). There were two fawns on the control diet that died. A doe fawn died from a case of bloat at 2 mo of age and a buck fawn died from a severe case of scours at 3 mo of age. Additionally, there were five fawns on the treatment diet that died, one of which was a doe fawn that broke her jaw and was unable to eat or drink sufficiently and consequently died of natural causes. She died at 3 mo of age. Furthermore, a buck fawn on the treatment diet had scours when he was born and later recovered, but became weak and lethargic before dying at 3 mo of age due to unknown causes. Another buck fawn on the treatment diet died from unknown causes at 4 mo of age. In addition, an albino doe fawn had scours when she was born and continued to scour until she died at 4 mo of age, and the last fawn, a doe fawn, was never found after being moved to the 20 x 20 m pen and presumed to be dead at 6 mo of age. From this information, it is possible to conclude that the mortality of fawns could be due to a compromised immune system or other health problems at birth. These fawns could have possibly been sick before they were removed from their dam. However, this is only a speculation. Additionally, the mean number of days treated for illness and mortality percentage was very similar between fawns consuming the treatment diet and those consuming the control diet. This could suggest that the treatment diet, while it was designed specifically to support animal health via the dietary supplement, did not enhance the immune system of the fawns.

Table 11

Least squares means (± SE) for morbidity, number of days treated for illnesses, and mortality in fawns that were consuming either a 16% crude protein (control) diet or 22% crude protein (treatment) diet in addition to milk replacer and forage

	Control	Treatment	*P* - value Diet
	Morbidity, %		
Overall	93.75 ± 5.83	96.90 ± 6.38	0.72
	Mean Number of Days Treated for Illness, d		
Overall	4.45 ± 0.66	4.30 ± 0.72	0.88
	Mortality, %		
Overall	12.5 ± 7.8	14.6 ± 8.52	0.86

Carstensen et al. (2009), found that predators were the primary cause of mortality of wild neonates studied in a survival and mortality study, with 86% of the neonates killed by black bears and bobcats. Additionally, a study conducted by Cook et al. (1971) found that 72% of wild white-tailed deer fawns died during the one-year trial. In this study, 93% of the deaths occurred during the first month of life and 7% in the second month of life. The major causes of death were 52% due to predators, mostly coyotes and 16% due to starvation or disease (Cook et al., 1971). Unfortunately, these studies were conducted in the wild and there is a lack of published information on mortality and morbidity of fawns in captivity. However, with this being said, fawns in captivity will

not encounter predators like fawns in the wild would, therefore choosing to pen-raise fawns might be a wiser choice for a producer.

CHAPTER V

Conclusion

The main objective of this research was evaluate a starter ration designed specifically for young white-tailed deer and a dietary supplement designed to enhance the immune system of young fawns. Currently, there is not a diet specifically formulated for young, growing white-tailed deer that is available to consumers and producers in the cervid industry. Furthermore, there is not a supplement or diet available that promotes growth, and increases immune response in white-tailed deer fawns. The results of the trial indicate that the starter ration had no effect on growth and performance of the fawns, except for the ADG of the male fawns. More specifically, there were no differences observed in the fawns consuming the two different diets in cannon length, leg length, body length, heart girth circumference, or BW. In addition to this, the dietary supplement did not significantly increase the overall immune health of the fawns consuming the treatment diet, based on morbidity and mortality rates. Furthermore, the fawns consuming the treatment diet did not exhibit a greater immune response to the vaccine administered based on antibody titers to BTV and EHD types 1, 2, and 6. Therefore, there was not a significant difference between the diets for intake or overall health. This is not to say that one diet was better than the other, but that both diets performed at the same level in terms of growth of female fawns, intake, and health.

Implications

Extensive research is needed to define normal growth rates in white-tailed deer fawns held in captivity. This information could prove to be very useful to producers because they could compare their herd to an industry standard. Additionally, further

research should be conducted on the hematology of pen-raised white-tailed deer to determine the normal CBC count when fawns are healthy and have a strong immune system. Traditionally, producers will look for exterior signs, such as coughing, decreased voluntary intake of food and water, and reduced movement, and from these signs they will determine health status of the fawn. By having hematology information available, it could significantly help producers to determine if an animal is ill. Moreover, producers could have blood analyzed by a local veterinarian or diagnostic lab and compare the results to a normal CBC, if that information was available for white-tailed deer fawns. Furthermore, producers can apply the use of a refractometer to their operation, as it is a very handy tool to estimate the serum IgG concentrations in fawns. From the estimates, the producer could conclude if the fawn received adequate colostrum and antibodies from the dam.

Altogether, the lack of information leads to a gap in the cervid industry for research, one that the authors and fellow colleagues at Sam Houston State University hope to fill with additional studies. Moreover, if one can better understand what normal ranges are for intake, growth rate, blood parameters, mortality and morbidity and what nutrients in the diet necessary for fawns to achieve their genetic potential for growth, then we can share this information with producers in the cervid industry.

