EFFECTS OF FORAGE SAMPLING METHOD ON NUTRITIVE VALUE OF BAHIAGRASS

By

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To Hank and McLovin.
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EFFECTS OF FORAGE SAMPLING METHOD ON NUTRITIVE VALUE OF BAHIAGRASS

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As with many tropical grasses, the nutritive value of bahiagrass *(Paspalum notatum)* has been reported to be relatively low. However, the data that does exist is based on hand-harvested samples and does not account for the ability of cattle to selectively graze within a pasture. Previous research has shown that the hand-sampled forage is inaccurate in its estimation of a grazing animal's selected diet. The objective of this study was to characterize the nutritive value of forage selected by grazing cattle compared to hand-collected forage during the winter and spring (December to May), as well as the summer and fall seasons (June to November). Four locations were utilized to represent variation in the Florida pasture landscape, the locations included: Range Cattle Research and Education Center, Ona; USDA- Subtropical Agricultural Research Station, Brooksville; Santa Fe River Ranch Beef Unit, Alachua; and North Florida Research and Education Center, Marianna. Forage availabilities (FA) were visually assigned to selected pastures, as either HIGH or LOW, to represent differences in forage quantity between pastures at each location. Forage and masticate samples were collected from each of the four locations from December 2006 to November 2007. Samples were analyzed to determine forage mass, in vitro digestible organic matter (IVDOM), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) concentrations. Selection indices (SI) were also

determined for each chemical analysis. Hand shears were used to cut the forage to an approximate height of 3.5 cm within a 0.25-m quadrat; masticate samples were collected using eight ruminally fistulated steers (two steers/ location).

During the winter and spring, masticate samples consistently had greater ($P<0.001$) IVDOM concentration (mean=59.1%) and CP concentration (mean=12.3%) compared to hand-collected forage samples (45.8% IVDOM; 10.5% CP). Concentration of IVDOM and CP of masticate and forage samples was also affected by month ($P<0.001$) resulting in a type x month effect for IVDOM and CP concentration ($P<0.001$ and $P=0.02$, respectively). Selection indices of IVDOM differed between FA ($P=0.04$) and month ($P<0.001$). The SI for IVDOM within the LOW FA was 10% greater compared to the HIGH FA. The selection index for CP concentration was also affected by FA ($P=0.01$) and month ($P=0.03$). The SI for CP within the LOW FA was nearly 20% greater than that for the HIGH FA. This indicates the steers were more selective of forage material within the LOW FA compared to the HIGH FA for IVDOM and CP concentration during the winter and spring. During the summer and fall, masticate samples consistently had greater ($P<0.001$) IVDOM concentration (mean=60.8%) and CP concentration (mean=11.2%) compared to hand-collected forage samples (51.7% IVDOM; 9.6% CP). Concentration of IVDOM and CP of masticate and forage samples was also affected by month ($P<0.001$) resulting in a type x month effect for IVDOM and CP concentration ($P=0.08$ and $P<0.001$, respectively). Selection indices for IVDOM did not differ between FA ($P=0.48$) or month ($P=0.43$). However, the steers selected forage material that was nearly 19% greater in IVDOM concentration compared to hand-collected forage samples. The selection index for CP concentration was also not affected by FA ($P=0.72$) or month ($P=0.16$). However, the steers selected forage material that was 20% greater in CP concentration compared to hand-collected forage samples during the summer and fall. Throughout the year, steers will selectively graze bahiagrass forage that is greater in IVDOM and CP concentration compared to forage collected by hand-sampling, thus influencing supplementation recommendations for cow-calf producers.

CHAPTER 1
INTRODUCTION

Southeastern U. S. cattle production is primarily involved with cow-calf production systems (Ball et al., 2002). In 2007, there were approximately 950,000 beef cows in Florida (USDA, 2007). Florida pastures are comprised primarily of tropical and subtropical forages, which are typically high yielding, but low in quality (Skerman and Riveros, 1990). Tropical and subtropical grasses are reported to contain more cell wall constituents and are less digestible than temperate grasses (Minson and Mcleod, 1970; Moore and Mott, 1973; Barton et al., 1976). Bahiagrass (*Paspalum notatum*) occupies approximately one million hectares within Florida and is the primary component of diets of grazing cattle in the state (Chambliss and Sollenberger, 1991). As with many tropical grasses, bahiagrass has been reported to be low in nutritive value, as determined by hand-harvested samples (Brown et al., 1976); however, this data does not account for the ability of cattle to selectively graze within a pasture. Previous research has shown that cattle selectively graze when adequate forage is available for grazing (Weir and Torrell, 1959; Fontenot and Blaser, 1965; Jung et al., 1989; Russell et al., 2004). Other research has illustrated that hand-sampled forage is inaccurate in its estimation of the forage selected by grazing animals (Kiesling et al., 1969; Coleman and Barth, 1973; Skerman and Riveros, 1990). If cattle select forage that is greater in nutritive value than hand-harvested samples indicate this may affect supplementation strategies for producers. The purpose of this study was to characterize the nutritive value of bahiagrass from four locations across the state of Florida during the winter and spring comparing sampling techniques, either by hand-sampling or collection of masticate sample within pastures of varying levels of forage availability.

CHAPTER 2
LITERATURE REVIEW

Predominant Florida Forages

According to Burns (2006), the ruminant industry in the Southeast is nearly 100% dependent on grasslands for production. Florida is comprised primarily of tropical and subtropical, perennial, warm-season forages, which are typically low in quality, yet yield high quantities of DM (Skerman and Riveros, 1990). Climatic conditions are the primary determinant of plant species adaptation and temperature and rainfall are the most critical climatic aspects of plant growth (Ball et al., 2002). Average temperatures in Florida range from 3 to 37^{o} C while annual rainfall amounts can vary from 97 to 170 cm (NOAA, 2008). Florida soils are classified as sandy, very acidic, low in nutrient-holding capacity, with very little organic matter, and a highly variable water table which can be difficult for forage persistence (Villapando and Graetz, 2001).

Warm-season grasses of tropical or subtropical origin have a primary growing season of late spring to early autumn (Ball et al., 2002). Jones et al. (1985) described warm-season, C_4 grasses, as generally lower in forage quality (as defined by crude protein [CP] and in vitro digestible organic matter [IVDOM] concentrations) than temperate grasses due to low leaf:stem ratios, rapid maturity rates, and chemical and physical characteristics associated with the C_4 photosynthetic pathway. Brown (1985) reported that C_4 grasses have greater N use efficiency, thus they have greater dry matter yields and are more competitive than C_3 grasses, especially when the both forage types are grown on soils with low N content. Bahiagrass *(Paspalum notatum)*, bermudagrass *(Cynodon dactylon)*, and limpograss *(Hemarthria altissima)* are three of the most important warm-season perennial grasses utilized by Florida cow/calf producers within their cattle grazing systems (Arthington and Brown, 2005).

Bahiagrass

Bahiagrass originated in the South American countries: Uruguay, Paraguay, Argentina, and Brazil, and was brought to America in the early 1900s (Chambliss and Sollenberger, 1991). Pensacola bahiagrass (*Paspalum notatum* cv. suarae Parodi) is the most widely grown cultivar in the Southeastern region of the United States (Beaty et al., 1968; Gates et al., 1999; Gates et al., 2001). It was introduced into Florida in 1936 (Burton, 1967), and occupies approximately one million ha in Florida (Chambliss and Sollenberger, 1991; Stewart et al., 2007). Bahiagrass is drought tolerant and best adapted to sandy soils, but will also grow on poorly drained soils (Ball et al., 2002; Chambliss and Sollenberger, 1991).

The 2000 Beef Cattle Nutrient Requirement Council (NRC) reported bahiagrass with 30% dry matter (DM) as having 54% total digestible nutrients (TDN) and 8.9% CP concentration. Fike et al. (2003) reported an equation converting TDN of Tifton 85 bermudagrass (*Cynodon dactylon* x. *C. nlemfuensis* cv. Tifton 85) and Florigraze rhizome peanut (*Arachis glabrata* cv. Florigraze) to in vitro digestible organic matter (IVDOM), which is useful since IVDOM is quantified in the lab, but TDN is not. The form of the equation is %TDN=[(IVDOM, % x 0.49) + 32.2] x organic matter (OM) concentration. Thus 54% TDN for bahiagrass (NRC, 2000) can be converted to 57.6% IVDOM. Brown et al. (1976) reported digestible dry matter (DDM) concentrations for Pensacola bahiagrass ranging from 55-66% (mean=59% DDM) and mean CP concentration of 14% CP from May to October. Chambliss and Sollenberger (1991) reported the greatest nutritive value of bahiagrass with a range of 48-68% IVDOM concentration and 4-22% CP concentration from April to September. Low forage IVDOM is an important factor that can negatively impact animal performance, thus forages need to be properly analyzed to accurately predict animal performance (Duble et al., 1971).

