IMPROVING MANAGEMENT TECHNIQUES IN SOUTHEASTERN BEEF CATTLE PRODUCTION: HEIFER DEVELOPMENT AND SUPPLEMENTATION OF FORAGES

by

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(Under the Direction of Robert Lawton Stewart, Jr.)

ABSTRACT

Two experiments were conducted to improve common management techniques on beef cattle operations. Experiment 1 analyzed beef heifers for pre-breeding measurements that relate to reduced time to conception and positive pregnancy outcome. Odds of pregnancy increased by 15% for every 2.5 cm increase in hip height, and by 20% for every one month increase in heifer age at the start of the breeding period. Hip height was not associated with conception during the first 35 days ($P = 0.204$) but after 35 days the hazard rate for conception increased by 15% for every 2.5 cm increase in hip height ($P = 0.005$). Experiment 2 studied the effect on ruminal kinetics in vitro when feeding forages varying in nutritive value in association with common supplementation strategies. The objective of this experiment was to measure the change in DM, NDF and ADF digestibility of two forage species (‘Kentucky 31’ tall fescue and ‘Tifton 85’ bermudagrass) over seven time points (0, 3, 6, 12, 18, 24, and 48 h). These forages were subjected to harvesting intervals typical of production systems that graze cattle or produce hay in Georgia. Samples of harvest data was subjected to NIR spectroscopy to determine quality. Forages were stratified by RFQ, in order to create three quality categories: high (HIG), median (MED), and poor (LOW). The various qualities were paired with common supplementation strategies: no supplementation control (CON), liquid molasses urea (LIQ), and corn gluten feed
Regression analysis showed an increase ($P < 0.01$) in IVDMD, total gas production, neutral detergent fiber digestible (NDFD) and acid detergent fiber digestible (ADFD) with increased incubation time. Diets that consisted of the HIG treatment had the greatest ($P < 0.001$) IVDMD, NDFD and ADFD compared to the AVG treatment which was intermediate between LOW and HIG treatments. However, effect of supplementation differed between varieties of forage. Poor quality tall fescue supplemented with CGF had greater ($P < 0.05$) DMD compared to CON and LIQ treatments.

INDEX WORDS: Replacement Heifer Development, Pregnancy outcome, Kentucky 31 Tall Fescue, Tifton 85 Bermudagrass, forage nutritive value, dry matter yield, supplementation strategies, liquid-molasses supplement, corn gluten feed
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DEDICATION

I would like to dedicate this work to my family who has supported me throughout my time at the University of Georgia. Without your presence in my life reaching this goal in my academic career would not have been possible. Thank you for your love and guidance.
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Foremost, I would like to thank God for providing me with this opportunity and the abilities to overcome the challenges that are presented for me. I would also like to thank my friends and colleges who have supported me and ultimately made this goal achievable.
# TABLE OF CONTENTS

ACKNOWLEDGEMENTS .................................................................................................................. v

LIST OF TABLES .............................................................................................................................. vii

LIST OF FIGURES ........................................................................................................................... ix

CHAPTER

1  INTRODUCTION ........................................................................................................................... 1

2  THE REVIEW OF THE LITERATURE .......................................................................................... 7

3  USING PERFORMANCE DATA AND REPRODUCTIVE MEASUREMENTS TO
   PREDICT FERTILITY IN REPLACEMENT BEEF HEIFERS ...................................................... 32

4  SUPPLEMENTATION STRATEGY AND FORAGE MANAGEMENT
   TECHNIQUES EFFECT ON FORAGE PRODUCTION AND DIGESTIBILITY OF
   KENTUCKY 31 TALL FESCUE AND TIFTON 85 BERMUDAGRASS ............................. 50

5  CONCLUSIONS AND IMPLICATIONS ....................................................................................... 75
LIST OF TABLES

Table 2.1: Description of Reproductive Tract Scores .......................................................... 31
Table 3.1: Descriptive statistics for characteristics of 1,914 heifers enrolled in a Georgia beef heifer development program .................................................................................................................. 45
Table 3.2: Characteristics and pregnancy outcomes of 1,914 heifers enrolled in a Georgia beef heifer development program between 2006 and 2011 ................................................................. 46
Table 3.3: Multivariable logistic regression model for the prediction of pregnancy status at the end of a 60-70 day breeding period in 1,914 heifers enrolled in a Georgia beef heifer development program between 2006 and 2011 ................................................................. 47
Table 3.4: Mean and median number of days to conception for 1,914 heifers enrolled in a Georgia beef heifer development program between 2006 and 2011 ................................................................. 48
Table 4.1: Grazing practices represented by harvest intervals of Kentucky 31 Tall Fescue and Tifton 85 Bermudagrass .................................................................................................................. 67
Table 4.2: In Vitro Diets ........................................................................................................ 68
Table 4.3: Characteristics of Kentucky 31 Tall Fescue Harvested at Various Intervals and Reproductive Stages During the Spring Growing Season ........................................................................ 69
Table 4.4: Characteristics of Kentucky 31 Tall Fescue Harvested at Various Intervals and Reproductive Stages During the Fall Growing Season ......................................................... 70
Table 4.5: Mean Comparison for Yield and Quality Characteristics of T85 Bermudagrass Harvested at Various Intervals .............................................................................................................. 71
Table 4.6: Effect of Relative Forage Quality and Supplement on Digestibility Characteristics of Kentucky 31 Tall Fescue ..........................................................72

Table 4.7: Effect of Treatment Interaction on In Vitro Dry Matter Digestibility of KY31 Tall Fescue ..........................................................73

Table 4.8: Effect of Forage Type and Supplement on Digestibility Characteristics of Tifton 85 Bermudagrass ..........................................................74
LIST OF FIGURES

Figure 3.1: Kaplan-Meier survival curves illustrating the time to conception for 1,914 beef heifers by location (A), reproductive tract score (B), hip height 3-4 weeks after delivery (C), and age at the beginning of the breeding period (D) ..................................................49
CHAPTER 1
INTRODUCTION

Nutrition and reproduction are two sectors of beef production that affect profitability and are heavily influenced by management (Patterson et al., 1992; Bormann et al., 2006). A producer must adhere to a 365 d calving interval for each female in the herd to maintain economic livelihood. Reproductive success however, is dependent upon proper nutrition (Wiltbank, 1970; Brooks et al., 1985). First calf heifers with a BCS of 5 at breeding will have a pregnancy rate around 90% compared to a 50% pregnancy rate for those with a BCS of 4 (Bell, 1990). Therefore, implementing a combination of management techniques focusing on improvement of fertility and diet is essential.

The period of heifer development, preceding the first breeding season, is a major determinant of future profitability in beef operations (Patterson et al., 2000). Since the time that puberty is reached positively correlates with time of conception, management of heifers should focus on factors that promote early puberty (Dearborn et al., 1973). Infertility along with dystocia account for 80% of the costs in beef cow-calf herds (Bellows et al., 2002). Thus, it is economically advantageous for producers to select heifers that have increased likelihood of fertility as replacements in the herd. Prior research has identified potential management practices to select replacement heifers including reproductive tract scoring (RTS) and hip height measurements (HH) (Anderson KJ, 1991; M. Pence, 2007). However, further research is needed to establish these and other methods as true predictors of fertility.
Reproductive success is the most important economic trait in beef cow-calf operations (Spire, 1991; Bormann et al., 2006). In order for reproduction to occur however, nutritional requirements of cattle must be satisfied. The majority of nutrients that cattle consume should come from forages to maintain economic stability in an operation (Don et al., 1994). Various factors including maturity and harvest interval will create deficiencies in forage nutrients over a growing season (Burton et al., 1963; Terry and Tilley, 1964; Burton et al., 1986).

Supplementation is a common practice to compensate for protein and energy deficiencies in low quality forage (DelCurto et al., 1990; Kunkle et al., 2000). Supplementation strategies should consider the nutrient deficit, cost, and convenience of administering the supplement (Bowman et al., 1995). Relatively inexpensive supplements, such as liquid feeds, have been shown to increase consumption of low quality forages (Beaty et al., 1994). However, when increasing forage intake does not satisfy cattle requirements, grain or by-product-based supplementation is necessary (Kunkle et al., 2000). There is a need for research that accounts for differences in forage quality over a growing season in order to properly implement supplementation strategies (Allen, 1996).

This thesis research was divided into two experiments. The first experiment evaluated variables linked to pregnancy status and time to conception in replacement beef heifers prior to breeding. The end objective of identifying these variables is to increase reproductive efficiency and improve selection intensities in cow-calf operations. Heifers from two heifer development programs in Georgia were evaluated for traits that influenced conception and pregnancy. Multivariate regression was used to identify traits that were significantly ($P < 0.05$) associated with the response variables.

The second experiment evaluated nutritive value and DM yield of tall fescue (Festuca arundinacea) and bermudagrass (Cynodon dactylon) at various harvest intervals throughout the
growing season. The goal of this research was to enhance supplementation strategies for cattle on forage based diets by accounting for nutritive value of these grasses over their respective growing seasons. Plots of spring harvested tall fescue was cut at 2 wk, 4 wk, boot stage, soft dough stage, and hard dough stage, while fall harvested tall fescue and bermudagrass was harvested at intervals of: 2, 4, 6, and 10 wk, and 2, 4, 6, 8, and 10 wk, respectively. Treatments were arranged in a randomized complete block design with four replications. Dry matter yield and forage quality of each plot were assessed over their respective growing seasons. In vitro digestibility was used to determine the rate that microbes degraded dry matter, NDF and ADF when various supplements were present.

The purpose of conducting this research was to improve management practices in the reproduction and nutrition sectors of beef cattle production. Producers will benefit foremost from these findings by implementing selection protocols and supplementation strategies that yield greater return on investments with fewer input costs. This work is also beneficial to nutritionists who will be able to more precisely formulate supplements that meet the need of cattle producers. Furthermore, these results should serve as a guideline for future studies focused on enhancing economic and reproductive efficiencies in beef cattle operations.
**Literature Cited**


Bell, D. 1990. Effects of body condition score at calving and postpartum nutrition on performance of two-year-old heifers, OSU.


CHAPTER 2

REVIEW OF THE LITERATURE

Heifer Development and Selection

Each year cow-calf operations replenish herd numbers and inferior genetics with heifers that potentially increase profitability of the herd (Patterson et al., 1992). Since economic compensation for raising or buying replacement heifers is initially unknown, it is advantageous for producers to select females based on traits that are most likely to lead to profitability (Wathes et al., 2014). Cow-calf operations strive to retain replacement heifers that produce offspring that meet the goals of an individual operation at market. Factors to consider when selecting heifers include: genetics, marketing capability, and potential for longevity in the herd (Endecott et al., 2013). This review will focus primarily on factors that relate to increasing the number of years a given heifer remains productive in the herd thus, increasing reproductive efficiency.

It is well documented by previous research that management during the period of development, from birth of the heifer to the first calving season, has a significant impact on lifetime productivity (Patterson et al., 2000; Funston and Deutscher, 2004; Funston et al., 2012). Since heritability of reproductive traits is low, advancement can be made more effectively through management practices (Bormann et al., 2006). Meeting the nutritional needs of a heifer for growth and maintenance should be a high priority. Pre-breeding nutrition impacts growth and maturity of the heifer (DeRouen et al., 1994), which affects timing of puberty (Schillo et al., 1992). Age at which effects productivity over the lifespan of the heifer (Patterson et al., 2000; Endecott et al., 2013).
**Puberty.** Puberty is the result of a process of reproductive development that marks the first chance for the heifer to conceive (Atkins et al., 2013; Gasser, 2013). Development of the reproductive system during this physiological event is noted by an increase in uterine growth and ovarian development. Successful development of reproductive organs requires coordination among organs via hormonal signals controlled by the endocrine system. Estrous cycling begins with the release of GnRH followed by LH, initiating ovulation. Puberty ends after first ovulation when no indication of further growth or maturation of reproductive organs occurs (Atkins et al., 2013; Gasser, 2013).