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Whitetail Deer Farm Supplies. 2018. Superior Fawn Milk Replacer - 20# pail.

APPENDIX A: Deer Nutrition Information

Feeds and supplements fed to animals throughout this study

1. Superior Fawn Milk Replacer (Whitetail Deer Farm Supplies, 2018)
    a. Superior Milk Replacers, INC, Waterloo, IL
    b. Ingredients: Dried Whey Protein Concentrate, Dried Whey, Animal and Vegetable Fat (Preserved with BHA and BHT), Dried Whey Product, Lecithin, Dicalcium Phosphate, DL-Methionine, Calcium Carbonate, Copper Sulfate, L-Lysine, Vitamin A Supplement, Vitamin D3 Supplement, Vitamin E Supplement, Vitamin B12 Supplement, Folic Acid, Choline Chloride, Riboflavin Supplement, Niacin Supplement, Calcium Pantothenate, Thiamine Mononitrate, [Sodium Propionate, Potassium Sorbate, Calcium Propionate (Preservatives)], Ferrous Sulfate, Cobalt Sulfate, Zinc Sulfate, Manganese Sulfate, Magnesium Oxide, Ethylenediamine Dihydriodide, Sodium Silico Aluminate, Sodium Selenite, Artificial Flavor.
    c. Guaranteed Analysis:

Crude protein, not less than 33.0%	Crude Fat, not less than 30.0%
Crude fiber, not more than 0.15%	Moisture, not more than 5.0%
Ash, not more than 9.0%	Vitamin E, of min 50 IU/lb
Calcium, not less than 0.70%	Calcium, not more than 1.20%
Phosphorus, not less than 0.60%	Selenium, of min 0.3 ppm
Vitamin A, of min 20,000 IU/lb	Vitamin D of 5,000 IU/lb

2. Starter Ration
    a. Cargill, Minneapolis, MN
    b. This feed is designed to be fed as the first dry feed to pre-ruminating fawns
    c. Ingredients: Plant Protein Products, Grain Products, Roughage Products, Processed Grain By-Products, Animal Protein Products, Dehydrated Alfalfa Meal, Vitamin A Supplement, Vitamin D3 Supplement, Vitamin B12 Supplement, Riboflavin Supplement, Niacin Supplement, d-Calcium Pantothenate, Folic Acid, Thiamine, Mononitrate, Biotin, Choline Chloride, L-Lysine, DL-Methionine, L-Sulfate, Copper Sulfate, Calcium Iodate, Cobalt Carbonate, Sodium Selenite, Ferrous Sulfate, Zinc Methionine Complex, Manganese Methionine Complex, Copper Lysine Complex, Cobalt Glucoheptonate, Dried Bifidobacterium thermophilum Fermentation Product, Dried Enterococcus faecium Fermentation Product, Dried Lactobacillus acidophilus Fermentation Product, Dried Lactobacillus casei Fermentation Product, Natural and Artificial Wild Berry Flavor, Natural and Artificial Flavors Added, Yeast Extract, Hydrolyzed Yeast, Propionic Acid (a preservative), Soybean Oil.
    d. Guaranteed Analysis:

Crude Protein, min of 22.0%	Lysine, min of 1.0%
Methionine, min of 0.55%	Crude Fat, min of 5.0%
Crude Fiber, Max of 11.0%	Calcium, min of 1.0%

Calcium, max of 1.25%
Salt, min of 0.8%
Sodium, min of 0.3%
Copper, min of 50 PPM
Zinc, min of 205 PPM
Vitamin E, min of 120 IU/lb
Phosphorus, min of 0.6%
Salt, max of 1.2%
Sodium, max of 0.6%
Selenium, min of 0.3 PPM
Vitamin A, min of 10,000 IU/lb

e. Dietary Supplement: *Saccharomyces cerevisiae* fermentation product

3. Record Rack Deer Breeder Formula
    a. Sportsman's Choice, Cargill, Minneapolis, MN
    b. This feed is designed to be fed to deer and elk when limited forbs and browse is available.
    c. Guaranteed Analysis:

Crude Protein, min of 16%
Crude Fat, min of 4.0%
Calcium, min of 1.6%
Phosphorus, min of 0.8%
Salt, max of 0.75%
Manganese, min of 200 ppm
Zinc, min of 200 ppm
Vitamin E, min of 20 IU/lb
Lysine, min of 0.9%
Crude Fiber, max of 20.0%
Calcium, max of 2.1%
Salt, min of 0.5%
Copper, min of 50 ppm
Selenium, min of 0.3 ppm
Vitamin A, 10,000 IU/lb