Chambliss and Sollenberger (1991) described bahiagrass as a good, general use pasture grass that can withstand drought and heavier grazing pressure than other common pasture grasses. Stanley et al. (1977) supported previous rancher experience that cattle performance would be satisfactory when heavily grazing bahiagrass pastures, while lightly or infrequently grazed pastures can negatively affect performance due to increased maturity of the forage. Bahiagrass is reported to produce 86% of its total annual forage mass during the summer (April to September; mean=11,200 kg/ha), while forage mass during the winter period (October to March) produced only 1,800 kg/ha (Mislevy and Everett, 1981). Pate (1992) described the major advantage of bahiagrass as its persistence, even with little to no management. Stanley et al. (1977) stated excellent bahiagrass persistence with a high tolerance for prolonged and intense defoliation without concern for complete loss of the forage stand. As reported by Sampaio et al. (1976), bahiagrass is not likely to be eradicated by grazing or mowing, thus management should focus on producing young, vegetative growth that is greater in digestibility without concern for complete loss of stand with increased grazing or mowing. Bahiagrass can maintain 1 to 2 animals units per acre from approximately mid-March to mid-November with forage mass ranging from 270 to 6,215 kg/ha from April to late September (Chambliss and Sollenberger, 1991).

Beaty et al. (1968) reported forage mass significantly less than Chambliss and Sollenberger (1991) from June to October (1,058 to 1,366 kg/ha), however with N fertilization rates of 336 kg N/ha, greater forage mass were achieved (2,148 to 4,236 kg/ha) in the same time period. While bahiagrass can persist in soils that are low in fertility, previous research (Ball et al., 2002; Chambliss and Sollenberger, 1991; Kalmbacher and Wade, 2003; Pate, 1992) described bahiagrass as responsive to N fertilization. However, while Stewart et al. (2007) also stated that bahiagrass pastures are responsive to fertilization, they concluded that large increases in fertilization intensity are uneconomical when comparing cattle performance to input costs. Bahiagrass total N concentration increased as N fertilization increased from 0 to 157 kg of N/ha/cutting); it doubled in forage mass during all harvests from June to September (769 to 1,479 kg/ha/cutting) when fertilization rates of 0 to 78 kg of N/ha/cutting were applied to the forage (Johnson et al., 2001). However, bahiagrass forage mass was the greatest at the fertilization rate of 78 kg of N/ha/cutting but IVDOM concentration of bahiagrass was unaffected by N fertilization (Johnson et al., 2001). Thus applying N fertilization rates greater than 78 kg of N/ha/cutting will not promote greater bahiagrass growth or improve its digestibility, but will increase its total N concentration.

Recommendations on the proper amount of N fertilization for bahiagrass pastures depend on soil nutrient levels and economic for producers (Kidder, 1991). The minimum recommended N application rate of 55 kg of N/ha for grazed bahiagrass pastures recognizes that N is usually the most limiting nutrient in bahiagrass pastures and when applied once in the spring, the fertilizer will provide enough N for adequate forage growth to maintain beef cattle during the summer (Kidder, 1991). Whereas, the maximum recommended fertilization rate of 179 kg of N/ha would allow maximum bahiagrass production (Kidder, 1991). However as reported by Johnson et al. (2001), N fertilization application rates greater than 78 kg of N/ha/cutting will not be effectively utilized by the forage and may be unprofitable. A single application of N fertilization during the spring, regardless of application rate, is recommended for bahiagrass, as opposed to split application in the spring and late summer, to increase the total N concentration of the forage, due to economic return of the N input. This will benefit the breeding herd, which will be lactating and needing to gain weight in order to increase the success of rebreeding (Kalmbacher and Wade, 2003).

Drought can negatively affect bahiagrass populations by slowing or stopping biological processes, including decreased leaf expansion, increased mature leaf senescence, and reduced tillering (Jones, 1985), thus reducing forage mass production. However, IVDOM and CP may increase in drought-stressed plants due to increases in soluble carbohydrates and N concentrations in the leaves (Ball et al., 2002; Burton et al., 1957). Temperature can also be an important factor to tropical and subtropical species whose optimum temperatures range from 39-35^{o}C; however forage mass significantly decreases at 24^{o}C and little growth occurs at 10^{o}C (Ball et al., 2002).

Bermudagrass

Bermudagrass originated in Southeastern Africa (Ball et al., 2002) and is the second most planted, improved, warm-season, perennial grass in Florida (Newman, 2008). Bermudagrass is typically used for pasture and hay production within Florida because of its persistence under heavy grazing, highly efficient response to N fertilization, and high forage mass (Chapman et al., 1972; Ball et al., 2002; Chambliss et al., 2006; Sollenberger, 2008). According to Sollenberger (2008), bermudagrass is best adapted to moderately to well-drained soils and is considered relatively drought tolerant. However, Newman (2008) stated that bermudagrass is adapted to soils ranging from fertile sandy loam to sand to clay, but agrees with Sollenberger (2008) that bermudagrass is best suited to well-drained sites and is drought tolerant. The primary growing season of bermudagrass in Florida is from May to October (Ball et al., 2002).

Common bermudagrass is a common pasture grass in the Piedmont and Coastal Plains regions of the Southeastern United States (Adams et al., 1967). However, the Coastal bermudagrass hybrid has proven to be superior to common bermudagrass in terms of forage mass

(Adams et al., 1967), but not in N or crude fiber concentrations (Adams and Stelly, 1958; Miller et al., 1961; Adams et al., 1967). Dry matter yields of non-fertilized common bermudagrass have been reported at 2,331 kg/ha from April to September, while non-fertilized Coastal bermudagrass had forage mass of 5,156 during the same time period (Adams and Stelly, 1958). Bermudagrass hybrids (Alicia, Hardie, Midland, and Tifton 44) were evaluated (Taliaferro et al., 1987) for nutritive value with mean IVDOM concentration of 41.6% and 9.5% CP concentration during the winter (November to February). Jolliff et al. (1979) declines in in vitro digestible dry matter (IVDDM) and CP of Coastal and Coastcross-1 bermudagrass varieties with increasing maturity, while the NDF and ADF concentrations increased.

In a study by Guerrero et al. (1984) using bermudagrass digestibility to predict animal gains, it was determined that while forage mass was abundant from May to October (mean=92.4 g DM/ kg live weight/ day), IVDMD concentration was insufficient (mean=56.9%) to meet nutritional requirements of grazing cattle. A curvilinear relationship between gain and available forage was reported (Guerrero et al., 1984); the parameters of both slope and the asymptote of the curve increased in magnitude as IVDMD increased, thus less available forage was required to optimize gain. Minson and McLeod (1970) reported that IVDDM concentrations of less than 65% are inadequate for cattle grazing tropical grasses as the sole diet. Therefore, cattle would have to selectively graze the forage to maximize performance since it would be physically impossible for the steers to consume enough forage to meet their requirements on a daily basis. As stated by Guerrero et al. (1984), an improved method of classifying forage relative to grazing animals is needed to improve the relationship between animal gain and available forage. Thus justifying the purpose of this study by illustrating the need for classification of the differences in forage chemical composition between hand-collected forage and masticate samples.

The economic benefits of grazing cows on fertilized bermudagrass were evaluated by Neville and McCormick (1976) who determined that when using bermudagrass forage as the only feed source, it was more profitable to fertilize pastures at lower application rates (152 kg of N/ ha) compared to more heavily managed pastures (322 kg of N/ ha) under favorable weather conditions. Cows had greater ADG (2.44 kg/ha) and greater saleable calf weight (410 kg/ha) when grazed on bermudagrass pasture that received the greater fertilization compared to values for the lower fertilization rate (ADG=1.88 kg/ha; saleable calf weight=328 kg/ha; Neville and McCormick, 1976), but after considering land, capital, labor, management, and other input costs, the lower fertilization treatment was the most profitable to the producer.