Puberty is defined as the first ovulatory estrus followed by a luteal phase of normal duration (Atkins et al., 2013). Selection of heifers that will replace brood cows in the herd should focus on factors that relate to puberty (Patterson et al., 2000). Age that puberty is obtained positively correlates with the time of first conception and calving (Funston and Deutscher, 2004). Research notes that BW influences the age at which a heifer reaches puberty (Patterson et al., 1992). Thus, nutrition prior to the heifer’s first reproductive period has a large impact on the lifetime productivity of an animal (Hall, 2013). Research conducted by Ciccioli et al. (2005) found heifers fed high-energy diets were younger ($P < 0.03$) at puberty compared with heifers grazing dormant little bluestem (*Andropogon scoparius*) and big bluestem (*Andropogon gerardii*) pastures. Previous studies have suggested that puberty occurs when an animal reaches a genetically predetermined body size and weight, defined as 65% of projected mature body weight (Patterson et al., 2000). Failure to reach this critical body weight results in reduced pregnancy rates (Patterson et al., 1992). However, Funston and Deutscher (2004) suggested that lowering the critical body weight has potential to reduce heifer development costs without losses in animal production. Eborn et al. (2013) assigned heifers to one of two treatment groups fed
from 8 to 15 mo of age. The low treatment-gain diet, comprised of corn silage and alfalfa haylage, was intended to feed heifers to 55% of mature bodyweight by 14 mo of age. The high-gain diet consisted of corn silage and high moisture corn, fed heifers to reach 65% of mature BW by 14 mo of age. Results of this work concluded that diet did not ($P = 0.07$) affect the proportion of heifers that became pregnant over the entire breeding period. However, a greater proportion ($P \leq 0.01$) of heifers on the high gain diet conceived within the first 21 d of the breeding period. Furthermore, (Brooks et al., 1985) acknowledges the importance of nutrition, but reports environmental factors play an equally important role in determining timing of puberty.

**Conception.** Conception is the time at which cattle achieve pregnancy. Research focuses primarily on management criteria that has the ability to increase conception rate over an entire herd while reducing the time interval from one subsequent conception to the next, increasing reproductive efficiency (Mihm et al., 1994). Analysis of 3,144 heifer records concluded heritability of pregnancy and first-service conception rates are $0.13 \pm 0.07$ and $0.03 \pm 0.03$, respectively (Bormann et al., 2006). Compared with heritability of other genetic traits such as hip height (0.54 to 0.75), heritability of fertility is considerably lower, indicating that management has the ability to alter these traits significantly (Neville et al., 1978). Various literature has noted nutritional management considerations that can increase first service conception rate (Sasser et al., 1988; Rae et al., 1996; Siddiqui et al., 2013). Buskirk et al. (1995) reported increasing weaning weight of 452 spring born calves from 150 to 275 kg increased the probability of calving to the first-service from 5.8 to 45.5 %. Similarly, (Mulliniks et al., 2013) found that increasing the percentage of rumen degradable protein (RUP) in the diet of British crossbred heifers from 36 to 50 % resulted in a 13% greater pregnancy rate. Heifers in this study were assigned to a high (36% CP containing 50% RUP) or low (36% CP containing 36% RUP)
treatment group which began at weaning and continued until the beginning of the breeding season. Sixty seven percent of the heifers fed the low treatment achieved pregnancy at the end of the breeding season compared to 80% of heifers that consumed the high treatment ($P = 0.02$) (Mulliniks et al., 2013).

**Reproductive Tract Scoring (RTS).** Reproductive tract scoring has been identified by previous research as a useful method of selecting profitable replacement females (Andersen et al., 1991; Patterson et al., 2000; Holm et al., 2009). Reproductive tract scoring uses methods described by Anderson et al. (1991) to assess the maturity of the reproductive tract 30-60 days prior to breeding (Atkins et al., 2013). This system assigns a score (1-5) to animals, of similar age, based on extent of reproductive tract maturity (Table 2.1) (Andersen et al., 1991). Holm et al. (2009) reported 77% of heifers with RTS 4 or 5 remained in the herd for their second breeding season compared with 54% of heifers with RTS of 1 or 3. Also, the RTS system (predictive ability = 0.67) is better (explained more variation) at predicting pregnancy after first AI season than other systems: BCS (0.56) ($P < 0.01$), BW (0.58) ($P = 0.045$) and age (0.54) ($P < 0.01$) (Holm et al., 2009). However, on a scale from 0.0 (no agreement) to 1.0 (perfect agreement), Rosenkrans and Hardin, (2003) reported a substantial repeatability within veterinarians (0.72) at determining puberty with RTS but only moderate agreement between veterinarians (.58), suggesting that the RTS system may be more useful as a screening tool for the entire herd instead of a method to cull individual cattle.

Reproductive tract score classification has also been shown to correlate with time at which conception occurs. Pence (2007) reported that, compared to heifers with a RTS of 5, the mean time to conception was 3.9 days longer for heifers with RTS 4, 13.4 days longer for RTS 3 and 22 days longer for RTS 1 or 2 ($P < 0.01$).
**Pelvic Area.** Pelvic area is calculated by multiplying the height and width of the pelvis using a procedure described by Bellows et al., (1971). Pelvic area can be a useful tool when evaluating the ability of a heifer to give birth to live calves unassisted (Johnson et al., 1988; Holm et al., 2014). Fetus-pelvic disproportion is the most common reason for dystocia or difficulty calving (Johnson et al., 1988). According to the Beef Improvement Federation (2010), dystocia most commonly occurs during a heifer’s initial calving due to the disproportional size of the calf and the birth canal of the heifer. Thus, pelvic area is commonly used as a selection tool to cull heifers having higher probabilities of dystocia. Calf birth weight is correlated with pre-breeding (0.34) and pre-calving (0.34) heifer weights ($P < 0.05$); thus bigger heifers have larger pelvises but also have calves that weigh more at birth (Johnson et al., 1988).

In a herd comprised of approximately 60% purebred angus or Hereford females and 40% crossbred females Morrison et al. (1986) found pelvic area is highly heritable (0.68 ± 0.34), with pelvic width (0.77 ± 0.29) being more heritable than pelvic height (0.62 ± 0.29). The authors suggested however, that selection for larger pelvic area can be achieved without increases in cow size because phenotypic correlation (-0.12) between pelvic measurements and cow BW is low (Morrison et al., 1986). Holm et al., (2014) reports for every 1 kg increase in calf birth weight the odds of dystocia increased by 37% after adjusting for year of birth, dam parity, and pelvic area ($P < 0.01$). Also, for every 1 cm² increase in pelvic area, the odds of dystocia tended to decrease by 2% ($P = 0.08$) (Holm et al., 2014).

**Hip Height.** Hip height is an indicator of the structural size of an animal and is also moderately heritable (Dhuyvetter, 1995). Heifers with greater hip heights will likely have calves that weigh more at harvest. Neville et al. (1978) reported that heritability for a group of heifers obtained by regression of daughter on dam in Tifton, GA (Angus, Polled Hereford and 3/4 and
7/8 Simmental) and Reidsville, GA (Angus, Polled Hereford and Santa Gertrudis) were 0.54 ± 0.18 and .75± 0.16 respectively for hip heights. Bullock et al. (1993) found that yearling hip height is highly correlated with mature weight in cattle (r = 0.73).

Frame scoring is commonly used to predict mature size of cattle which is important when estimating the nutrient requirements of growing and finishing cattle (Dhuyvetter, 1995).

According to the Beef Improvement Federation (2010), this scoring system, based on scale of 1 to 9 (small to large), takes into account the age and hip height of a given animal at a point in time, and projects mature weight based on characteristics of their breed type (Parish et al., 2012). Vargas et al. (1999) assigned heifers to a small (115 to 126 cm), medium (127 to 133 cm), and large (134 to 145 cm) groups based on frame score at 18 mo of age. Results of this study showed that heifers with small and medium frame scores reached puberty at younger (P<0.05) ages (633.2 ± 12.3 and 626.4 ± 12.0 d) compared to heifers with large frame scores (672.3 ± 17.1 d).

**Prepartum body condition.** Body condition scoring is a useful assessment of energy reserves in beef cattle (Stewart and Dyer, 2000). Scoring is achieved by visual assessment of back, tail head, pins, hooks, ribs, and brisket of cattle and based on a scale from 1 to 9 (thin to obese) (Hall and Dietz, 2009). Body condition of cattle prior to calving has a significant effect on subsequent calving seasons and future profitability (Endecott et al., 2013). DeRouen et al. (1994) reported pregnancy rates of cows with BCS 6 and 7 (87.0 and 90.7%) at calving were higher (P < 0.05) than those of cows with BCS 4 and 5 (64.9 and 71.4%). Also, cattle in moderate to high body condition (BCS ≥5) at calving had shorter (P < 0.05) postpartum intervals than thin cows (BCS ≤4). This agrees with work by (Mulliniks et al., 2012) who found cows grazing blue gama (* Bouteloua gracilis*) and common wolfstail (* Lycurus phleoides*), with body condition scores of 4 and 5 at calving tended to lose 58 and 57 kg of BW, respectively;
compared to cows with a BCS of 6 which lost only 50 kg of BW ($P = 0.06$), at the end of the breeding season. Thus, nutritional management during the prepartum period effects reproductive performance significantly.

Nutritional management also affects longevity. Heifers that received a supplement supplying 50% RUP had a greater ($P < 0.01$) retention rate (70 %) after 4 breeding seasons compared to heifers receiving a supplement supplying 36% RUP (42%) (Mulliniks et al., 2013).

**Forage Defoliation and Quality**

Cattle producers in Georgia depend on forage from pastures and hay stores to meet the nutritional needs of their animals. Therefore, in order to provide cattle with appropriate nutrition, forage must be managed intensively, considering quality and yield (Beck et al., 2007). Defoliation of forage either by cutting or grazing impacts the plant significantly (Kerrisk and Thomson, 1990). Ability of the forage to regrow depends largely on the severity of defoliation and how often defoliation occurs (Burns et al., 2002).

**Forage Quality.** Forage quality is dependent upon nutritive value of the plant plus DMI by the grazing animal. Thus, many factors pertaining to the composition of plant tissue determine forage quality, including: plant species, proportion of leaf to stem, and stage of maturity (Allen, 1996; Ball et al., 2007b). It is well documented that as forages mature the fiber component increases, causing the digestibility of the forage to decrease (Jung and Allen, 1995). Therefore, maturity and thus fiber content, is suggested by various research to be the major determinant of forage quality (Griffin and Jung, 1983; Phillips and Horn, 1998; Waramit et al., 2012). A common way to maintain vegetative state of forage is to harvest prior to reaching mature stages. In a study of crabgrass (*Digitaria ciliaris*) hay fields harvested at 21, 35 and 49 d, Beck et al. (2007) reported a linear decrease ($P < 0.01$) in CP (14.1, 13.7, and 10.6% of DM, respectively)
and increase \( (P < 0.01) \) in NDF (65.3, 70.6, and 70.2\% of DM, respectively) and ADF (35.7, 38.9, and 43.7\% of DM respectively). This work agrees with Burton et al. (1963) who reports a decrease in CP content of bermudagrass (\textit{Cynodon dactylon}) from 18.5 to 8.4\% as the period of cutting was increased from 3 to 24 weeks. Also, as harvesting interval decreased from 3 to 24 weeks, digestible DM dropped from 65.2\% to 43.2\% respectively, with digestible energy following similar patterns.

In order for forage digestion to occur, cattle must first consume adequate amounts of forage to meet nutrient requirements (Ball et al., 2007b). Plant material that is high in fiber content often decreases fermentation rate and slows passage through the reticulorumen compared to low fiber plant tissue. As passage rate slows, the gut becomes full of indigestible plant material making the animal stop eating before nutritional needs are satisfied (Jung and Allen, 1995). According to Bhatti et al. (2008), dry matter disappearance (DMD) increased 35\% \( (P = 0.001) \) when steers consumed a combination of orchardgrass and alfalfa compared with orchardgrass alone. This was contributed to a low NDF content of alfalfa (50.4 \%) compared to orchardgrass (69.0 \%). Neutral detergent fiber accounts for 30 to 80\% of the organic matter in forage crops that is normally digested by ruminant animals, while the remaining organic matter is indigestible (Buxton and Redfearn, 1997). Adding sources of NDF has been shown to benefit the digestion of concentrate diets in feedlot scenarios by slowing passage rate, allowing more time for rumination and increasing rate and extent of fermentation in the rumen (Owens et al., 1998). Galyean and Defoor, (2003) reported that dietary NDF content explained 92\% of the variation in DMI of feedlot diets containing roughage levels between 0 to 30\%. However, for cattle receiving nutrition solely from forages, high NDF components can have a negative impact.
on DMI and DMD (Buxton and Redfearn, 1997). In a review of 15 studies (Allen, 2000) reports a general decrease in DMI when NDF was higher than 25% in the diet.