4. Alfalfa Hay
    a. Texas grown alfalfa hay

APPENDIX B: IACUC PAGE

Sam Houston State University

A Member of the Texas State University

Institutional Animal Care and Use Committee

Committee Members

Regular Members	Alternate Members
Marcy Beverly, Ph.D.	Kyle Stutts, Ph.D.
James Harper, Ph.D.	Todd Primm, Ph.D.
Mark Anderson, Ph.D.	Ilona Petrikovics, Ph.D.
Autumn Smith-Herron, Ph. D.	Jeff Wozniak, Ph.D.
T.C. Sim, Ph.D.	Michael Moore, D.V.M.
Gerald Etheredge, D.V.M.	Vernette Porter, Community Member
Diana Oliver, Community Member	

Date: October 14, 2016

To: Matlin Sain [Faculty Sponsor: Dr. Kyle Stutts]
ASET
Box 2088
Campus

From: Dr. Marcy Beverly, IACUC Chair

Re: **Form C**: Research
ID # 16-10-13-1019-3-01
Course Title: *Evaluation of a dietary supplement to improve health and survivability in young white-tailed deer [Student Thesis]*

Species: *White-tailed deer*

Start: October 13, 2016 **End:** October 13, 2019

Your **IACUC Initial Review** submission was reviewed and approved under **Designated Member Review** (DMR) procedures on **October 13, 2016** with the following result:

Approved

Annual Review Form Deadline: September 30, 2017

VITA

Matlin A. Sain, M.S.

EDUCATION

Master of Science (August 2018) in Agricultural Sciences
Sam Houston State University; Huntsville, Texas
Thesis title: Evaluation of a Starter Ration on Growth and Performance of White-Tailed Deer Fawns.

Bachelor of Science (May 2016) in Animal Science
Sam Houston State University; Huntsville, Texas
Minors in Equine Science and Agricultural Business

PROFESSIONAL EXPERIENCES

SAM HOUSTON STATE UNIVERSITY; Huntsville, Texas

Graduate Teaching Assistant; August 2016-present

- EQSC 3340 – Equine Breaking and Training I (Fall)
- EQSC 4391 – Equine Behavior and Training II (Spring)
  - ⇒Coordinate delivery of horses with owners
  - ⇒Manage training fee collection
  - ⇒Assist with instructing students to safely train and break young horses
  - ⇒Evaluate student performance
  - ⇒Manage equine housing facilities, performance arena, and inventory

Graduate Research Assistant; May-December, 2016

- Ensured adherence to research protocol and procedures
- Coordinated and conducted cervid nutrition research for white-tailed fawns
  - ⇒Obtained blood samples via jugular venipuncture into a non-additive and 15% EDTA additive vacutainer
  - ⇒Utilized whole blood and serum concentrations to determine Brix, Total Protein, and IgG concentrations with a digital refractometer
  - ⇒Operated a centrifuge at 2000 rpms for 20 minutes to obtain serum from the non-additive blood vacutainers
  - ⇒Transported blood samples to Texas Veterinary Medical and Diagnostics Lab (College Station, TX) for a full CBC and disease analysis

Student Research Assistant; February-July 2015

- Assisted in conducting equine nutrition research
    - Collected blood samples via jugular venipuncture from horses
    - Obtained rectal temperature from horses
    - Assisted in feeding horses and maintaining stall cleanliness

BRAZORIA VET CLINIC; Brazoria, Texas

Intern; May-July 2014

- Assisted multiple veterinarians and vet-technicians in exam and surgery rooms
- Prepared vaccines and prepared animals for procedures
- Aided with dental cleanings
- Maintained cleanliness within the vet clinic

PUBLICATIONS

Sain, M.S., K.J. Stutts, M.J. Anderson, J.S. Bedore-Suagee, and J.L. Leatherwood. (2018, March). *Evaluation of a Starter Ration on Growth and Performance of White-Tailed Deer Fawns.* J. Anim. Sci. Vol. 96, Suppl. 1: 12.

Sain, M.S., K.J. Stutts, M.J. Anderson, J.S. Bedore-Suagee, and J.L. Leatherwood. (2018, August). *Evaluation of Starter Ration on Growth and Performance of White-Tailed Deer Fawns.* (Unpublished master's thesis). Sam Houston State University, Huntsville, TX.

ACTIVITIES

- HORSE JUDGING TEAM; Sam Houston State University; Member, 2014-2016
- HORSEMEN'S ASSOCIATON; Sam Houston State University; Member, 2014-16

HONORS AND AWARDS

- SAN ANTONIO LIVESTOCK EXPOSITION SCHOLARSHIP; Sam Houston State University; Recipient, 2016-18

PROFESSIONAL AFFILIATIONS

- AMERICAN SOCIETY OF ANIMAL SCIENCE; Southern Section; Member, 2018
- AMERICAN QUARTER HORSE ASSOCIATION; Member, 2016-2017