Limpograss

Limpograss is native to South Africa, specifically the Limpopo River area, and was introduced into Florida in 1967 (Kretschmer and Snyder, 1979). Limpograss has been described as best adapted to acidic soils, fertile or fertilized sand to clay soil types. It is better adapted to flatwoods than well-drained sands, and highly adaptive to flooded areas (Quesenberry et al., 1987; Newman, 2008). Limpograss is typically used for grazing, hay, and stockpiling (Pate, 1992; Newman, 2008). Stockpiling is defined as a standing hay crop used for grazing cattle after the primary forage growing phase has ceased (Sollenberger et al., 2006). Stockpiling is a common practice for limpograss compared to bahiagrass or bermudagrass due to its superior digestibility, even with increased maturity (Quesenberry and Ocumpaugh, 1980; Davis et al., 1987; Pate, 1992; Sollenberger et al., 2006). However, while limpograss digestibility remains significant during late fall and early winter, CP concentration is generally low and cattle should be supplemented with a protein supplement to improve animal performance (Rusland et al., 1988; Holderbaum et al., 1992; Brown and Adjei, 2001; Sollenberger et al., 2006). Brown and Adjei (2001) indicated that limpograss IVDOM concentrations of the total canopy can range from 34-44% from July to November. Sollenberger et al. (2006) described limpograss IVDOM concentrations ranging from 40-70% during the year, which includes early spring growth as well as mature, stockpiled grass. This range is consistent with the results of Kretschmer and Snyder (1979). Crude protein concentrations of limpograss are reported to vary from 3-10% during March to July (Quesenberry and Ocumpaugh, 1980; Brown and Adjei, 2001; Sollenberger et al., 2006). Pitman et al. (1994) reported that limpograss CP and IVDOM concentrations were 2% and 5% greater from pastures with high stocking densities (8 steers/ha) than pastures with lower stocking densities (4 steers/ha) during the summer.

Cattle ADG on limpograss pastures has been reported (Sollenberger et al., 1989) to be greatest in the spring (mean=0.50 kg/d), while ADG declined with increasing forage maturity. Low CP concentrations are also found during the fall and winter, thus negatively impacting cattle performance. However, cattle performance can be positively affected by the addition of N to limpograss, whether through N fertilization of the forage (Kretschmer and Snyder, 1979; Davis et al., 1987; Sollenberger et al., 1989), addition of legumes (Rusland et al., 1988), ammoniation of limpograss hay (Brown et al., 1987), or through protein supplement fed to the herd (Pate, 1992; Brown and Adjei, 2001; Arthington and Brown, 2005; Sollenberger et al., 2006). Davis et al. (1987) reported no differences in limpograss ADF or NDF concentration (37 to 39% ADF and 63 to 67% NDF) from December to April, but their IVDDM concentrations never reached 65%, which has been determined to be the minimum IVDMD threshold for cattle grazing tropical grasses (Minson and McLeod, 1970). Milford and Haydock (1965) reported that the minimum level of CP concentration needed for maintenance of dry cows grazing tropical grasses to be no less than 7.2% CP. However, CP concentration of limpograss (Davis et al., 1987) increased from a minimum of 7.0% to a maximum of 15.5% CP from December to April as N fertilization application increased (0 kg/ha to 400 kg/ha; Davis et al., 1987), thus illustrating the positive effect of N fertilization on CP concentration. Rusland et al. (1988) reported greater ADG in steers grazing limpograss pastures over-seeded with aeschynomene compared to steers grazing limpograss pastures fertilized with 50 kg N/ha (0.70 kg/d and 0.39 kg/d, respectively). The previous studies conclude that with the addition of N to tropical grass pastures, improvements in ADG can be expected, which can prove to be useful since tropical grasses are reported to be low in CP and digestibility during much of the year.

Comparison of Florida Forages

While bahiagrass is the most commonly used pasture forage in Florida (Chambliss and Sollenberger, 1991), there are often distinct differences among the predominant forages used in Florida. Duble et al., (1971) reported that the primary factor affecting animal performance is the chemical composition of the standing forage when adequate forage is available for grazing. In a grazing evaluation of perennial grasses in Florida using yearling steers (Pitman et al. 1984), there were no differences in ADG among stargrass (ADG=0.40 kg/head), bermudagrass (ADG=0.36 kg/head) and limpograss (ADG=0.40 kg/head) during cool- and warm-seasons (November to August). In a study by Arthington and Brown (2005), limpograss contained the lowest CP concentration after 4 and 10 weeks of regrowth (8.5% and 6.0% CP, respectively) compared to bahiagrass (10.0% and 7.0% CP, respectively) and bermudagrass (11.0% and 7.0% CP, respectively). Bahiagrass had the lowest mean NDF concentration (79.0%) at compared with the other grasses (bermudagrass=84.1%; limpograss=86.3%) and it was also the only forage that did not have a greater NDF concentration after 10 to 4 wk regrowth. Limpograss had the greatest ADF concentration (46.0%) in comparison to the other grasses (bahiagrass=40.0%; bermudagrass=43.8%). Arthington and Brown (2005) also reported a decrease in IVDOM concentration from 4 to 10 wk regrowth for bermudagrass (53.9% and 44.1%, respectively), but not bahiagrass (52.4% and 51.3%, respectively). The authors concluded that bahiagrass was the most favorable tropical grass for cattle compared to bermudagrass and limpograss due to low NDF and ADF concentrations, greater IVDOM and CP concentrations, and greater retention of nutritive value regardless of time of regrowth.

Mislevy and Everett (1981) reported that Pensacola bahiagrass produced of 86% of its annual forage mass from April to September, while bermudagrass produced 73% of its annual forage mass in the same time period, indicating the possibility for grazing bermudagrass longer into the fall and winter compared to bahiagrass. In a study by Johnson et al. (2001), unfertilized bahiagrass had greater forage mass (769 kg/ha) compared to unfertilized bermudagrass (656 kg/ha), however with increased N fertilization rates (0 to 157 kg N/ha/cutting), bermudagrass was consistently greater in forage mass (mean=1,756 kg/ha) compared to bahiagrass (mean=1,429 kg/ha). Bertrand and Dunavin (1985) stated that beef steers consuming bermudagrass cultivars (Callie, Tifton 72-81, Tifton 72-84) gained faster (0.49 kg/head/day) than steers grazing Pensacola bahiagrass (0.37 kg/head/day); bermudagrass also had greater forage mass (11,148 kg/ha) than bahiagrass (8,824 kg/ha). Utley et al., (1974) reported that forage mass of Coastal and Coastcross-1 bermudagrases was nearly 35% greater (22,192 kg/ha) than Pensacola bahiagrass forage mass (15,467 kg/ha) when measured from May to October; bermudagrass also produced greater ADG of steers (0.72 kg/d) compared to bahiagrass (0.49 kg/d). Thus from the reports by Bertrand and Dunavin (1985) and Utley et al. (1974), it can be concluded that bermudagrass will produce greater cattle and forage performance compared to bahiagrass. Sollenberger et al. (1989) compared steer performance while grazing either Floralta limpograss or Pensacola bahiagrass pastures, ADG were reported to similar for both forage species from July to November (mean=0.41 and 0.38 kg/d, respectively). Mean limpograss

IVDOM concentration (60.4%) was greater than bahiagrass (55.0%), but bahiagrass had greater CP concentration (11.0%) than limpograss (7.0%) in the same time period (Sollenberger et al., 1989). It can be concluded from this study that ADG may not differ between limpograss and bahiagrass (Sollenberger et al. 1989). These results may be attributed to chemical composition of the forages; while limpograss had greater IVDOM concentration, bahiagrass had greater CP concentration thus possibly equating the value of the forages when measured as gains experienced by the animal.

Tropical grasses have been reported to be low in IVDOM and CP concentrations with greater NDF and ADF concentrations compared to temperate grasses, while their forage mass is abundant for much of the year. Thus management of the forages should involve proper sampling to ensure correct evaluation of the nutritive value of the pastures to minimize nutrient deficiencies when comparing forage nutrient supple to beef cattle requirements.

Beef Cattle Nutritional Requirements

The primary objectives of commercial cow-calf producers are to maintain the cow while maximizing profitability, obtain efficient reproduction rates, and attain high calf weaning weights (Ball et al., 2002). Nutrition is the most significant factor influencing the cow-calf producer's objectives (Kunkle et al., 2002). Nutritional requirements can be characterized in several specific ways: energy, protein, minerals, vitamins, and water (Ensminger, 1987; Kunkle et al., 2002). The nutritional requirements for maintenance are considered to be the most important requirements and should be met before other production requirements (Cullison, 1975). Various factors affect maintenance requirements such as body weight, breed or genotype, sex age, season, temperature, physiological state, and previous nutrition (NRC, 2000).

Factors Affecting Requirements

Cassard and Juergenson (1971) stated that energy is the most important consideration when feeding livestock. Protein should be fed to meet maintenance requirements since protein fed in excess of an animal's needs will be deaminated in the liver and used as a source of energy by the animal (Cullison, 1975). As reported by Ferrell and Jenkins (1984a), approximately 70% of the energy required to maintain the non-pregnant, non-lactating cow herd can be attributed to energy costs for maintenance and, about 50% of the total feed energy required for beef production is for maintenance. Cullison (1975) defines maintenance as the maintaining of an animal in a state of well-being or good health from day to day and a maintenance ration is defined as the feed required to adequately support an animal doing no non-vital work, not growing, developing no fetus, storing no fat, or yielding no product. However, the NRC (2000) defines the maintenance requirement for energy as the amount of feed energy intake that will result in no net loss or gain of energy from the tissues of the animal body. The processes or functions comprising maintenance energy requirements include body temperature regulation, essential metabolic processes, and physical activity (NRC, 2000). Age, body weight (BW), body condition score (BCS), sex, stage of production, environment, dry matter intake (DMI) and breed are some of the factors that influence cow energy requirements. Metabolizable protein (MP) is used by the 2000 Beef Cattle NRC as the estimate for protein required by cattle because it accounts for rumen degradation of protein and identifies the requirements of gastrointestinal microorganisms, as well as the animal. Metabolizable protein is defined as the true protein absorbed by the intestine, as supplied by microbial protein and undegraded intake protein (NRC, 2000). Factors which can affect metabolizable protein requirements are metabolic fecal N, urinary N, and scurf losses, but also include the previously mentioned factors that also influence energy requirements.