**Near Infrared reflectance (NIR).** All agricultural food products including forage species have chemical components that have near infrared absorption properties. Near infrared reflectance spectroscopy (NIRS) can be used to scan samples of forages to determine forage quality, using an electro-magnetic scan over a spectral wavelength of 400 to 2500 nm (Corson et al., 1999; Andueza et al., 2011). When properly calibrated, NIR analysis has the ability to accurately determine 18 nutrients present in agricultural products in about 60 seconds. The rapid speed, low cost and large output of data associated with using NIR makes it advantageous in determining quality of forage species. However, the limitation with NIR is the ability to accurately calibrate for various sample characteristics (Corson et al., 1999).

Studies exist regarding the accuracy and repeatability of NIR when assessing nutritional components of various forage crops. Marten et al. (1984) found NIR analysis is useful in evaluating forage quality of four perennial legumes: alfalfa (Medicago saliva L.), birdsfoot trefoil (Lotus corniculatus L.), red clover (Trifolium pretense L.), and white clover (Trifolium repens L.). The r² between NIR analysis and conventional laboratory analyses were 0.96 or greater for all characteristics tested (IVDMD, CP, NDF, and ADF). Additionally, (Gislum et al., 2004) reported correlation coefficients of 0.97 – 0.98 when predicting nitrogen concentration in dried and ground grass samples.

**Kentucky 31 Tall Fescue.** Tall Fescue (Festuca arundinacea) is a perennial, cool season, bunch grass with short rhizomes. This grass is primarily utilized for grazing and hay production in the south eastern United States. In Georgia, seasonal production of tall fescue usually ranges from September – December, and March – June. Kentucky 31 (KY-31) is the predominant Tall
Fescue variety grown in the United States (Roberts et al., 2009). Grazing cattle on KY-31 tall fescue pastures is cautioned due to its association with a fungal endophyte (*Neotyphodium coenophialum*) that lives its entire life within the plant. The plant benefits from its symbiotic relationship with the endophyte in several ways, the most important of which is drought tolerance. It is speculated that the increased tolerance to dry weather is the result of greater root depth and volume of Tall Fescue as a result of the endophyte (Ball et al., 2007b). In addition, plants infected with the endophyte have shown increases in seed germination rate, seedling vigor, and seed production. However, cattle grazing endophyte infected tall fescue have been shown to exhibit reduced conception and growth rates (Stuedemann and Hoveland, 1988; Ball et al., 2007a; Roberts et al., 2009). This condition, known as fescue toxicosis, is caused by alkaloids produced by *N. coenophialum* (Hill et al., 1998). Nihsen et al. (2004) reported that steers grazing endophyte infected Kentucky 31 Tall Fescue had reduced \(P < 0.05\) ADG (0.34 kg/d) compared to steers grazing novel-endophyte (0.60) or endophyte-free (0.61 kg/d) tall fescue.

Stockpiling tall fescue to graze during autumn months can be an advantageous management decision that is simple to implement and utilize. Typically producers would begin allocating stored hay reserves to cattle during this time of the year. However, by extending the grazing season, stored hay is reserved for winter months, while cattle consume a higher quality forage during the fall (Ball et al. 2007). Nutritive value of stockpiled tall fescue was reported by (Flores et al., 2007). Crude protein content reduced over the sampling period (Dec. 4 – Feb. 26) from 15.6 % to 12.8 % of DM, while NDF and ADF concentrations increased due to later sampling date, from 56.5 to 64.6 % and 27.7 to 31.4 % of DM, respectively. Furthermore, this study found no difference \(P \geq 0.470\) between forage mass over the previously mentioned sampling dates when comparing an novel endophyte and endophyte infected cultivars, and
neither cultivar of fescue exhibited a relationship with time (\(P = 0.109\)). This agrees with Kallenbach et al. (2003) that herbage mass (2370 kg/ha\(^{-1}\)) of stockpiled KY-31 tall fescue was consistent from mid-December through mid-March in southern Missouri, indicating that DM did not deteriorate rapidly after mid-December. However, management during the spring growth period is essential to an adequate stand of stockpiled tall fescue. Ocumpaugh and Matches, (1977) reported that frequent defoliation of tall fescue during the summer-spring period decreased dry matter yields of stockpiled tall fescue by 30-40%.

**Tifton 85 Bermudagrass.** Bermudagrass (*Cynodon dactylon*) is a warm season perennial, commonly established for pasture grazing and hay production throughout the state of Georgia. This forage is extremely drought tolerant and spreads vigorously via rhizomes and stolons. With adequate fertilization, bermudagrass has the ability to provide high DM yields during the months of May – September. However, quality of bermudagrass is relatively low compared with cool season grasses (Ball et al., 2007a).

Hybrid bermudagrass cultivars, such as Tifton 85 (T-85), have shown increased DM yield and forage quality compared to varieties such as Coastal (Hill et al., 1993). Compared with Coastal bermudagrass, T85 increased (\(P < 0.03\)) cow 91-d ADG (0.10 kg/d), cow gain/ha (42.6 kg/ha) and calf 91-d ADG (0.15 kg/d) when creep grazing was implemented (Corriher et al., 2007). Compared to another hybrid variety (Tifton 78), nutritive value was similar during the early part of the growing season (May and July) however, the Tifton 85 variety was higher (\(P < 0.05\)) in CP and IVDMD in September (Hill et al., 1993). Furthermore, yield data from 1989 – 1991 showed that T85 yielded 14.7 t/ha of DM annually, compared to 11.3 t/ha by Tifton 78. This research suggested that the T85 variety has the ability to extend grazing into later months compared with other hybrid varieties.
Supplementation Strategies

Quality of forage often falls below the threshold of meeting the requirements of cattle, especially for lactating brood cows. Even in intensively managed grazing systems various factors including weather and season of growth may contribute to high maturity forage at time of consumption by the animal. When forage quality declines to the extent that it no longer meets nutritional needs of cattle, supplementation is essential to maintain performance (Kunkle et al., 2000). Energy and protein are two nutrients that are most limiting in cattle consuming forage based diets (Allison, 1985). Studies regarding supplementation of protein and energy to cattle most often show increases in BW or improvement in DMI due to the supplement (Kunkle et al., 2000). However, it is important to consider nutrient deficit in order to supplement adequately, yet few studies exist that adjust supplementation strategy based on forage nutritive value (Bailey and Kallenbach, 2010).

Corn Gluten Feed. Corn gluten feed is a corn by-product resulting from the process of making corn starch or syrup. Wet milling causes corn kernels to swell (steeping) in which some nutrients are converted to the liquid fraction referred to as steep liquor. The corn germ is removed from the kernel in order to extract corn oil and starch is removed in order to produce corn sweetener. Once extraction of starch, gluten, and germ from the corn kernel is complete, bran is mixed back with the remaining steep liquor and dried to form dry corn gluten feed (DCGF) (Hoffman, 1989).

The NRCS (2000) reports nutritive values of CGF as follows: 90% DM, 23.8% CP, 36.2% NDF, and 3.9% crude fat. However, amount of steep liquor inclusion will affect final color and nutritive value (Meyer, 2008). Also, the drying procedure can create a Maillard reaction in which protein digestibility is decreased by heat damage (Segers et al., 2013). Rumen
degradable protein is considered the most limiting component in the diet for cattle consuming low quality forages as it enhances DM intake and assists in passage of nutrients to the small intestine (Köster et al., 1996). As previously mentioned, the CP in CGF constitutes roughly 23.8% of DM, of which 75% is ruminally degraded, supporting it as a viable source of protein for cattle that are grazing moderate to low quality forages. However, very little current research reports the effects of supplementing low quality forage diets with CGF.

**Molasses Supplements.** Cane molasses is a by-product from the manufacture of sugar from sugar cane. This product contains roughly 60 - 65% sugar 6% CP and 70 - 75% TDN on a DM basis (Perry, 1995). Molasses is often incorporated into feeds for the purpose of diminishing dust. It is also commonly used as a supplement for feeding cattle due to being economically feasible and labor efficient to administer. Molasses supplements are regarded as a source of rapidly fermentable carbohydrates to cattle because they are composed mainly of sucrose. (Kunkle et al., 1997).

Molasses supplements containing non protein nitrogen (NPN) in the form of urea can be a means of increasing consumption of nitrogen and energy (Bond and Rumsey, 1973). Urea also limits the consumption of the liquid supplement when higher concentrations are added. Phillips and Horn (1998) reported an increase in ADG in steers consuming Bermudagrass pastures from .51 kg (control group) to .69 kg over a 131-d grazing period when supplement was provided either in block or dry form. A 2-yr case study conducted by the NRCS (2011) reports that no significant differences were found in rumen dynamics or dairy cow performance when molasses was fed at the same rate as corn meal. Various studies have reported that addition of molasses to forage based diets of ruminants increases dry matter digestibility, but decreases the digestibility
of crude fiber or cellulose (Martin et al., 1981). However, studies have shown that true protein sources such as soybean meal or corn gluten feed are superior to non-protein nitrogen sources.

**Conclusions**

Literature has shown that management decisions have the ability to create efficiencies in beef cattle operations. Criteria for selection of replacement heifers should be based on factors that promote early puberty, timing of conception and confirmed pregnancy, however correlation of variables with these phenomenon must be assessed. Additionally, supplementation strategies should focus on quality of forage to meet cattle nutritive requirements, but there is little data regarding the ruminal kinetics of common supplementation strategies when forages of varying quality are present in the rumen environment. The research that follows includes two experiments that address these issues.
Literature Cited


Table (2.1) Description of Reproductive Tract Scores

<table>
<thead>
<tr>
<th>Reproductive Tract Score</th>
<th>Uterine Horns</th>
<th>Length (mm)</th>
<th>Height (mm)</th>
<th>Width (mm)</th>
<th>Ovarian Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Immature &lt;20 mm diameter, no tone</td>
<td>15</td>
<td>10</td>
<td>8</td>
<td>No palpable follicles</td>
</tr>
<tr>
<td>2</td>
<td>20 to 25 mm diameter, no tone</td>
<td>18</td>
<td>12</td>
<td>10</td>
<td>8 mm follicles</td>
</tr>
<tr>
<td>3</td>
<td>25 to 30 mm diameter, slight tone</td>
<td>22</td>
<td>15</td>
<td>10</td>
<td>8 – 10 mm follicles</td>
</tr>
<tr>
<td>4</td>
<td>30 mm diameter, adequate tone</td>
<td>30</td>
<td>16</td>
<td>12</td>
<td>&gt;10 mm follicles,</td>
</tr>
<tr>
<td>5</td>
<td>&gt;30 mm diameter, good tone</td>
<td>&gt;32</td>
<td>20</td>
<td>15</td>
<td>&gt;10 mm follicles, palpable corpus luteum</td>
</tr>
</tbody>
</table>

Adapted from Andersen et al. (1991)
CHAPTER 3

USING PERFORMANCE DATA AND REPRODUCTIVE MEASUREMENTS TO PREDICT FERTILITY IN REPLACEMENT BEEF HEIFERS

Abstract

This study investigated the effect of reproductive tract and growth characteristics measured 30-70 d prior to the breeding season on 1) pregnancy outcome and 2) time to conception in replacement beef heifers. A total of 1,992 heifers (BW 329±42 kg; age 347±27 d) were delivered for enrollment in the Georgia Heifer Evaluation and Reproductive Development (HERD) program between 2006 and 2011 at two locations. Variables were chosen to estimate management of heifers prior to entering the program in addition to developmental traits traditionally measured in the HERD program and included: reproductive tract score (RTS), weight 70-d prior to breeding as a percentage of target weight, hip height (HH) 40-50 d prior to breeding, and ADG 40-50 d prior to breeding. Cattle entered in the program were of similar age and subjected to comparable nutritional and management protocols. Chi-square test of homogeneity (pregnancy status) and the Kaplan-Meier product limit method (number of days from initial breeding to conception) were used to analyze univariate associations with predictor variables. Multivariate analyses of pregnancy status and time to conception were performed using logistic regression and Cox regression respectively. The odds of pregnancy increased by 15% for every 2.5 cm increase in HH ($P = 0.001$), and by 20% for every 30-d increase in heifer age at the start of the breeding period ($P = 0.019$). Although RTS was associated ($P = 0.015$) with pregnancy status in the univariate analysis, after adjusting for the other variables included in the final multivariable model there was no significant association ($P > 0.05$). Reproductive tract score and heifer age were not associated ($P > 0.05$) with time to conception in the multivariable analysis and were not included in the final model. However, HH was significantly ($P = 0.005$)
associated with the time to conception after adjusting for location and year of enrollment. After 35 d the hazard rate for conception increased 15% for every 2.5 cm increase in HH [hazard ratio (95% CI) = 1.15 (1.04, 1.26); \( P = 0.005 \)]. Variables intended to indicate prior management (ADG and weight 70-d prior to breeding as a percentage of target weight) were not found to be associated with pregnancy or time to conception. The results suggest that factors relating to maturity can be used to select heifers that are more likely to achieve pregnancy and have reduced times to conception.