Age is a known variable influencing energy and protein maintenance requirements; however the primary influencing factor may be correlated more closely to weight and BCS than physiological age. An equation by Corbett et al. (1985) indicates energy maintenance requirements decrease by 3% per year. This concept is also supported by the work of Van Es (1972), which stated that for very young growing cattle (<100 kg), energy maintenance requirements appear to be greater than those for older animals. However, Vermorel et al. (1980) indicated that maintenance requirements of cattle changed little between 5 and 34 weeks of age. Neville, Jr. (1971) also reported that age does not affect the energy requirements of lactating Hereford cows.

Thus there are more important factors influencing maintenance requirements besides age alone. Sex class is also a consideration when determining maintenance requirements for energy and protein. Assuming cattle are of a similar genotype, there is a 15% greater maintenance requirement for energy for bulls compared to steers or heifers (NRC, 2000). However Chizzotti et al. (2008) concluded that there were no differences in energy or protein required for maintenance between Nellore or Nellore x *Bos taurus* bulls and steers or heifers. Chizzotti et al. (2008) is also in agreement with the results of Chizzotti et al. (2007) which reported no differences for energy or protein required for maintenance between F1 Nellore x Red Angus bulls, heifers, or steers.

There are conflicting results as to the influence of BW on maintenance energy requirements. Lofgreen and Garrett (1968) and Thonney et al. (1976) reported that maintenance requirements of beef cows within specific stages of production and similar environments are dependent primarily on BW. Lofgreen and Garrett (1968) stated that as metabolic body weight ($W^{0.75}$=average empty BW) increases, the fasting heat production is increased and can result in an increase in maintenance energy requirements. In contrast, Geay (1984) reported an apparent decrease in maintenance requirements as live weight increased in Charolais and Fresian bulls. Geay (1984) reported that for every 100 kg increase in BW, the metabolizable energy required for maintenance decreased by 3 kcal/$W^{0.75}$ for Charolais bulls and 10.5 kcal/ $W^{0.75}$ for Fresian bulls. Tyrell and Moe (1980) also reported a 13 to 18 kcal/ $W^{0.75}$ decrease in metabolizable energy required for maintenance for Hereford heifers. While breed differences influenced the amount of energy required for maintenance, these results indicate that as weight increases, the metabolizable energy required for maintenance decreases. Additionally, studies by Klosterman et al. (1968) and Thompson et al. (1983) suggest that an increase in BW due to increased fat deposition does not necessarily increase maintenance energy requirements. However, Houghton et al. (1990) compared 128 pregnant, mature Charolais x Angus cows, reported that when energy was expressed as total daily predicted maintenance energy, fatter cows (BCS=4) required 21% more energy than cows in moderate condition (BCS=3) during the last trimester of pregnancy. According the NRC (2000), energy requirements are calculated based on metabolic BW, thus a cow with increased BW would have increased maintenance energy requirements.

Therefore, BW alone cannot be used to accurately predict the energy requirements of larger breeds (Hereford, Angus x Hereford, Charolais x Hereford, and Brown Swiss x Hereford) with greater milk production potential (Lemenager et al., 1980). A model proposed by Lemenager et al. (1980) predicted TDN requirements from two yearly trials and initial lactation cow BW; initial lactation cow BW was an important factor in the equation accounting for 60.5% of the variation (r^2=0.60). But in a second model by Lemenager et al. (1980), trial year, initial lactation cow BW, BCS at start of lactation phase; cow weight and BCS accounted for more variation (r^2=0.81) than BW alone. In a third model estimating TDN required during lactation proposed by Lemenager et al. (1980) which included trial year, initial lactation cow BW, initial BCS and estimated milk production; the estimated milk production was an important factor while BW (*P*<0.14) and BCS (*P*<0.25) were not. However, initial cow BW, initial BCS and estimated milk production accounted for nearly all variation (r^2=0.98) in the estimated TDN requirements during early lactation (Lemenager et al., 1980). Thus BW alone should not be used to predict energy requirements, but when BW, BCS and estimated milk production are combined, a more accurate prediction of energy requirements can be established. Houghton et al. (1990) also reported that some indicator of BCS needs to be used in combination with BW or BW plus milk production to estimate the levels of energy needed to maintain beef cows during late gestation and early lactation.

Previous plane of nutrition and energy intake are also factors when estimating maintenance energy requirements. According to Fox et al. (1972) who used Hereford steers, adjusting maintenance requirements for previous plane of nutrition is more biologically accurate when projecting gains over an entire feeding period of approximately 180 days compared to the measurement of compensatory gains experienced in the first 2 to 3 months of a feeding period. In a study by Houghton et al. (1990), two energy level regimes (low energy- 70% NRC requirement and maintenance energy- 100% NRC requirement) were fed prepartum to 128 mature, pregnant Charolais x Angus cows. At the initiation of the trial, no differences were observed between the cows from either treatments. However, at parturition, cows on the maintenance energy intake had at least 0.5 greater BCS and 40 kg greater BW than those on the low energy feeding level. These results are similar to those from Birkelo et al. (1991) who reported that a high plane of nutrition caused a consistent increase in fasting heat production (7%) and maintenance metabolizable energy (14%) in Hereford steers compared to steers on a low plane of nutrition. Papas (1977) determined that non-lactating, non-pregnant ewes are responsive to increased N in the diet, whether by protein or non-protein N supplement, when provided at levels greater than required for maintenance. Carroll et al. (1964) used 40 weanling heifers to determine the effects of a low-protein diet (37% of protein required for maintenance) on total gain, heifers consuming a low-protein diet were negatively impacted (0.27 kg total gain/ heifer) compared to heifers receiving adequate dietary protein for maintenance (12.25 kg total gain/ heifer). Thus consideration must be made to previous and current planes of nutrition when adjusting cow energy and protein maintenance requirements.

The stage of production is an important factor to consider when calculating cow energy maintenance requirements since there will be increased heat production during fetal growth and milk production. NRC (2000) states that, based on previous research values, maintenance requirements of lactating cows are approximately 20% greater than those of non-lactating cows. In a study by Neville and McCullough (1969) using 20 lactating, non-pregnant and 8 non-lactating, non-pregnant Hereford cows, it was reported that lactating cows have 30% greater maintenance requirements than non-lactating, non-pregnant cows. However, in a later study by Neville (1974) comparing 40 non-lactating and 24 lactating Hereford cows, it was determined that the energy maintenance requirements for lactating cows are 39 to 41% greater than for non-lactating cows. The variation between Neville and McCullough (1969) and Neville (1974) may have been affected by diet and differences in the amount of TDN provided during the feeding trials. While greater requirements for lactation have been established, there have also been studies designated to understanding the requirements of other stages of production, such as gestation. Montano-Bermudez et al. (1990) concluded that energy requirements for gestation were lower than requirements for lactation. In two gestation trials (Montano-Bermudez et al.,

1990) utilized 71 and 77 first cross cows, respectively, from Hereford, Red Poll, and Milking Shorthorn sires and Angus dams, the results from the first trial indicated that the energy requirements associated with gestation were 86.5% of the requirements for lactation. Whereas in the second trial (Montano-Bermudez et al., 1990) maintenance energy requirements for gestation were 78% of the requirements for lactation. Differences in BCS, BW, and genetic variation of the cows were used to account for the maintenance requirement differences between the two studies by Montano-Bermudez et al. (1990). Overall, it was concluded that the cattle with greater milk production (Milking Shorthorn x Angus) had the greatest maintenance requirements. While gestation requires increased energy for maintenance, there are differences in the amount of energy required depending on the stage of pregnancy. The energy required for gestation is initially very small, only 0.1% of the energy requirement during the third month postpartum Hersom, 2007). In contrast, the gestation energy requirement one month prior to parturition is approximately 56% of the total energy requirement (Hersom, 2007). Warrington et al. (1988) showed that maintenance metabolizable energy requirements increased by 25% as gestation progressed for two-yr old, pregnant heifers. It can be concluded that maintenance requirements for gestation are greater than those for non-pregnant cows and requirements for lactation are greater than requirements for gestation.

Differences between breeds also affect maintenance requirements. Dairy breeds are known to have greater maintenance requirements (Garrett, 1971; Holloway et al., 1975; Thompson et al., 1983), compared to beef cattle breeds. The 2000 Beef Cattle NRC estimates that approximately 20% greater maintenance energy is required for dairy breeds compared to beef breeds; however, within beef breeds, *Bos indicus* breeds are reported to require 10% less energy for maintenance compared to *Bos taurus* breeds due to genetic potential for productivity (NRC, 2000). Solis et al. (1988) stated that genetic, environmental, physiological, body composition, and nutritional aspects must be considered in maintenance requirements for cows of different breeds. Also, Solis et al. (1988) reported that some cattle types may be better suited for survival on feed of lower quality than other breeds. This is crucial for Florida cows, which are maintained on low-quality forages. The cattle types (dry, mature, non-pregnant cows) with the lowest maintenance requirements in the trial by Solis et al. (1988) were the Angus x Hereford and Brahman x Hereford crosses (89 and 92 kcal/$W^{0.75}$, respectively), while the purebred cows (Angus, Brahman, and Hereford) had greater, similar mean maintenance energy requirements 102 kcal/$W^{0.75}$. The lower maintenance requirements of Brahman cows were attributed to the lower quantities of internal fat and smaller metabolically active organs usually found in Brahman cattle. This is helpful in Florida cow-calf breeding operations since Brahman genetics are commonly utilized due to increased heat and pest tolerance. Ferrell and Jenkins (1998) reported that the net energy required for maintenance differed between *Bos taurus* (mean=98.3 kcal/$kg^{0.75}$/d) and *Bos indicus* (mean=110.4 kcal/$kg^{0.75}$/d) sired breeds. However, in a study by Chizzotti et al. (2008) establishing protein and energy requirement of Nellore and Nellore-cross cattle, it was determined that there were no differences in required maintenance energy between breeds (Nellore, Nellore x Angus, Nellore x Red Angus, Nellore x Simmental, Nellore x Limousin, and Nellore x Brangus). Also, there was no difference for net protein required for maintenance between breeds (Chizzotti et al., 2008). However, it a study by Thompson et al. (1983) comparing 20 Angus x Hereford and 20 Angus x Holstein five-yr old cows, it was determined that Angus x Hereford cows had greater protein maintenance requirements compared to Angus x Holstein cows, which may have been due to breed type and BCS differences. The results of Chizzoti (2008) may be different from other research due to the influence of the Nellore breed in the crossbred cattle.

Environment can greatly affect maintenance requirements of cattle with temperature as one of the leading factors affecting requirements (Fuquay, 1981). Extreme heat and cold can affect maintenance requirements since cattle will need to either dissipate or increase body heat production to maintain homeostasis. Florida cattle may not experience extreme cold environments, as experienced by Northern and Midwestern cattle; however heat tolerance is necessary for Florida cattle due to the subtropical climate of the state. Hammond et al. (1998) discussed the importance of heat tolerance in cattle within tropical or subtropical conditions; it was determined that the relationship to feed intake or, under grazing conditions, grazing time of cattle is primarily affected by heat tolerance. Declining feed intake has been a cause of decreased milk production in dairy cows (Wayman et al., 1962). This is important for cow-calf production systems since calf weights may be affected negatively by decreased milk production. Heat stress also affects maintenance energy requirements since higher temperatures in cows necessitate use of greater energy for dissipating heat (Morrison, 1983). There has also been a tendency for an increase in protein requirement for lambs during times of heat stress (Ames and Brink, 1977). In a study by Delfino and Mathison (1991) conducted at the University of Alberta, Canada, 49 Hereford or Herford-cross yearling steers were fed either inside (mean temp=16.9^{0}C) or outside (mean temp=-7.6^{0}C) from January to April. Delfino and Mathison (1991) concluded that the net energy required for maintenance increased by 18% for the steers exposed to the cold winter environment compared to the indoor steers.

Plant-Animal Interface

Previous research shows that cattle will selectively graze when adequate forage is available for grazing (Weir and Torrell, 1959; Fontenot and Blaser, 1965; Jung et al., 1989; Russell et al., 2004). Weir and Torrell (1959) used wethers grazing Northern California native range and other temperate forages to show that sheep selected forage that was 4.3% greater in CP compared to hand-collected forage samples. Russell et al. (2004) reported that Simmental cows grazing smooth bromegrass *(Bromus inermis)* during the summer selected forage material that was greater in IVDMD and CP, and lower in NDF compared to hand-collected forage samples. Similarly, Jung et al. (1989) determined wether lambs grazing bromegrass *(Bromus inermis)* selected forage material with lower NDF concentration (52% vs 68%), but greater IVDMD (64% vs 52%) and CP (14% vs 8%) compared to hand-sampled forage when samples were taken every 14-d from May to August during a three-yr trial.

Other research has illustrated that hand-sampled forage is inaccurate in its estimation of a grazing animal's selected diet (Kiesling et al., 1969; Coleman and Barth, 1973; Skerman and Riveros, 1990). Kiesling et al. (1969) reported esophageal extrusa samples of steers contained greater concentrations of ash, protein, silica, and ether extract compared to hand-plucked tobosa grass *(Pleuraphis mutica)* samples, therefore the hand-collected forage samples incorrectly estimated selected forage material. Coleman and Barth (1973) reported esophageal-fistulated steers grazing either tall fescue- Korean lespedeza *(Festuca arundinacea-Lespedeza stipulacea)* or orchardgrass-ladino clover *(Dactylis glomerata-Trifolium repens)* pastures were selective of forage material that was greater in CP concentration (difference=4.7%), ADF concentration (difference=10.9%) and DDM concentration (difference=2.0%) in comparison to hand-collected forage samples from May to November. If cattle are able to select a diet that is greater in nutritive value than what hand-harvested samples indicate, this may affect supplementation strategies for producers. In a study by Johnson et al. (1998), it was determined that nutritional deficiencies of grazing cattle need to be identified for proper formulation of supplementation strategies and decisions in order to optimize animal performance. However, comparison of hand-collected and masticate samples of bahiagrass has not been reported in the literature, thus validating the purpose of this research.

While there are noted differences between masticate and hand-collected forage nutritive value, there may also be differences between the extrusa samples from esophageal and ruminal fistulated animals. Holecheck et al. (1982) reviewed methods for determining the nutritive value of ruminant diets concluding that while esophageal fistulated animals are superior to rumen fistulated animals since less labor is involved and diet samples are more representative of actual forage consumed, there are advantages and disadvantages to both fistula types. Some of the main problems associated with esophageal fistulae sampling are salivary contamination, rumen fluid contamination from eructation, use only for grazing studies, and incomplete recovery of selected forage material (Blackstone et al., 1965; Acosta and Kothmann, 1978; Arnold and Dudzinski, 1978). Advantages of ruminal fistulae over esophageal fistulae include easier establishment and maintenance of the fistula, less care of the fistulated animal required during collection, use in other experiments besides grazing trials, and entire collection of sampled forage (Lesperance et al., 1960). However, time needed for emptying and washing the rumen before collection, as well as for returning rumen contents to the animal are disadvantages to rumen fistulas (Lesperance et al., 1960). Both fistulation techniques are approved for collection of forage material from cattle, but preference for type of experimental usage is one of the primary determinants of choice of fistula type.

There may also be differences in DM loss between drying procedures used for masticate and hand-collected forage samples. Mayland (1968) reported that oven-drying alfalfa (*Medicago sativa*) at 60, 80 and 100^{0}C led to C, N, and DM losses compared to zero losses by freeze-drying;

however, the differences in C and N losses were less than 1% of the total C or N concentration of the forage. However, Acosta and Kothmann (1978) concluded that oven-drying (60^0C) and air-drying ($28\text{-}35^0$C) were not satisfactory for drying esophageal extrusa samples of post oak savannah range (*Quercus stellata*) and Coastal bermudagrass due to increased OM losses from increased heat and extended drying times of the samples. However, freeze-drying the extrusa samples accurately reflected the nutritive value of the collected forages (Acosta and Kothmann, 1978). There were no differences in CP, acid detergent lignin (ADL), cellulose, or hemi-cellulose concentrations of the hand-plucked bermudagrass samples between all drying techniques (Acosta and Kothmann, 1978); however, total nonstructural carbohydrates were less in the oven- and air-dried hand-plucked bermudagrass samples. Wilkinson et al. (1969) contradict the results of Acosta and Kothmann (1978) since they found greater cell wall components, ADF, and ADL in air- and oven-dried hand-clipped Coastal bermudagrass samples compared to freeze-dried samples. Schimd et al. (1970) reported that oven-drying at 60 and 85^0C was acceptable for determining IVDMD of corn (*Zea mays*) and sorghum (*Sorghum bicolor*) fodder and silage and lyophilization resulted in the lowest amount of DDM loss. Thus consideration should be given when determining drying method choice for forage samples.