**Introduction**

Cattle numbers in the United States are currently estimated at 87.7 million, which is the lowest inventory since 1951 (USDA, 2013). With cow inventory low, current prices of purchasing replacement heifers are substantial, making it important for cattle producers to consider the return on investment that will generate from each addition to the herd. Profits are generated from heifers that will sustain productivity over a number of years (Endecott et al., 2013). Heifers are expected to produce their first live offspring at two years of age and maintain a 365 d calving interval. However, in order to reach puberty and achieve pregnancy in this time frame, various physiological events must take place in the heifer (Gasser, 2013). Puberty is attained when the heifer exhibits her first ovulatory estrus followed by a luteal phase of normal duration, leading to the ability to conceive and therefore achieve pregnancy (Atkins et al., 2013).

In addition to phenotypic appearance, selection intensities should focus on factors that relate to age at puberty. Since heifers are normally bred during a defined period of 60 -70 d, heifers that reach puberty early are more mature at breeding (Short and Bellows, 1971). Heritability of reproductive traits, such as first-service conception rate, is considerably low (0.03 ± 0.03) thus, management practices can greatly affect reproductive efficiency (Bormann et al.,...
Selection of profitable heifers however, can be arduous in that many variables affect the ability of the animal to be productive over her lifetime in the herd. Selecting replacement females based on growth characteristics, such as hip height, reproductive tract scoring, and pelvic area, during the developmental period from birth to first breeding period have been shown to increase reproductive efficiency over the life of the animal (Endecott et al., 2013). These growth variables include age, hip height, and reproductive tract scores. However, there is a need for research that validates these characteristics as true predictors of fertility.

The objective of this study was to identify growth and reproductive measurements that related to pregnancy and time to conception in a group of beef heifers and assess the value of these measurements as a selection tool to increase reproductive efficiency. Heifers from two heifer development programs in Georgia were evaluated for traits that influenced conception and pregnancy. Results of this work will benefit producers by improving replacement heifer selection techniques.

**Materials and Methods**

*Animal Management.* The University of Georgia Heifer Evaluation and Reproductive Development Program (HERD) allows producers in Georgia and surrounding states to consign yearling heifers to a development program for educational purposes. For this study, a total of 946 and 949 heifers were assessed at HERD program facilities in Tifton and Calhoun, Georgia between the years of 2006 and 2011. Females in Tifton were born in September and November of each year, and were delivered to HERD facilities during early October the following year. Heifers in the Calhoun program were born in December and February of each year and delivered to HERD facilities in early December the following year. Heifers had a mean age of $347 \pm 27$ d upon arrival at HERD facilities. Additionally, similar management practices were utilized at
each location, including nutrition, estrous synchronization and stocking rate. Methods of synchronization and/or heat detection differed throughout years and across locations of the study. However, all heifers were subjected to artificial insemination and placed with clean-up bulls for 58 d for a total breeding season ranging from 60 – 70 d. Pregnancy status was assessed with ultrasound 35 d after bulls were removed.

**Data Collection.** Heifers were weighed upon arrival at HERD facilities and again at intervals to assess 22-d ADG, 37-d ADG, 75-d ADG, and 112-d ADG. Hip heights (HH) were measured at 60 d, while reproductive tract maturity scores (RTS) and pelvic area (PA) measurements were assessed 30 d prior to the breeding season. Hip heights were determined as heifers passed by a measuring stick located on the back panel of the working chute. Pelvic measurements were assessed using a Rice Pelvimeter (Lane Manufacturing, Inc. Denver, CO). Pelvic area (PA) was attained by multiplying height and width of the pelvic opening. Heifers that did not achieve a PA of 140 cm$^2$ 30 d prior to breeding were considered non-eligible for sale but were retained on HERD facilities by discretion of the owner due to probability of dystocia (Johnson et al., 1988). Pelvic area was used solely as a culling tool and was not analyzed as a predictor of fertility in this study. Reproductive tract scores were recorded by a veterinarian in each year of the study. Scores were given based on procedures described by Andersen et al. (1991). Heifers were considered non-eligible for sale prior to the breeding period if a minimum RTS of 2 was not achieved due to decreased fertility of heifers with infantile reproductive tracts, if the tract was absent, or if the heifer was pregnant. Although females were culled from the program that did not meet the minimum requirements from PA and RTS, they could still proceed with the breeding protocol at the discretion of the owner. In addition to these growth traits, BW gain during the time of development at HERD facilities, and prior to arrival at HERD facilities
was of interest. Management of heifers prior to arrival was unknown thus, it was presumed that this may factor in to pregnancy status at the end of the breeding season. Therefore, ADG over the first 22 d was used to assess management prior to arrival based on potential compensatory gains.

**Statistical Analysis.** All statistical tests assumed a two-sided alternative hypothesis, and \((P < 0.05)\) was considered significant. All analyses were performed using commercially available statistical software (Stat version 12.1, StataCorp LP, College Station, TX.)

Pre-breeding reproductive data were examined for correlations with reproduction outcomes. To identify variables that influence pregnancy, univariate associations between categorical predictor variables and the pregnancy status at the end of the breeding period was evaluated using a chi-square test of homogeneity. A multivariable logistical regression model was then constructed. Multivariable model selection proceeded from a maximum model containing all variables that were associated \((P < 0.20)\) with pregnancy status in the univariate analysis. With the exception of enrollment year and location, variables were removed from the maximum model in a manual stepwise process until only those with \((P < 0.05)\) remained. Enrollment year and location were included in all models regardless of their significance because of their theoretical importance as confounding variables. After reaching a preliminary main-effects model, all two-way interactions with heifer characteristic variables were evaluated. Both categorical and continuous forms of continuous predictor variables were assessed. The form of predictors that led to the lowest value of Akaike’s Information Criterion (AIC) was preferred. The goodness of fit of the final model was evaluated using the Hosmer-Lemeshow goodness of fit test (Hosmer and Lemeshow, 2000). Data were screened for outliers by examining plots of the predicted probabilities versus delta-deviance, delta-beta, and delta-\(\chi^2\).
Univariate associations between categorical predictors and the time from the beginning of the breeding period to conception were evaluated using the Kaplan-Meier product limit method in conjunction with the log rank test. Restricted mean conception times were calculated as the area under Kaplan-Meier survival curves. Multivariable analysis of the time to conception was performed using Cox regression. Model selection followed the same approach as previously described for logistic regression models. The proportional hazards assumption was graphically evaluated for predictors by plotting ln (-ln) survival curves, and statistically evaluated by using a score test based on the scaled Schoenfeld residuals (Hosmer et al., 2008). Stratification was used to adjust for variables that failed to meet the proportional hazard assumption if they were primarily considered to be important as confounders. When it was desirable to estimate the effect of a variable that failed to meet the proportional hazards assumption, it was allowed to interact with a function of time in an extended Cox model (Kleinbaum and Klein, 2005). The most appropriate form of the interaction with time was determined by comparison of AIC values for competing models.

**Results and Discussion**

Of the 1,992 heifers that were delivered for enrollment in the Georgia beef heifer development program between 2006 and 2011, 78 heifers left the program either before the start of the breeding period or before their pregnancy status could be ascertained. The reasons that heifers left the program included: small pelvic area (n = 26); low reproductive tract score (n = 10); pregnant at arrival (n = 5); free martin (n = 4); death (n = 4); injury (n = 2); genetic disorder (n = 2); and unspecified (n = 25).

Characteristics for the 1,914 heifers that completed the program are summarized in Table 3.1, and the distribution of heifers by categorical variables and the percentages in each category
that were identified as pregnant at the end of a 60-70 day breeding period are summarized in Table 3.2. In the univariate analysis, RTS, HH 3-4 weeks after delivery, and age at the beginning of the breeding period were associated \((P < 0.05)\) with the percentage of pregnant heifers (Table 3.2). Results of the multivariable analysis for the prediction of pregnancy status are summarized in Table 3.3. Hip height \((P = 0.001)\) and heifer age \((P = 0.019)\) were associated with pregnancy status after adjusting for the year and location of enrollment, respectively. The odds of pregnancy increased by 15% for every 2.5 cm increase in HH, and by 20% for every one month increase in heifer age at the start of the breeding period. Although RTS was significantly associated with pregnancy status in the univariate analysis, it was not significantly associated with pregnancy after adjusting for the other variables that were included in the final multivariable model. The Hosmer-Lemeshow goodness of fit test indicated that the final logistic regression model provided a good fit to the data \((P = 0.660)\).

Literature notes the ability of HH to predict mature weights by calculating frame scores (Dhuyvetter, 1995). However, there is little research reporting the effect of HH on pregnancy outcome. Eler et al. (2014) reported that low genetic correlations between HH and heifer pregnancy \((0.00)\) suggest different genes are responsible for influencing these traits. This is consistent with work by Silva Ii et al. (2003) who reported a genetic correlation between HH and heifer pregnancy status of \((0.10)\) in Nelore cattle. These reports differ to findings of the current study that HH has a significant correlation to pregnancy outcome. However, genetic correlations were not assessed in the present study. In this study, it is thought that by selecting heifers with greater HH, indirect selection of heifers that were more mature most likely occurred.

Holm et al. (2009) and Pence (2007) both reported significant \((P < 0.01)\) univariate correlations between RTS category and pregnancy status after a 60 – 70 d breeding period, which
agrees with findings of the current study. However, in multivariate logistical regression Holm et al. (2009) reported that RTS was significantly associated ($P < 0.01$) with pregnancy outcome. These results differ from findings of the current study in that age and HH explained more variation in pregnancy outcome than RTS. Different veterinarians assigned RTS over the years of this study. Thus, it is possible that variation could have resulted making this variable less reliable. This agrees with work by Rosenkrans and Hardin (2003) who found, on a scale of 0.0 – 1.0 (low to high), only moderate agreement (.46) between veterinarians assigning RTS.

As previously mentioned, age was valuable as a predictor of fertility in this population of heifers in univariate and multivariate analysis. This observation disagrees with findings of Pence (2007) who reported an insignificant ($P = 0.139$) univariate correlation between age at the beginning of the breeding period and pregnancy status after a 60 – 70 d breeding period. Furthermore, using a multivariate logistical regression model, Holm et al. (2009) reported that age was not associated ($P = 0.76$) to pregnancy status after the first breeding season.

Survival analysis was used to determine whether heifer characteristics were associated with the number of days from the beginning of the breeding period to conception. The time to conception is summarized by categories of predictor variables in Table 3. Survival analysis was used to determine whether heifer characteristics were associated with the number of days from the beginning of the breeding period to conception. The time to conception is summarized by categories of predictor variables in Table 3.4. As in the analysis of pregnancy status as a dichotomous outcome, RTS ($P = 0.021$), HH ($P = 0.002$), and age at the beginning of the breeding period ($P = 0.047$) were all significantly associated with time to conception in the univariate survival analyses. Kaplan-Meier survival curves for all variables that had an association ($P < 0.20$) with time to conception in the univariate analysis are shown in Figure 3.1. In the multivariable Cox regression analysis, location, year of enrollment, and HH all failed to meet the proportional hazards assumption. Consequently, location and year of enrollment were included in the model by stratification, and HH was included by allowing it to
interact with a function of time that divided the follow-up period into segments before and after 35 days. Only HH was significantly associated with the time to conception after adjusting for location and year of enrollment. The effect of HH differed during the breeding period. Hip Height was not associated with conception during the first 35 days ($P = 0.204$). However, after 35 days, the hazard rate for conception increased by 15% for every 2.5 cm increase in HH [hazard ratio (95% CI) = 1.15 (1.04, 1.26); $P = 0.005$]. Reproductive tract score and heifer age were not significantly associated with time to conception after adjusting for HH, enrollment year, and location, and consequently were not included in the final multivariable Cox regression model. Hazard ratio estimates were not available for enrollment year and location because these variables were incorporated in the final model by stratification.