Previous research (Bennett et al., 1999) has shown that when forage mass is not limiting, the main determinant of diet selection by steers is the chemical composition of the available forage. However, in a range grass grazing study, Bailey (1995) reported that steers develop preferences for native range and temperate forages with greater CP concentrations regardless of the forage quantity available. Guerrero et al. (1984) used bermudagrass digestibility to predict animal gains and determined that while forage mass was abundant from May to October (mean=92.4 g DM/ kg live weight/ day), forage IVDMD concentration was insufficient (mean=56.9%) to meet grazing cattle requirements. Since the steers continuously gained BW during the trial (Guerrero et al., 1984), it was concluded that cattle selectively grazed the available forage because it was physically impossible for the steers to consume enough forage to meet their energy requirements, as determined by forage IVDMD concentration. Fisher et al. (1991) determined that steers grazing bermudagrass, switchgrass *(Panicum virgatum)*, flaccidgrass *(Pennisetum flaccidum)*, and bermudagrass select forage material 16.9% greater in IVDMD concentration and 12.6% lower in NDF concentration when forage mass was not limiting (mean forage mass=1,818 kg/ha) from May to September. This indicates that steers were selective of available forage, as determined by forage chemical composition, during the summer with a mean selection index of 115.4% for all grasses (Fisher et al., 1991). There have not been any studies to date comparing the nutritive value of hand-collected bahiagrass to forage material selected by grazing animals.

Jung et al. (1989) found that wethers grazing smooth bromegrass selected forage material 10% greater in CP concentration compared to pasture samples. Dubbs et al. (2003) reported that CP concentrations of hand-clipped tall fescue were greatest in April (16.5%) and decreased during the remainder of the summer (mean=12.7%); masticate samples selected by steers averaged approximately 4% greater CP concentration than hand-collected samples from April to September. Since tall fescue is a cool-season grass, the chemical composition will be negatively affected at the end of the spring, as shown by Dubbs et al. (2003), since increased temperatures and solar radiation end the primary growing season of cool-season grasses (Ball et al., 2002). Whereas bahiagrass, a warm-season grass, will have greatest CP in late spring/ early summer due to low rainfall and vegetative growth state (Kalmbacher and Wade, 2003). Weir and Torrell (1959) reported that esophageal extrusa samples of native range, as well as temperate grasses and legumes, had greater CP concentration (mean=18.0%) than forage samples collected by hand-clipping (14.7%) during a two-yr study. Bailey (1995) concluded that in heterogeneous areas of forage (ie. differing forage chemical composition and forage mass within a pasture), cattle will develop preferences for patches of grass with greater CP concentration regardless of forage quantity, which is in agreement with previously mentioned research (Bailey et al., 1995; Bennett et al., 1999).

Cattle are less selective of NDF compared to other ruminant species (Reid et al., 1990), because of cattle's ability to maintain greater levels of intake of cell wall constituents. In contrast, in a trial by Dubbs et al. (2003), hand-clipped tall fescue samples had 5% greater NDF concentrations compared to masticate samples from April and May while forage quantity was at a minimum. Dubbs et al. (2003) also reported that hand-clipped fescue samples averaged 5% greater ADF concentration from April to May compared to masticate samples. Thus while fescue was in the vegetative growth state during April and May, steers were selective of forage material with the least proportion of cell wall contents even though the forage itself was low in fiber content. However, Norman et al. (2004) concluded that sheep grazing saltbushes would not show preference for forage material on the basis on ADF concentration; however, the sheep did select between two saltbush species (*Atriplex amnicola and Atriplex nummularia*) preferring the saltbush variety with greater ADF concentration, which may be attributed to greater palatability of the preferred species since the sheep were not selecting for digestibility, CP, DM, or OM.

Previous research has demonstrated differences in the selection by grazing animals of forage based on nutritive value. Thus the proper characterization of the nutritive value of masticate samples in comparison to the nutritive value of hand-collected forage samples is necessary to identify possible nutritional deficiencies so that diet supplementation strategies can be properly formulated to optimize animal performance.

CHAPTER 3
EFFECTS OF FORAGE SAMPLING METHOD ON NUTRITIVE VALUE OF BAHIAGRASS DURING THE WINTER AND SPRING

Introduction

Florida pastures are comprised primarily of tropical and subtropical forages, which are typically low in quality, yet yield high quantities of DM (Skerman and Riveros, 1990). Bahiagrass (*Paspalum notatum*) occupies approximately one million hectares within Florida and is the primary component of Florida grazing cattle diets (Chambliss and Sollenberger, 1991). Bahiagrass has a primary seasonal production from April to October, however it can be grazed into the winter if managed properly (Ball et al., 2002). Advantages to providing bahiagrass in a cattle grazing system are persistence under little to no management and moderate quality during most of the year. However, a consistently high-quality bahiagrass is rarely achieved, regardless of management or fertilization, therefore bahiagrass may not be a good forage choice for cattle with greater nutritional requirements, such as lactating or pregnant animals (Pate, 1992). As with many tropical grasses, bahiagrass has been reported to be low in nutritive value, as determined by hand-harvested samples; however, this data does not account for the ability of cattle to selectively graze within a pasture. According to the NRC (2000), bahiagrass contains 8.9% CP or less and 54.0% TDN on a DM-basis, whereas beef cow requirements range from 6-12% CP and 45-65% TDN depending on the weight and physiological state of the cow. Currently, there is very little published data available detailing changes in bahiagrass chemical composition during the winter and early spring. Most cows are not able to consume enough low quality forage to meet their protein and possibly energy requirements when forage quantity is lacking, especially during the winter. However, if cattle are able to select a diet that is greater in nutritive value than what hand-harvested samples indicate, this may affect supplementation strategies for producers. Previous research has shown that cattle will selectively graze when adequate forage is available for grazing (Weir and Torrell, 1959; Fontenot and Blaser, 1965; Jung et al., 1989; Russell et al., 2004). Other research has illustrated that hand-sampled forage is inaccurate in estimating forage selected by a grazing animal (Kiesling et al., 1969; Coleman and Barth, 1973; Skerman and Riveros, 1990). During the winter and spring months, bahiagrass forage mass can be limiting, while the forage will typically have greater quality since the bahiagrass is early in its growing season (Ball et al., 2002). However, due to temperature and environmental differences, the chemical composition and forage mass of bahiagrass will vary widely across Florida. The purpose of this study was to characterize the nutritive value of masticate or hand-sampled bahiagrass from pastures differing in forage availability (**FA**) from four locations across the state of Florida during the winter and spring.

Materials and Methods

Locations and Collections

Four locations were utilized to represent variation in the Florida pasture landscape, the locations included: Range Cattle Research and Education Center, Ona; USDA- Subtropical Agricultural Research Station, Brooksville; Santa Fe River Ranch Beef Unit, Alachua; and North Florida Research and Education Center, Marianna. The soils of the research site in Ona are a sandy, siliceous, hyperthermic Alfic Alaquod (EauGallie sand). At the Brooksville research site, the soils are a loamy, siliceous, semiactive, hyperthermic Grossarenic Paleudult (Arredondo fine sand). The soils of the research site in Alachua are a hyperthermic, uncoated Typic Quartzipsamment (Tavares sand). At the Marianna research site, the soils are a loamy, kaolinitic, thermic Arenic Kanhapludult (Chipola loamy sand), fine-loamy, kaolinitic, thermic Typic Kandiudult (Orangeburg loamy sand), and loamy, kaolinitic, thermic Grossarenic Kandiudult (Troup sand). The pasture sizes at each location were: 1.0 ha (Ona), 1.0 ha (Brooksville), 0.8 ha (Alachua), and 1.5 ha (Marianna). Bahiagrass (*Paspalum notatum)* was the primary forage of interest for this trial. However, there were different cultivars at each location. At the Ona research site, the bahiagrass cultivar used for the trial was Pensacola (*Paspalum notatum* cv. Suarae Parodi), while the cultivar found in Brooksville was primarily Argentine bahiagrass, which is similar to Pensacola, but may be more palatable. At the Alachua research site, the bahiagrass cultivar was Pensacola, while Marianna contained Pensacola bahiagrass. The selected pastures were managed at each location either by grazing or mowing to allow for differences in available forage mass. Pastures were not fertilized prior to or during the trial.

Samples were collected over a six-mon period from December 2006 to May 2007. Eight ruminally-cannulated Angus or Brangus steers were used for this experiment (mean BW=500 kg); two steers (one Angus and one Brangus) were placed at each location one-mon before the start of the trial. Steer fistulation surgery and daily care were approved by the University of Florida Institutional Animal Care and Use Committee (E#105). Forage and masticate samples were collected monthly (approximately every 30 days) from two pastures at each location. Forage availabilities were visually assigned to the selected pastures, as either HIGH or LOW, at each location to represent differences in forage quantity. Within each pasture, two individuals hand-collected three forage samples each for a total of six samples per pasture. Hand shears were used to cut the forage to an approximate height of 3.5-cm within a 0.25-m^2 quadrat. Samples were placed in paper bags, transported to the lab, and weighed. Forage samples were dried for 48 h in a 55^{o}C forced-air oven to determine DM concentration and forage mass.

Simultaneously, masticate samples were collected using two ruminally fistulated steers. At sunrise, the steers were removed from the pasture and penned for rumen evacuation; rumen contents were removed by hand as described by Lesperance et al. (1960), except that the rumen walls were also wiped with sponges to remove adherent particles. Both steers were allowed to graze either the HIGH or LOW designated pasture for approximately 1 h. The masticate was removed from the rumen and excess liquid drained. Samples were stored in individual, labeled plastic cups, placed on ice for transport, and frozen in the lab (-20^{0}C). The masticate sample collection process was repeated for the other forage availability pasture. At the conclusion of the masticate collections, ruminal contents were returned to the steers.

Laboratory Analysis

Masticate samples were lyophilized to a constant DM content. Hand-collected forage and masticate samples were ground to pass through a 1-mm screen with a Wiley mill. All forage and masticate samples were composited by person or steer, and pasture availability and subsampled. All samples were analyzed for residual DM and OM (AOAC, 2007). Concentrations of NDF and ADF were determined using an Ankom 200 Fiber Analyzer (Ankom Technology Corp., Fairport, NY) without the use of sodium sulfite or decalin (Van Soest et al., 1991). Crude protein concentration was determined by the combustion method using the Elementar Vario Max CN (Elementar Americas Inc., Mt. Laurel, NJ). In vitro digestible organic matter, (**IVDOM**) was determined according to Tilley and Terry (1963), as modified by Marten and Barnes (1980), for all samples using rumen fluid inoculum obtained from a ruminally fistulated, dry Holstein cow consuming a basal diet of ad libitum bermudagrass hay and 450 g soybean meal daily. The selection index (**SI**) for chemical composition was determined using the following equation: SI={[(Masticate analyte concentration – hand-collected forage analyte concentration) / hand-collected analyte forage concentration] * 100} + 100.

Statistical Analysis

Data were analyzed as a split plot design with the whole plot completely randomized using the MIXED procedure of SAS (SAS Inst., Inc., Cary, NC). The experimental unit was steer or person for sample collection. Fixed effects in the model included FA, month, sampling type (masticate or hand-collection), and their subsequent interactions. Repetition (steer or person) within each FA was used for the repeated measures and random effect. The least squares means were determined. Means were separated using the P-diff option when protected by a significant F-value (P<0.05).

Results and Discussion

Forage Mass

Month affected the overall state mean forage mass (Table 3-1; P<0.001), while there was a tendency for a difference between FA (P=0.10). All months were similar in forage mass in each respective FA, except for May, which had the greatest forage mass for the LOW FA, which was likely due to the onset of the summer season and the greater increase in forage mass at Ona compared to the other locations. The forage mass of HIGH FA decreased through the winter and spring until increasing to its greatest value in May. The LOW FA remained fairly constant from December to February until increasing by approximately 500 kg/ha in March and April with a larger increase (1,500 kg/ha) in forage mass in May. Bahiagrass is reported to produce only 14% (1,800 kg/ha) of its total annual forage mass (13,000 kg/ha) during the winter (October to March; Mislevy and Everett, 1981). As noted by Williams and Hammond (1999), at the USDA-ARS Brooksville research station, bahiagrass growth and FA are affected by seasonality and rainfall, especially during the spring. Williams and Hammond (1999) reported that before mid-June, when rainfall can be limiting, FA is usually <1,100 kg DM/ ha and low forage mass during this period can limit animal performance. The average forage mass (1,850 kg/ha) in this study was greater than those of Williams and Hammond (1999; 1,460 kg/ha); however, rainfall was limiting (Table 3-5) during both studies, thus overall forage growth during both studies was negatively affected. However, as long as bahiagrass forage mass is accumulating during the spring, as was seen in this study, cattle can selectively graze the highest quality forage material (Williams and Hammond, 1999).

In Vitro Digestible Organic Matter

Masticate samples were consistently greater (Table 3-2; *P*<0.001) in IVDOM concentration by 13.3% on average compared to hand-collected forage samples during the winter and spring. While not as great of a difference was seen compared to the results of this studA smaller, but similar response in cattle grazing fescue-lespedeza and orchardgrass-clover pastures; selected forage material was 2.0% greater in digestible dry matter (**DDM**) compared to samples collected by hand (Coleman and Barth, 1973). Concentration of IVDOM in masticate and hand-collected forage samples was also affected by month (*P*<0.001). The IVDOM concentrations of the hand-collected forage samples were lowest in January, followed by December and February, while March, April, and May had the greatest values with a mean of 50.3% IVDOM (51.6% TDN; Fike et al., 2003) during the three mon. Minson and McLeod (1970) stated IVDDM concentrations less than 65% are inadequate for meeting energy requirements of cattle grazing tropical grasses. As reported by the 2000 Beef Cattle NRC, a 544 kg cow with 9 kg peak milk will require a mean of 56.3% TDN during the first three mon of lactation. Thus according to the hand-collected forage IVDOM values in December, January, and February (mean=41.3%; 47.1% TDN), grazing cattle will not be able to consume enough forage to meet energy maintenance energy requirements and must be supplemented to make up for the 9.2% TDN deficiency during the three mon.

December, January, and February represent the coldest months, thus limiting bahiagrass growth and maximizing senescent material, while temperature increases in March, April, and May allow for spring forage growth. Joliff et al. (1979) reported similar low IVDMD concentration (41.6%) for bermudagrass from November to February, which is likely due to the dormancy of tropical grasses during the winter. Gates et al. (2001) observed that bahiagrass pastures at two locations, Ona, FL and Tifton, GA, had variable IVDOM concentration between locations and across months. Concentration of IVDOM of hand-sampled forage decreased from September to February but increased in March and April. The sampled forage at Ona (Gates et al., 2001) was fertilized with 34 kg N/ha during the trial which may have resulted in greater hand-collected forage IVDOM concentration (55-65%) compared to the state mean hand-collected forage IVDOM concentration from this trial (37-51%). Also, when the mean IVDOM concentrations from Ona and Tifton are averaged from Gates et al. (2001), the mean IVDOM concentration (53.8%) is more reflective of the state mean IVDOM concentration found in this study (45.8%). The similarity of IVDOM concentration during both studies may be due to the similar temperature and environmental variation between locations of the current study, as well as the locations utilized by Gates et al. (2001).

The masticate sample IVDOM concentrations were similar in December and January (mean=55.94%; 49.82% TDN), while March, April, and May did not differ in IVDOM concentration with a mean of 60.28% (54.21% TDN) for the three mon. While the hand-collected forage samples were unable to meet cow energy maintenance requirements during the first three mon of lactation (9.2% TDN deficiency), values for masticate samples were also less than the recommended TDN concentration during December, January, and February. However, there was only a 1.8% deficiency in TDN concentration during the three months for masticate samples compared to the 9.2% deficiency for hand-collected forages, thus implying producers would be able to supplement less energy during the winter than previously determined by hand-collected forage TDN concentration. The sample type and month effects led to a type x month ($P<0.001$) effect for IVDOM concentration during the winter. This indicates the steers were able to select forage material different in chemical composition than hand-collected forage material and the differences between sample types also varied during each month of the study.

However, hand-collected forage and masticate IVDOM concentrations (Table 3-3) were not affected by FA (*P*=0.75 and *P*=0.19, respectively) during the winter and spring. There was a trend for a FA x month interaction for masticate IVDOM concentration (*P*=0.10), but not for hand-collected forage IVDOM (*P*=0.21). The lack of a FA effect is indicative of the steers selecting forage material with similar IVDOM concentration (59.1%) from both FA pastures. In a study by Schlegel et al. (2000) comparing esophageal extrusa samples collected from alfalfa pastures maintained under two stocking densities (5.3 and 11.7 steers/ha); there was no effect of stocking density on the IVDOM and CP concentrations of masticate samples, suggesting steers were selecting similar forage material from both pastures. Whereas Pitman et al. (1994) reported 5% greater IVDOM concentration in limpograss pastures with greater stocking densities (8 steers/ha) compared to lower stocking densities (4 steers/ha). This contradicts the results of this study in which there were no FA or FA x month effects (*P*=0.75 and *P*=0.21, respectively).