Results of survival analysis in the current study disagree with work by Pence (2007), who reported that time of conception for heifers with a RTS of 4 or 5 was significantly ($P < 0.001$) higher than heifers with RTS of 1 or 2. Little research exists that reports the relationship between HH and timing of conception. However, Eler et al. (2014) reported a negative genetic correlation between HH and age at first calving (- 0.01), which disagrees with the current study and suggests little relationship exists between HH and time that conception occurs. However, results of this study suggest that increased heifer HH was indicative of maturity, leading to more successful pregnancy outcomes earlier in the breeding period.

Results of this work suggest that maturity of a heifer at time of breeding plays a significant role in determining ability to achieve pregnancy and timing of conception. Univariate analysis showed that older heifers with higher RTS and HH were more likely to achieve pregnancy early in the breeding season. However, multivariate analysis showed in many of these variables are confounding. Reproductive tract scoring is based primarily on maturity of heifers
which could be better accounted for by assessing age and HH prior to entering the breeding period in this population of heifers.

Heifers were subjected to various methods of heat detection/synchronization across years in this study. The 14-d CIDR-PG protocol used in the final two years of this study is designed to induce estrus in peripubertal heifers. The estrogen combined with progestins affects the endocrine system of heifers in a way that mimics blood hormones around the time of puberty (Patterson et al., 2013). As a result, heifers in the final years of this study may have been more receptive to the synchronization protocol which could explain the discrepancies between the current study and results of Pence et al. (2007).

Although heifers were subjected to various management practices prior to entering HERD facilities, body weight prior to arrival at HERD facilities, or weight gain during the developmental period did not affect final pregnancy outcome. Thus, variables selected in this study to investigate plane of nutrition prior to the breeding period was not associated with pregnancy outcome or timing of conception considering the variables tested in this study. Furthermore, it is believed that nutritional management from the time that heifers arrived at HERD facilities to first breeding period (approximately 70 d) was such that heifers were on similar planes of nutrition by first AI date, regardless of previous management.

**Implications**

Based on findings of this research, it is evident that growth characteristics that related to maturity were most important when selecting heifers that would achieve pregnancy early within a defined breeding season. Future research in this area should focus on the relationship of HH to heifer pregnancy outcomes and time to conception. It was apparent in this study that proper nutritional management during the last 70 d of the developmental period was adequate time
achieve the same plane of nutrition across heifers coming from different management backgrounds.

**Literature Cited**


USDA. 2013. Cattle. ISSN: 1948-9099

Table (3.1) Descriptive statistics for characteristics of 1,914 heifers enrolled in a Georgia beef heifer development program

<table>
<thead>
<tr>
<th>Variable</th>
<th>Min, Max</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at delivery, d</td>
<td>279, 404</td>
<td>347 (27)</td>
</tr>
<tr>
<td>Age at the beginning of the breeding period, d</td>
<td>365, 476</td>
<td>426 (26)</td>
</tr>
<tr>
<td>Weight at delivery, kg</td>
<td>214, 503</td>
<td>329 (42)</td>
</tr>
<tr>
<td>Weight at delivery as a percentage of target breeding weight, %</td>
<td>63.6, 129.9</td>
<td>91.5 (10.1)</td>
</tr>
<tr>
<td>Hip height 3-4 weeks after delivery, cm</td>
<td>110, 137</td>
<td>122 (4)</td>
</tr>
<tr>
<td>Average daily gain during the first 3-4 weeks after delivery, kg/d</td>
<td>-1.20, 3.67</td>
<td>1.04 (0.66)</td>
</tr>
</tbody>
</table>
Table (3.2) Characteristics and pregnancy outcomes of 1,914 heifers enrolled in a Georgia beef heifer development program between 2006 and 2011.

<table>
<thead>
<tr>
<th>Variable</th>
<th>(^1)No. heifers (% pregnant)</th>
<th>(^2)P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reproductive tract score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>9 (55.6)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>197 (81.7)</td>
<td>0.015</td>
</tr>
<tr>
<td>3</td>
<td>762 (84.7)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>700 (86.1)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>246 (89.4)</td>
<td></td>
</tr>
<tr>
<td>Weight at delivery as a percentage of target weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>63.6-79.9%</td>
<td>249 (84.3)</td>
<td>0.934</td>
</tr>
<tr>
<td>80.0-89.9%</td>
<td>622 (85.1)</td>
<td></td>
</tr>
<tr>
<td>90.0-99.9%</td>
<td>657 (85.8)</td>
<td></td>
</tr>
<tr>
<td>100.0-129.9%</td>
<td>386 (85.8)</td>
<td></td>
</tr>
<tr>
<td>Hip height (cm) 3-4 weeks after delivery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>111-118</td>
<td>283 (78.5)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>119-122</td>
<td>740 (84.1)</td>
<td></td>
</tr>
<tr>
<td>123-126</td>
<td>548 (87.6)</td>
<td></td>
</tr>
<tr>
<td>127-137</td>
<td>343 (90.4)</td>
<td></td>
</tr>
<tr>
<td>Age (days) at the beginning of the breeding period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>365-394</td>
<td>276 (81.5)</td>
<td>0.047</td>
</tr>
<tr>
<td>395-424</td>
<td>626 (83.9)</td>
<td></td>
</tr>
<tr>
<td>425-454</td>
<td>752 (87.0)</td>
<td></td>
</tr>
<tr>
<td>455-476</td>
<td>260 (88.5)</td>
<td></td>
</tr>
<tr>
<td>Average daily gain (kg/d) during the first 3-4 weeks after delivery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-1.20-0.58</td>
<td>481 (83.6)</td>
<td></td>
</tr>
<tr>
<td>0.59-1.03</td>
<td>482 (85.9)</td>
<td>0.642</td>
</tr>
<tr>
<td>1.04-1.43</td>
<td>460 (85.9)</td>
<td></td>
</tr>
<tr>
<td>1.44-3.67</td>
<td>491 (86.2)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,914 (85.4)</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Number of heifers in each category and the percentage that were identified as pregnant following a 60-70 day breeding period
\(^2\) Chi-square test of homogeneity
Table (3.3) Multivariable logistic regression model for the prediction of pregnancy status at the end of a 60-70 day breeding period in 1,914 heifers enrolled in a Georgia beef heifer development program between 2006 and 2011.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient (SE)</th>
<th>(^1)OR (95% CI)</th>
<th>(^2)P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>2006</td>
<td>-0.241 (0.227)</td>
<td>0.79 (0.50, 1.23)</td>
<td>0.590</td>
</tr>
<tr>
<td>2007</td>
<td>-0.076 (0.243)</td>
<td>0.93 (0.58, 1.49)</td>
<td>0.290</td>
</tr>
<tr>
<td>2008</td>
<td>-0.289 (0.222)</td>
<td>0.75 (0.47, 1.19)</td>
<td>0.756</td>
</tr>
<tr>
<td>2009</td>
<td>-0.289 (0.222)</td>
<td>0.75 (0.48, 1.16)</td>
<td>0.218</td>
</tr>
<tr>
<td>2010</td>
<td>-0.357 (0.220)</td>
<td>0.70 (0.45, 1.08)</td>
<td>0.193</td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td>0.105</td>
</tr>
<tr>
<td>Location</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>Calhoun</td>
<td>0.078 (0.131)</td>
<td>1.08 (0.84, 1.40)</td>
<td>0.553</td>
</tr>
<tr>
<td>Tifton</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip Height (2.5 cm increments) 3-4 weeks after delivery</td>
<td>0.141 (0.044)</td>
<td>1.15 (1.06, 1.25)</td>
<td>0.001</td>
</tr>
<tr>
<td>Age (months) at the beginning of the breeding period</td>
<td>0.183 (0.078)</td>
<td>1.20 (1.03, 1.40)</td>
<td>0.019</td>
</tr>
<tr>
<td>Constant</td>
<td>-7.42 (2.14)</td>
<td>NA</td>
<td>0.001</td>
</tr>
</tbody>
</table>

\(^1\)Odds ratio and 95% confidence interval

\(^2\)Based on Wald statistics

NA = not applicable
Table (3.4) Mean and median number of days to conception for 1,914 heifers enrolled in a Georgia beef heifer development program between 2006 and 2011.

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. heifers</th>
<th>Mean (95% CI)</th>
<th>Median (95% CI)</th>
<th>1P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>42.6 (23.8, 61.4)</td>
<td>57 (3, ∞)</td>
<td>0.021</td>
</tr>
<tr>
<td>2</td>
<td>197</td>
<td>24.9 (21.3, 28.5)</td>
<td>15 (4, 22)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>762</td>
<td>21.1 (19.4, 22.9)</td>
<td>4 (3, 10)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>700</td>
<td>20.1 (18.3, 21.9)</td>
<td>4 (3, 4)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>246</td>
<td>19.0 (16.2, 21.8)</td>
<td>4 (3, 10)</td>
<td></td>
</tr>
<tr>
<td><strong>Weight at delivery as a percentage of target weight</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.871</td>
</tr>
<tr>
<td>63.6-79.9%</td>
<td>249</td>
<td>21.8 (18.8, 24.8)</td>
<td>10 (4, 15)</td>
<td></td>
</tr>
<tr>
<td>80.0-89.9%</td>
<td>622</td>
<td>20.7 (18.8, 22.6)</td>
<td>4 (3, 10)</td>
<td></td>
</tr>
<tr>
<td>90.0-99.9%</td>
<td>657</td>
<td>20.4 (18.5, 22.2)</td>
<td>4 (3, 9)</td>
<td></td>
</tr>
<tr>
<td>100.0-129.9%</td>
<td>386</td>
<td>21.9 (19.4, 24.4)</td>
<td>4 (3, 14)</td>
<td></td>
</tr>
<tr>
<td><strong>Hip height (cm) 3-4 weeks after delivery</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.002</td>
</tr>
<tr>
<td>111-118</td>
<td>283</td>
<td>24.3 (21.2, 27.5)</td>
<td>9 (4, 15)</td>
<td></td>
</tr>
<tr>
<td>119-122</td>
<td>740</td>
<td>21.8 (20.0, 23.6)</td>
<td>4 (4, 12)</td>
<td></td>
</tr>
<tr>
<td>123-126</td>
<td>548</td>
<td>19.1 (17.1, 21.1)</td>
<td>3 (3, 4)</td>
<td></td>
</tr>
<tr>
<td>127-137</td>
<td>343</td>
<td>19.4 (17.0, 21.8)</td>
<td>4 (3, 10)</td>
<td></td>
</tr>
<tr>
<td><strong>Age (days) at the beginning of the breeding period</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.047</td>
</tr>
<tr>
<td>365-394</td>
<td>276</td>
<td>23.5 (20.4, 26.6)</td>
<td>4 (3, 15)</td>
<td></td>
</tr>
<tr>
<td>395-424</td>
<td>626</td>
<td>22.2 (20.2, 24.1)</td>
<td>4 (4, 14)</td>
<td></td>
</tr>
<tr>
<td>425-454</td>
<td>752</td>
<td>19.6 (17.9, 21.2)</td>
<td>4 (3, 5)</td>
<td></td>
</tr>
<tr>
<td>455-476</td>
<td>260</td>
<td>19.5 (16.7, 22.3)</td>
<td>4 (3, 10)</td>
<td></td>
</tr>
<tr>
<td><strong>Average daily gain (kg/d) during the first 3-4 weeks after delivery</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.840</td>
</tr>
<tr>
<td>-1.20-0.58</td>
<td>481</td>
<td>21.2 (19.0, 23.4)</td>
<td>4 (3, 15)</td>
<td></td>
</tr>
<tr>
<td>0.59-1.03</td>
<td>482</td>
<td>20.8 (18.6, 23.0)</td>
<td>4 (4, 14)</td>
<td></td>
</tr>
<tr>
<td>1.04-1.43</td>
<td>460</td>
<td>20.1 (17.9, 22.3)</td>
<td>4 (3, 5)</td>
<td></td>
</tr>
<tr>
<td>1.44-3.67</td>
<td>491</td>
<td>21.7 (19.6, 23.8)</td>
<td>4 (3, 10)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,914</td>
<td>21.0 (19.9, 22.1)</td>
<td>4 (4, 5)</td>
<td></td>
</tr>
</tbody>
</table>

1Based on a log rank test for equality of survivor functions
**Figure (3.1)** Kaplan-Meier survival curves illustrating the time to conception for 1,914 beef heifers by location (A), reproductive tract score (B), hip height 3-4 weeks after delivery (C), and age at the beginning of the breeding period (D)
CHAPTER 4

EFFECT OF SUPPLEMENTATION STRATEGY AND FORAGE QUALITY ON IN VITRO
FIBER DIGESTIBILITY OF KENTUCKY 31 TALL FESCUE AND TIFTON 85
BERMUDAGRASS

\[ \text{Studstill, M. W., D. W. Hancock, and R. L. Stewart, To Be Submitted to Journal of Animal Science.} \]
Abstract

Two experiments were conducted to evaluate nutritive value, DM yield, and digestibility characteristics of Kentucky 31 (KY-31) tall fescue and Tifton 85 (T-85) bermudagrass. In the first experiment, KY-31 (spring growing season) was harvested at intervals of 2 wk, 4 wk, boot stage, soft dough stage, and hard dough stage, while KY-31 (fall growing season) and T-85 were subjected to 2, 4, 6 and 10 and 2, 4, 6, 8 and 10 wk harvest intervals, respectively. The harvest intervals were intended to represent grazing and hay production scenarios in Georgia. After harvesting at assigned interval, DM percentage was quantified to determine DM yield (DMY), and nutritive value was assessed via near infrared spectroscopy (NIRS). In the second experiment, samples of both KY-31 and T-85 were stratified by relative forage quality (RFQ), in order to create three quality categories: high (HIG), medium (AVG), and poor (LOW). The three categories of nutritive value were treated with common supplementation strategies: no supplementation control (CON), liquid molasses urea (LIQ), and corn gluten feed (CGF). Diets were formulated assuming a 522-kg cow consuming 2% of her BW as DM on a daily basis. Diets were subjected to in vitro digestion for 7 distinct lengths: 0, 3, 6, 12, 18, 24, and 48 h, to evaluate IVDMD, production of fermentation gas, NDF, and ADF. Results from the first experiment showed that CP, DM, TDN, and RFQ generally decreased with increased (P < 0.05) harvest interval, while DM yield, NDF, and ADF generally increased as the interval increased. Results from the in vitro experiments showed higher values of in vitro dry matter digestibility (DMD), neutral detergent fiber digestibility (NDFD) and acid detergent fiber digestibility (ADFD) when forages of greater nutritive value were present in fermentation bottles. In addition,
supplementation generally increased all digestibility parameters compared to CON treatment. However, a treatment interaction was observed \((P < 0.05)\) when supplementing poor quality forage, with CGF showed higher values of DMD compared to other supplementation strategies.

**Introduction**

Forage systems in the southeastern United States commonly use tall fescue and bermudagrass to supply grazing or hay to cattle throughout the year (Ball et al., 2007). As these forages reach maturity, the fiber component increases in stems (Jafari and Rezaeifard, 2010). When consumed by cattle, forages high in fiber decrease rumen passage rate (Bhatti et al., 2008). Once forage quality declines to the extent that it no longer meets nutritional needs, supplementation is needed to maintain level of production (Kunkle et al., 2000; Bailey and Kallenbach, 2010).

Liquid molasses-urea lick tanks are commonly used to provide additional protein and energy to cattle diets (Bond and Rumsey, 1973). Molasses is high in soluble carbohydrates which are rapidly fermented in the rumen (Kunkle et al., 1997). Urea is added to molasses to supply a form of non-protein nitrogen (Bowman et al., 1995). Corn gluten feed, a corn by-product resulting from the process of making corn starch and syrup, is also commonly used to supplement low quality forages (Hoffman, 1989; Poore et al., 2002). Crude protein values in corn gluten feed are typically around 23.8 % (NRC, 2000). However, nutritive value can be affected by: 1) a Maillard that occurs during the drying process and 2) inclusion of steep liquor from the wet milling process. (Hoffman, 1989; Segers et al., 2013)

Previous literature has compared similar supplementation strategies on a variety of forages (Bowman et al., 1995; Moore et al., 1999; Poore et al., 2002), however results are variable based on forage and supplement combinations. Therefore, the objectives of this study
were to evaluate: 1) the effect of harvest intervals representing different grazing management on forage quality and 2) the ruminal kinetics of liquid molasses-urea and corn gluten feed as supplements to Kentucky 31 tall fescue and Tifton 85 bermudagrass at varying levels of quality.

**Materials and Methods**

This research was divided into two experiments. Experiment 1 evaluated nutritive value and DM yield of tall fescue and bermudagrass when the two forages were subjected to various harvesting intervals. This experiment was conducted at the University of Georgia Plant Science Farm, located in Watkinsville, GA. Experiment 2 was an *in vitro* trial in which three subsamples of the same forages subjected to harvesting intervals were used as substrates in conjunction with common supplementation strategies, and IVDMD, NDF, ADF, and gas production were quantified.

**Experiment 1**

**Forage Management.** The experiment was conducted in areas of previously established ‘Kentucky 31’ tall fescue (KY-31) and ‘Tifton 85’ bermudagrass (T-85) prior to their respective growing seasons in Georgia. Two separate areas were used for the tall fescue experiment. Within forage type, individual plots were 1.52 m x 4.57 m. Plots were arranged in a randomized complete block design with five harvest frequency treatments assigned to each block and replicated four times. A 1.52 m lane separated blocks within the plot and it was clipped every 2 wk to prevent contaminating the plots. Harvest timing was intended to represent grazing and hay management scenarios typical of cow-calf operations in Georgia (Table 1). On 27 February 2013, the KY-31 plot was clipped of all forage down to 7.62 cm of stubble height. Prowl H₂O (BASF Corporation, Research Triangle Park, NC), a commercially available pre-emergent herbicide, was then applied at 9.35 L/ha, for residual weed control. Also, nitrogen fertilizer
(urea) was applied at 56.0 kgN/ha on this date, and every 6 wk after this initial application until the last harvest was taken on June 19, 2013. This procedure was also conducted for the KY-31 plot during the fall growing season with initial clear-off on August 28, 2013 and termination on November 6, 2013. On April 24, 2013, the T-85 plot was cleared of all forage down to 5.0 cm of stubble height and the pre-emergent herbicide was applied at rates previously described for KY-31 plots. For the bermudagrass plots, N was applied at 84.1 kgN/ha at initial clear-off and every 6 wk after, until termination of the plot on September 11, 2013.

Data Collection. Forage was harvested at the assigned interval for the specified treatments starting 2 wk after the initial clean-off using a Gravely plot harvester (Gravely, Brillion, WI) which was set to leave 5.08 and 7.62 cm of stubble height for T-85 and KY-31, respectively. All clipped forage was collected by the plot harvester and placed on a tarp that had been previously tared on a hanging scale. The tarp was again attached to the hanging scale in order to determine weight of forage in each plot. Grab samples of each plot were weighed initially then dried at 60°C for 48 hr to determine DM percentage ((dry wt/wet wt) x 100)) for calculating dry matter yield. A Model 4 Wiley Mill (Thomas Scientific, Swedesboro, NJ) with a 2-mm screen was used to coarsely grind samples. Following, the samples were passed through a CT 193 Cyclotec Sample Mill (FOSS, Eden Prairie, MN) fitted with a 1-mm screen for forage analysis. Samples were sent to the University of Georgia Agricultural & Environmental Services Laboratory and subjected to Near Infrared Reflectance Spectroscopy (NIRS). Nutritive value of forage was determined by a model 6500 near infrared reflectance spectroscopy analyzer (FOSS NIRSystems Inc. Laurel, Maryland) calibrated with the NIRS consortium’s calibration equations.

Statistical Analysis. Data were analyzed using the PROC ANOVA procedure of SAS (SAS Institute Inc. Cary, NC). Plots were arranged in a randomized complete block design with
five harvesting intervals in each row, replicated four times. Plot was defined as the observational unit, used to determine differences across the harvesting intervals. Least squares means were generated and separated using the P-DIFF option of LSMEANS. Differences were considered significant at \( \alpha < 0.05 \) and tendencies were considered at \( \alpha < 0.10 \).

**Experiment 2**

Two *in vitro* trials were conducted for KY-31, harvested during the spring growing season, and T-85. Within forage type, samples were stratified by RFQ and samples were then selected to represent high (HIG), median (AVG), and poor (LOW) forage quality. Relative forage quality for KY-31 was 171, 111, and 78 for HIG, AVG, and LOW, respectively. Relative forage quality for T-85 was 142, 101, and 80 for HIG, AVG, and LOW, respectively. Dietary amount of substrates to be put in each incubation bottle were formulated based on a 522 kg cow consuming 2% of BW daily. A total of 1.5 g of substrate (forage plus supplement) was placed into each incubation bottle. Treatments included a control with no supplement (CON), a liquid molasses-urea feed (LIQ), and corn gluten feed (CGF). The LIQ treatment was included at a rate representative of intake by the animal (1.043 kg/h/d) and delivered 35% supplemental CP on an as fed basis. The corn gluten feed (CGF) treatment was added at a rate (0.365 kg/h/d) to equal the CP offered by the LIQ treatment. Dietary amounts are presented in Table 2. Treatments were structured in a 3 x 3 factorial design including three forage qualities and three supplements. Treatments were subjected to *in vitro* fermentation in duplicate over seven time points (0, 3, 6, 12, 18, 24, and 48) along with two blanks at each time point. Thus, a total of 140, 160 ml septum bottles were used to hold diets for each trial.

**Inoculation Process.** Along with the diets, 67 ml of McDougall’s buffer was added to each bottle and left overnight to hydrate the substrate. For both trials ruminal fluid was collected
at 0900 from yearling beef steers, that had been currently grazing tall fescue pastures, at 0900 on the morning the experiment was initiated. Approximately 1,200 ml was collected from each of five animals using a plastic tubing fitted with a stainless steel strainer. A low pressure vacuum pump (Fisher Scientific Pittsburgh, PA) was attached to the tubing in order to draw fluid from the rumen. A Frick speculum tube (Nasco Corp. Fort Atkinson, WI) was placed in the mouth of the animal prior to passing the tube into the rumen. Upon extraction, ruminal fluid was placed in a sealed thermos and transported to the laboratory. Ruminal fluid from each animal was strained through a 500-micron nylon mesh filter to remove particulate and was composited across animals. The mixture was then gassed with CO₂. Each of the 160-ml septum bottles received 33 ml of the ruminal fluid, in a 2:1 ratio with the McDougall’s buffer added the previous night. Bottles were gassed with CO₂, sealed with rubber stoppers, and placed in a 39°C water bath incubator (Blue M Electric Company, Blue Island, IL). Incubation times included: 0, 3, 6, 12, 18, 24, and 48 h following inoculation.

**Gas Collection.** Fermentation gases were collected using a 22-guage needle fitted to a three-way valve and a 60-ml syringe. Gas was collected every 3 hr on all collection times to prevent pressure from building in the bottles and potentially affecting fermentation. The valve was directed to allow gas to flow from the incubation bottle to the syringe during gas collection. The pressure from gasses inside the incubation bottle displaced the plunger of the syringe until equilibrium was reached. The incubation bottles were swirled to remove all gas created during the fermentation process. When the plunger ceased movement the syringe reading was recorded.

**Digestibility Analysis.** Incubation bottles were opened at the respective time points after final gas collection. Contents of each bottle were transferred to Nalgene bottles and the fermentation process was halted by freezing at -20°C and stored in the freezer until further
analysis. Once completed, the bottles were allowed to thaw and the contents were separated into liquid and particulate fractions by centrifuging at 1,400 x g for 6 min using a C-6000 centrifuge (International Equipment Company, Needham Heights, MA). The liquid fraction was poured off and discarded while the particulate fraction was dried in a forced-air oven at 55°C for 48-hr for DM determination (Blue M Electric Company, Blue Island, IL). Digestibility was calculated as the difference between the original and residual weights. The dried samples were then subjected to NDF and ADF fiber analysis in an ANKOM 2000 Fiber Analyzer (ANKOM Technology, Macedon, NY) to determine NDF and ADF disappearance (NDFD and ADFD, respectively).

**Statistical Analysis.** An ANOVA was performed to validate the effects of treatment, incubation time, and their interaction on the fermentation characteristics. Differences were compared using Tukey’s honest significant difference test, and were considered significant at $\alpha < 0.05$. Regression analysis was performed to evaluate the trends in fermentation characteristics over the incubation times. Analyses were achieved using commercially available statistical software R (The R Foundation for Statistical Computing, Vienna, Austria).

**Results and Discussion**

**Experiment 1**

**KY-31 Tall Fescue.** Quality and yield data for KY-31 harvested during the spring is presented in table 4.3. Cumulative dry matter yield (DMY) was highest ($P < 0.05$) in the boot stage (12,193 kg/ha) compared to values reported by 2 wk (10,674 kg/ha) and 4 wk (9,933 kg/ha) harvests, but was similar ($P > 0.05$) to values observed in soft and hard dough stages. The boot stage harvest also offered the greatest value ($P < 0.05$) for digestible dry matter yield (DDMY), but was similar ($P > 0.05$) to 2 wk, soft dough and hard dough harvests. The percentage of digestible dry matter (DDM) calculated as (DDMY / DMY) was greatest ($P < 0.05$) for 2 and 4
wk harvest intervals (59 and 55 % respectively), compared to the percentage of DDM values observed in boot, soft and Hard dough harvests (53, 49 and 49 %, respectively). Neutral detergent fiber and ADF increased ($P < 0.05$) as the harvest interval increased with no similarities observed between treatments. The CP value offered by the 2 wk harvest was highest ($P < 0.05$) over treatments. The 4 wk harvest had a higher CP value (18.20 %) compared to boot (14.68 %), soft dough (14.55 %), and hard dough stages (9.84 %). There was no statistical difference between boot and soft dough stage CP values, however the hard dough harvest was lowest ($P < 0.05$) over all treatments. The lowest percentage of TDN was found in the soft dough harvest, which was similar to hard dough. However, the boot stage TDN value (54.05 %) was similar to the 4 wk harvest (57.59 %). Relative forage quality values were lowest for the hard dough harvest and ($P < 0.05$) decreased as interval of harvest decreased with no similarities observed between treatments.

Llamas-Lamas and Combs (1990) harvested alfalfa at early vegetative (EV), late bud (LB), and full bloom (FB) reproductive stages. Analysis of forage quality showed decrease in CP from 26.7 (EV) to 18.8 (FB). The current study presented similarities as CP values in KY-31 decreased as maturity level increased. Jafari and Rezaeifard (2010) reported CP values of tall fescue in the vegetative stage of 17.82% compared to 9.84% for tall fescue at maturity. These results agree with CP values reported for spring harvested tall fescue in the current study. Authors of the same study reported DMY for tall fescue to be 3,083 and 5,080 kg/ha for vegetative and soft dough stages, respectively. Thus concluding, around half the yield can be expected at the vegetative stage compared to soft dough stage, in tall fescue. The present study differs in that DMY was found to be 2,440 and 3,358 kg/ha for vegetative and soft dough stages,
respectively. Differences in these studies can most likely be attributed to differences in varieties of tall fescue used in trials (entophyte free varieties compared to wild type variety).

Quality and yield data for KY-31 harvested during the fall growing season are presented in table 4.4. High and low DMY values were from 10 and 2 wk harvests, respectively and a significant difference ($P < 0.05$) was reported between the treatments. However, 4 and 6 wk harvests had similar DMY values. The 10 wk harvest was highest ($P < 0.05$) in DDMY. However, a greater ($P < 0.05$) percentage (66%) of forage in the plots harvested every 6 wk was digestible compared to the 10 wk (62%). Furthermore the 6 wk harvest also was higher ($P < 0.05$) in CP, TDN, and RFQ and lower ($P < 0.05$) in NDF and ADF, compared to other harvests.

Ball (2003) reported CP values of stockpiled tall fescue to be 14.8% when fertilized properly. This is consistent with values reported by Curtis et al. (2008) of 12% when the forage was subjected to NIRS. The current study however, reported higher values for all intervals of harvest. Flores et al., (2007) also reported nutritive value of KY-31. In this study, KY-31 was clipped to a stubble height of 7.5 cm on September 9, 2003. Grazing and forage sampling was initiated approximately 3 mo later. Forage mass, NDF, ADF, and CP values were 5, 170 kg/ha, 56.5 %, 27.7 % and 15.6 % respectively. These findings agree with the results of the current study for forage harvested at 10 wk intervals. However, the current study suggests that allowing fewer than 10 wk of growth could provide higher quality stockpiled KY-31 without a large reduction in DMY.

**T-85 Bermudagrass.** Quality and yield data are presented in Table 4.5. The low and high values for DMY were from 2 and 10 wk harvests, respectively. Two week harvestings had a higher ($P < 0.05$) percentage (55 %) of digestible dry matter (DDMY) compared to 4, 6, 8, and 10wk intervals (53, 50, 52, and 50%, respectively). Crude protein was highest ($P < 0.05$) in
forage that was harvested at 2 wk intervals, yet no differences ($P > 0.05$) were observed between 6, 8, and 10 wk cuttings. Similarly, 2 wk harvests reported the lowest ($P < 0.05$) percentages of NDF and ADF and highest values of TDN and RFQ with no significant ($P > 0.05$) differences between 6, 8, and 10 wk cuttings for any quality characteristic.

Beck et al. (2007) reported DMY of crabgrass harvested every 21 and 49 d to be 2,872 and 9,788 kg/ha, respectively. Dry matter yield for the 3 wk harvest is consistent with findings of the T-85 trial in the current study. However, the 7 wk harvest is much lower than values reported for similar intervals of harvest in the present study. Romero et al. (2013) reported bermudagrass hay that was given a 5 wk regrowth period had: NDF (78.6%), ADF (40.6%) and CP (12.2%), compared to hay given a 13 wk regrowth period: NDF (75.0%), ADF (39.3%), and CP (9.1%). The current study found comparable CP, NDF, and ADF values in bermudagrass harvested at similar intervals, with the exception of the 5 wk ADF and NDF values, which were much higher than what was reported by Romero et al. (2013).

**Experiment 2**

*KY-31 Tall Fescue.* Regression analysis showed an increase ($P < 0.01$) in IVDMD, total gas production, neutral detergent fiber digestible (NDFD) and acid detergent fiber digestible (ADFD) with increased incubation time (data not shown). Effect of forage quality on 24/48 hr digestibility parameters is presented in Table 4.6. Diets that consisted of the HIG treatment had the greatest ($P < 0.001$) IVDMD, NDFD, and ADFD compared to the AVG treatment which was intermediate between LOW and HIG treatments. Effect of supplement on digestibility outcomes are presented in Table 4.6. Dry matter digestibility was highest ($P < 0.001$) for diets supplemented with CGF and LIQ compared to the CON treatment. However, NDFD ($P = 0.424$) and ADFD ($P = 0.089$) were not significantly affected by supplemental treatment. The CON and
CGF treatments produced a greater \( (P < 0.001) \) amount of gas than the LIQ treatment. A supplement \( \times \) forage quality interaction was observed for IVDMD and is presented in Table 4.7. Supplement did not affect 24/48 hr digestibility within forage quality except for poor quality forage. Within poor quality forage CGF supplementation caused a greater percentage of dry matter to be digested compared to LIQ and CON treatments.

**T-85 Bermudagrass.** Similar to results reported from the tall fescue trial, regression analysis showed an increase \( (P < 0.001) \) in IVDMD gas production, NDFD and ADFD due to time (data not shown). Furthermore, effect of forage quality on all digestibility parameters measured followed similarly and are presented in table 4.8. The HIG treatment resulted in greatest \( (P < 0.001) \) IVDMD, NDFD, ADFD, and gas production, followed by AVG and finally the LOW treatment. Effects of supplementation are presented in Table (4.8). Dry matter digestibility was highest \( (P < 0.001) \) for the CGF and LIQ supplement compared to CON. The CGF treatment reported the highest \( (P < 0.01) \) value of NDFD, but was similar to LIQ which was intermediate between HIG and CON. The CGF treatment was significantly higher \( (P < 0.01) \) in ADFD compared to LIQ and CON treatments. No interactions were observed between supplement and quality treatments in this trial.

Forages with higher RFQ had greater values for IVDMD, NDFD and ADFD. This agrees with work by Dixon (1999) who reported that microbial digestion is highly dependent on forage type regardless of supplementation strategy implemented. Furthermore, it is well documented that as forage nutritive value declines, forage quality also decreases (Jung and Allen, 1995; Griffin and Jung, 1983; Waramit et al., 2012). However, supplementation of forage diets generally increased IVDMD, NDFD and ADFD. According to White et al. (1973), supplementation of forage diets with molasses increased DMD from 44.7% to 48.7% when urea
was added at 4% compared to no supplemental urea. These findings are consistent with the current study as DMD increased from 43% to 47% as a result of the LIQ treatment. There were no statistical differences between CGF and LIQ treatments on DMD or NDFD when supplementing T-85. This is consistent with work by Kononoff et al., (2006) who reported no differences in daily gain of steers when fed a NPN source compared to soy bean meal. Similarly, Cooke and Arthington, (2008) reported similar BCS and pregnancy rates when urea was substituted for cottonseed meal in supplements. However, findings of the current study suggest that poor quality KY-31 supplemented with CGF had higher DMD compared to LIQ and CON treatments.

Implications

Generally, as forages increased in yield, nutritive value decreased due to maturity level. Thus, it is essential to harvest forage at intervals that optimize yield and quality. The current study suggests that harvesting spring grown KY-31 during the boot stage, and stockpiled KY-31 at 6 wk intervals is a good compromise for yield and quality. Nutritive value of T-85 dropped sharply from 4 wk to 6 wk harvests. Therefore, 4 wk harvest intervals are suggested to be the best management practice as a result of this study.

Also, this study suggests that supplementation of forages improved DMD, NDFD, and ADFD. Corn gluten feed caused the greatest amount of DMD as a supplement to poor quality KY-31. However, with higher quality KY-31 as in AVG and HIG treatments, there was no difference between the LIQ and CGF treatment. Likewise the T-85 trial showed little differences between LIQ and CGF treatments, suggesting both supplements are useful if forage RFQ does not drop below 80. Although supplementation was successful in increasing digestibility
parameters, forage quality had the most significant effect on digestibility than other variables tested.
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Table (4.1). Grazing practices represented by harvest intervals of Kentucky 31 Tall Fescue and Tifton 85 Bermudagrass

<table>
<thead>
<tr>
<th>Simulation</th>
<th>T-85 Bermudagrass</th>
<th>KY-31 Tall Fescue (Spring)</th>
<th>KY-31 Tall Fescue (Fall)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Stocking</td>
<td>2 weeks$^1$</td>
<td>2 weeks</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Rotational Grazing</td>
<td>4 weeks</td>
<td>4 weeks</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Hay Production</td>
<td>6 weeks</td>
<td>Boot stage</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>8 weeks</td>
<td>Soft-dough stage</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>10 weeks</td>
<td>Hard-dough stage</td>
<td>-</td>
</tr>
<tr>
<td>Stockpiled Forage</td>
<td>-</td>
<td>-</td>
<td>6 weeks</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>10 weeks</td>
</tr>
</tbody>
</table>

$^1$Following an initial clipping to clear off the plot areas and to make them even.
Table (4.2) In Vitro Diets

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Forage (g)</th>
<th>Supplement (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON</td>
<td>1.5</td>
<td>-</td>
</tr>
<tr>
<td>LIQ</td>
<td>1.407</td>
<td>0.15</td>
</tr>
<tr>
<td>CGF</td>
<td>1.2717</td>
<td>0.25</td>
</tr>
</tbody>
</table>

1Treatments: CON = no supplement, LIQ = liquid molasses-urea, CGF = corn gluten feed
2 Diets based on 522 kg cow consuming 2% of BW in DM
LIQ offered at rate to represent intake by the animal
CGF offered at a rate equal to the CP offered by the LIQ treatment
Table (4.3) Characteristics of Kentucky 31 Tall Fescue Harvested at Various Intervals and Reproductive Stages During the Spring Growing Season

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment&lt;sup&gt;1&lt;/sup&gt;</th>
<th>2wk</th>
<th>4wk</th>
<th>Boot Soft Dough</th>
<th>Hard Dough</th>
<th>SE&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMY&lt;sup&gt;2&lt;/sup&gt;, kg/ha</td>
<td>2,440&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>2,289&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3,389&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3,358&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3,194&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>268.32</td>
</tr>
<tr>
<td>UDMY&lt;sup&gt;3&lt;/sup&gt;, kg/ha</td>
<td>992&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1013&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1618&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1698&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1624&lt;sup&gt;a&lt;/sup&gt;</td>
<td>138</td>
</tr>
<tr>
<td>DDMY&lt;sup&gt;4&lt;/sup&gt;, kg/ha</td>
<td>1449&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1277&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1771&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1660&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1570&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>133</td>
</tr>
<tr>
<td>CP, %</td>
<td>20.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>14.68&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14.55&lt;sup&gt;c&lt;/sup&gt;</td>
<td>9.84&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.29</td>
</tr>
<tr>
<td>DM, %</td>
<td>25.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>25.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>26.8&lt;sup&gt;c&lt;/sup&gt;</td>
<td>29.5&lt;sup&gt;c&lt;/sup&gt;</td>
<td>37.2&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.68</td>
</tr>
<tr>
<td>NDF, %</td>
<td>54.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>57.5&lt;sup&gt;d&lt;/sup&gt;</td>
<td>63.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>65.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>72.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.57</td>
</tr>
<tr>
<td>ADF, %</td>
<td>29.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>31.6&lt;sup&gt;d&lt;/sup&gt;</td>
<td>35.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>38.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>42.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.52</td>
</tr>
<tr>
<td>TDN, %</td>
<td>59.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>57.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>54.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>51.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>49.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.76</td>
</tr>
<tr>
<td>RFQ</td>
<td>132.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>123.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>107.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>82.1&lt;sup&gt;d&lt;/sup&gt;</td>
<td>94.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.60</td>
</tr>
</tbody>
</table>

<sup>abc</sup> Means within a row with different superscripts differ (P < 0.05)
<sup>1</sup> Treatment = interval or stage of harvest
<sup>2</sup> DMY = Dry matter yield
<sup>3</sup> UDMY = Indigestible dry matter yield
<sup>4</sup> DDMY = Digestible dry matter yield
Table 4.4 Characteristics of Kentucky 31 Tall Fescue Harvested at Various Intervals and Reproductive Stages During the Fall Growing Season

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>2wk</th>
<th>4wk</th>
<th>6wk</th>
<th>10wk</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMY², kg/ha</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>661c</td>
<td>918b</td>
<td>824b</td>
<td>1,447a</td>
<td>156</td>
<td></td>
</tr>
<tr>
<td>UDMY³, kg/ha</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>255b</td>
<td>362b</td>
<td>283b</td>
<td>553a</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>DDMY⁴, kg/ha</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>406b</td>
<td>556b</td>
<td>541b</td>
<td>894a</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>CP, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.6ab</td>
<td>20.0b</td>
<td>23.9a</td>
<td>20.3b</td>
<td>1.26</td>
<td></td>
</tr>
<tr>
<td>DM, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>26.2b</td>
<td>26.0b</td>
<td>30.7a</td>
<td>29.5a</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>NDF, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>51.4a</td>
<td>52.0a</td>
<td>41.5b</td>
<td>51.4a</td>
<td>2.36</td>
<td></td>
</tr>
<tr>
<td>ADF, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25.6ab</td>
<td>28.4a</td>
<td>21.5b</td>
<td>27.9a</td>
<td>1.76</td>
<td></td>
</tr>
<tr>
<td>TDN, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>62.2b</td>
<td>61.0b</td>
<td>66.4a</td>
<td>61.1b</td>
<td>1.39</td>
<td></td>
</tr>
<tr>
<td>RFQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>145.14b</td>
<td>150.69ab</td>
<td>165.66a</td>
<td>144.24b</td>
<td>2.60</td>
<td></td>
</tr>
</tbody>
</table>

a-c Means within a row with different superscripts differ (P < 0.05) ¹ DMY = Dry matter yield
1 Treatment = Interval of harvest
2 UDMY = Indigestible dry matter yield
3 DDMY = Digestible dry matter yield
4 DDMY = Digestible dry matter yield
Table (4.5) Mean Comparison for Yield and Quality Characteristics of T85 Bermudagrass Harvested at Various Intervals

<table>
<thead>
<tr>
<th>Item</th>
<th>2wk</th>
<th>4wk</th>
<th>6wk</th>
<th>8wk</th>
<th>10wk</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMY(^2), kg/ha</td>
<td>6,184.13(^b)</td>
<td>8,211.85(^c)</td>
<td>10,908(^b)</td>
<td>11,770(^b)</td>
<td>15,381(^a)</td>
<td>398.98</td>
</tr>
<tr>
<td>UDMY(^3), kg/ha</td>
<td>2,793.54(^d)</td>
<td>3,839(^c)</td>
<td>5,428(^b)</td>
<td>5,831(^b)</td>
<td>7,709(^a)</td>
<td>218.69</td>
</tr>
<tr>
<td>DDMY(^4), kg/ha</td>
<td>3,391(^d)</td>
<td>4,373(^c)</td>
<td>5,479(^b)</td>
<td>5,939(^b)</td>
<td>7,672(^a)</td>
<td>191.38</td>
</tr>
<tr>
<td>CP, %</td>
<td>16.54(^a)</td>
<td>14.53(^b)</td>
<td>10.31(^c)</td>
<td>10.39(^c)</td>
<td>9.74(^c)</td>
<td>0.28</td>
</tr>
<tr>
<td>DM, %</td>
<td>27.54(^c)</td>
<td>26.50(^c)</td>
<td>29.86(^b)</td>
<td>29.45(^b)</td>
<td>32.71(^a)</td>
<td>0.37</td>
</tr>
<tr>
<td>NDF, %</td>
<td>64.52(^d)</td>
<td>67.59(^c)</td>
<td>72.67(^b)</td>
<td>73.19(^ab)</td>
<td>73.87(^a)</td>
<td>0.53</td>
</tr>
<tr>
<td>ADF, %</td>
<td>33.25(^d)</td>
<td>35.10(^c)</td>
<td>38.86(^b)</td>
<td>38.98(^b)</td>
<td>39.99(^a)</td>
<td>0.30</td>
</tr>
<tr>
<td>TDN, %</td>
<td>54.89(^a)</td>
<td>53.63(^b)</td>
<td>50.31(^c)</td>
<td>50.79(^c)</td>
<td>49.89(^c)</td>
<td>0.42</td>
</tr>
<tr>
<td>RFQ</td>
<td>112.62(^a)</td>
<td>105.88(^b)</td>
<td>90.41(^c)</td>
<td>90.80(^c)</td>
<td>87.22(^c)</td>
<td>1.63</td>
</tr>
</tbody>
</table>

\(^{a-c}\) Means within a row with different superscripts differ (P < 0.05)

\(^1\) Treatment = Interval of harvest

\(^2\) DMY = Dry matter yield

\(^3\) UDMY = Indigestible dry matter yield

\(^4\) DDMY = Digestible dry matter yield
Table (4.6) Effect of Relative Forage Quality and Supplement on Digestibility Characteristics of Kentucky 31 Tall Fescue

<table>
<thead>
<tr>
<th>Item, 24/48 hr³</th>
<th>Forage Type¹</th>
<th>Supplement²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIG</td>
<td>AVG</td>
</tr>
<tr>
<td>IVDMD, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIG</td>
<td>64ᵃ</td>
<td>49ᵇ</td>
</tr>
<tr>
<td>AVG</td>
<td>49ᵇ</td>
<td>36ᶜ</td>
</tr>
<tr>
<td>LOW</td>
<td>36ᶜ</td>
<td></td>
</tr>
<tr>
<td>NDFD, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIG</td>
<td>61ᵃ</td>
<td>49ᵇ</td>
</tr>
<tr>
<td>AVG</td>
<td>49ᵇ</td>
<td>38ᶜ</td>
</tr>
<tr>
<td>LOW</td>
<td>38ᶜ</td>
<td></td>
</tr>
<tr>
<td>ADFD, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIG</td>
<td>82ᵃ</td>
<td>75ᵇ</td>
</tr>
<tr>
<td>AVG</td>
<td>75ᵇ</td>
<td>66ᶜ</td>
</tr>
<tr>
<td>LOW</td>
<td>66ᶜ</td>
<td></td>
</tr>
<tr>
<td>GAS, mL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIG</td>
<td>133</td>
<td>124</td>
</tr>
<tr>
<td>AVG</td>
<td>124</td>
<td>131</td>
</tr>
<tr>
<td>LOW</td>
<td>131</td>
<td></td>
</tr>
</tbody>
</table>

¹Forage Type: CON = forage based diet with no supplementation; CGF = forage based diet with a corn gluten feed supplement; LIQ = forage based diet with a liquid molasses-urea supplement

²Treatment: HIG = high quality forage (RFQ = 171); AVG = average quality forage (RFQ = 111); LOW = poor quality forage (RFQ = 78)

³Averages after 24/48 hours of incubation

ᵃ⁻ᵈ Means within row with different superscripts differ (P ≤ 0.01)
Table (4.7) Effect of Treatment Interaction on In Vitro Dry Matter Digestibility of KY31 Tall Fescue

<table>
<thead>
<tr>
<th>Item, 24/48 hr</th>
<th>HIG</th>
<th>CON</th>
<th>LIQ</th>
<th>CGF</th>
<th>AVG</th>
<th>CON</th>
<th>LIQ</th>
<th>CGF</th>
<th>LOW</th>
<th>CON</th>
<th>LIQ</th>
<th>CGF</th>
<th>SE</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVDMD, %</td>
<td></td>
<td>62a</td>
<td>65a</td>
<td>65a</td>
<td>48b</td>
<td>49b</td>
<td>50b</td>
<td></td>
<td>32c</td>
<td>35c</td>
<td>40d</td>
<td></td>
<td>0.007356</td>
<td>P ≤ 0.01</td>
</tr>
</tbody>
</table>

1 Forage Type: CON = forage based diet with no supplementation; CGF = forage based diet with a corn gluten feed supplement; LIQ = forage based diet with a liquid molasses-urea supplement
2 Treatment: HIG = high quality forage (RFQ = 171); AVG = average quality forage (RFQ = 111); LOW = poor quality forage (RFQ = 78)
3 Averages after 24/48 hours of incubation
a-d Means within row with different superscripts differ (P ≤ 0.01)
Table (4.8) Effect of Forage Type and Supplement on Digestibility Characteristics of Tifton 85 Bermudagrass

<table>
<thead>
<tr>
<th>Item, 24/48 hr³</th>
<th>Forage Type¹</th>
<th>Supplement²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIG</td>
<td>AVG</td>
</tr>
<tr>
<td>IVDMD, %</td>
<td>49⁴</td>
<td>45 ⁵</td>
</tr>
<tr>
<td>NDFD, %</td>
<td>52⁴</td>
<td>46 ⁵</td>
</tr>
<tr>
<td>ADFD, %</td>
<td>77⁴</td>
<td>75 ⁵</td>
</tr>
<tr>
<td>GAS, mL</td>
<td>221⁴</td>
<td>164⁵</td>
</tr>
</tbody>
</table>

¹Forage Type: CON = forage based diet with no supplementation; CGF = forage based diet with a corn gluten feed supplement; LIQ = forage based diet with a liquid molasses-urea supplement

²Treatment: HIG = high quality forage (RFQ = 142); AVG = average quality forage (RFQ = 101); LOW = poor quality forage (RFQ = 80)

³Averages after 24/48 hours of incubation

⁴-⁶Means within row with different superscripts differ ($P \leq 0.01$)
CHAPTER 5
CONCLUSIONS AND IMPLICATIONS

Reproduction and nutrition are arguably the most important sectors of the cattle industry when considering economic stability. Implementation of management practices portrayed in this study have the ability to create efficiencies for cattle operations in Georgia.

Results from the first experiment showed selection of replacement heifers should be based on maturity 70 d prior to the initial breeding season. Hip height and age were more reliable estimates of maturity compared to RTS. Furthermore, heifers with greater HH during the last 35 d of the developmental period were likely to conceive earlier in the breeding season. Although management prior to the 70 d developmental period was assessed in this study, no association was found with pregnancy status or timing of conception.

Results of the second experiment showed that as interval of harvest increased, quality typically decreased as a result of plant maturity. Therefore, harvesting spring grown KY-31 at the boot stage of development and fall grown KY-31 at 6 wk intervals is a good compromise for yield and quality. Furthermore, Tifton 85 bermudagrass should be harvested at 4 wk intervals for yield and quality.

Dry matter digestibility, NDFD, and ADFD were greater with higher quality forages. Additionally, forages that were supplemented with CGF or LIQ were generally higher in DMD, NDFD, and ADFD compared to forage diets with no supplementation. Supplementation of poor quality KY-31 with CGF reported higher values of *in vitro* DMD than other supplements tested in this study. However, the LIQ and CGF treatments had similar results when RFQ was 80 or
greater. The findings of this study suggest a larger impact can be made from properly managing forages as opposed to relying on supplementation to meet the nutritional needs of cattle.