Selection indices (**SI**; Table 3-4) for IVDOM concentration differed between FA (*P*=0.04) and month (*P*<0.001). The LOW FA had a 10% greater SI than the HIGH FA indicating the steers were more selective of forage material within the LOW FA compared to the HIGH FA. January and February did not differ in SI and had the greatest SI values, thus illustrating the steers' ability to select forage material that was 51% greater in IVDOM concentration than the hand-collected forage values. Previous research has shown (Bennett et al., 1999) that when forage mass is not limiting, the main determinant of diet selection by steers is the chemical composition of the available forage. However, in December, March, April, and May, when forage mass was similar with the exception of May, SI were not different (20.73, 21.29, 19.94, and 20.26%, respectively). Thus while forage growth was not at its full potential during the winter and spring, the steer's were still able to select forage material with greater digestibility than hand-clipped forage material. During the current study, regardless of forage mass, the steers selected material that was greater in IVDOM compared to hand-collected forage samples.

Crude Protein

Similar to IVDOM, CP concentrations (Table 3-2) of masticate samples were greater ($P<0.001$) than those of hand-collected forage samples for the state. Masticate samples were 2.3% greater in CP concentration than the hand-collected forage samples during the winter and spring, thus the steers selected a diet that was greater in CP concentration compared to clipped forage samples. Jung et al. (1989) found that wethers grazing smooth bromegrass selected forage material 10% greater in CP concentration compared to pasture samples. Month also affected CP concentration ($P<0.001$) during the winter and spring, resulting in a type x month interaction ($P=0.02$), which was likely influenced by the convergence of the CP data in March. For the hand-collected forage samples, CP concentration was lowest in December (7.8% CP), followed by January (9.5% CP); the remaining mon (February, March, April, and May) had relatively consistent CP concentrations, and March had the greatest hand-collected forage CP concentration of 11.9%. For a 1,200 lb beef cow (20 lb peak milk) in the first three mon of lactation, the NRC (2000) recommends intake of 10.2% CP to meet maintenance requirements for protein. Based on the hand-collected forage samples, bahiagrass in December and January will have 1.5% less CP than required total dietary CP for lactating beef cattle. However, for the remainder of the spring, bahiagrass pastures had 1.2% excess CP concentration than required for lactating beef cattle, thus protein supplementation is not needed (NRC, 2000). Gates et al. (2001) reported that CP concentrations of bahiagrass remained relatively constant from autumn until early spring ranging from 13-17% CP. While Gates reported bahiagrass with greater CP concentrations compared to the current study (7-12% CP), the forage was fertilized with 34 kg N/ha thus contributing to greater CP concentration; Johnson et al. (2001) reported that bahiagrass total N concentration increased with increased N fertilization. Regardless, our data demonstrate a similar pattern to Gates et al. (2001) since hand-collected forage CP concentration remained fairly constant during the winter and spring period except in December and January when CP concentrations were lowest.

Masticate CP concentrations were the least in December, January, and March (mean=11.5% CP); the greatest masticate CP concentrations occurred in February, April, and May (mean=13.2% CP). The CP concentration of masticate samples were in excess of recommended CP requirements for lactating beef cattle (NRC, 2000) during the entire sampling period; indicating bahiagrass pastures provide adequate CP concentration when steers are selectively grazing. Dubbs et al. (2003) reported that tall fescue CP concentrations were greatest in April until they decreased in May with masticate samples having approximately 6% greater CP concentration than hand-collected forage samples. Since tall fescue is a cool-season grass, the nutritive value will begin to decrease at the end of the spring, as seen by the results of Dubbs et al. (2003), whereas bahiagrass, a warm-season grass, will have greatest CP concentration at the same time, as indicated by the current study. Waterman et al. (2007) reported that the CP concentration of ruminal extrusa from cows grazing range grasses found in the Great Plains [grama (*Bouteloua gracilis*), needlegrass (*Stipa pennata*), and wheatgrass (*Tritcum aestivum*)] followed typical seasonal patterns with lowest CP concentrations in winter (7.9% CP; December) and greatest concentrations in early summer (12.1% CP; May) with substantial increases in early spring (8.1% CP; March) due to the onset of the primary growing season. There was a trend (Table 3-3; *P*=0.08) for greater CP on the HIGH FA pastures. While the HIGH FA had greater forage mass, the forage mass was less mature; whereas the LOW FA may have had more senescent forage material and not enough new growth to strongly impact CP concentration. The type and month effects led to a type x month interaction (P=0.02) for CP concentration indicating the differences between masticate and hand-collected forage samples and the variation between months during the study.

The SI (Table 3-4) for CP concentration was affected by FA (P=0.01) and month (P=0.03). The SI for the LOW FA was nearly 20% greater than the HIGH FA. There was greater forage mass in the HIGH FA, but greater selectivity in the LOW FA, which may have contained greater amounts of senesced material. The data indicates the steers were selective of forage material that was greater in CP concentration although there may have been a prevalence of dead forage material. This data contrasts with the results of Jung et al. (1989), who reported that SI for CP concentration (115%) did not differ between bromegrass pastures with different stocking densities (15 vs 30 lambs/ha). The contrast may have been due to the differences in forage species between the two studies. There was little indication of selection for CP during March (0.16%) with moderate selection during April (16.42%) and May (12.76%), while the greatest selection (mean=33%) occurred in December, January, and February. These results demonstrate that cows requiring 10.2% CP during the first three mon of lactation could select bahiagrass forage with adequate CP concentration to meet maintenance requirements for CP. In a range grass grazing study, Bailey (1995) demonstrated that steers develop preferences for forage with greater CP concentrations regardless of the forage quantity available, which contrasts the results of this study. Weir and Torrell (1959) reported that esophageal extrusa samples had greater CP concentration than those of hand-clipped forage, as seen in this study.

Neutral Detergent Fiber

There was an effect (Table 3-2) of sampling type and month (*P*<0.001) on NDF concentrations with a slight trend (*P*=0.13) for a type x month effect. Forage samples had greater NDF concentration across all months compared to masticate samples (mean difference=5.2%). Neutral detergent fiber concentrations of hand-collected forage samples were lowest in March (55%), followed by April (57%) and May (59%), and greatest in December and January (mean=63%). These results are because bahiagrass would be regrowing during the early spring, and thus will have low NDF concentrations due to the relatively lower concentration of cell wall constituents in young, immature plants (Barnes et al., 2007). However, shorter day length and cold temperatures in December and January may have increased senescence of bahiagrass forage and therefore increased its NDF concentration. Waterman et al. (2007) observed that NDF concentration of range grasses during a two-yr study increased during the production season (May to December). The greatest concentration of NDF occurred in December, mainly because of the presence of senescent material, while the lowest NDF concentration was in May due to the immaturity of the forages.

In the current study, masticate NDF concentration was lowest in February and March (49%), followed by April and May (53%), and greatest in December and January (60%). During the winter, hand-collected forages will have increased amounts of senescent material, thus fiber concentrations will be greater. However, in the spring, cell wall components of bahiagrass will be less due to the immaturity of the forage. The hand-collected forage samples averaged 5.3% greater NDF concentration during the trial compared to masticate samples, which is similar to differences reported by Dubbs et al. (2003). The results imply that cows are able to select material that is lower in cell wall components compared to forage samples collected by hand-clipping during the spring. There were no differences in NDF concentration between FA for hand-collected forage (P=0.72) or masticate samples (P=0.18). The data indicates hand-collected forage NDF concentration did not differ between FA and the selection of forage material by steers was similar in NDF concentration between both FA. However, NDF concentration of masticate samples was less than hand-collected forage NDF concentration during the winter and spring.

There was a trend (Table 3-4; P=0.10) for a month effect on SI of NDF concentration. The lower SI for NDF concentration indicates that the steers selected a diet lower in cell wall components compared to hand-collected forage samples. However, there were no differences in the SI (P=0.16) for NDF concentration between HIGH and LOW FA for both hand-clipped and masticate samples. In the trial by Dubbs et al. (2003), hand-clipped tall fescue samples had 5% greater NDF concentration compared to masticate samples during April and May. Fescue is dormant during April and May, steers were selecting forage material with the lowest proportion of cell wall contents even though the forage itself was low in fiber content. Bahiagrass has been classified as extremely fibrous when mature (Chambliss and Sollenberger, 1991). However, research has found that cattle are less selective of NDF compared to other ruminant species (Reid et al., 1990) because of their ability to maintain high levels of intake of cell wall constituents. This selective ability proves to be useful when dealing with Florida's subtropical grasses, especially during the winter when forages may not be as mature as during the summer months, while still having considerable NDF concentration due to their C_4 anatomy.

Acid Detergent Fiber

Sampling type (Table 3-2) affected ADF concentration of hand-collected forage and masticate samples (P<0.001). Masticate samples concentrations of ADF were less than hand-collected forage sample concentrations (mean difference=3.5%). The exception was in April when hand-collected forage and masticate ADF concentration only differed by 0.5%, resulting in a type x month effect (*P*<0.001). Dubbs et al. (2003) reported differences in ADF concentration between masticate and hand-clipped samples of fescue pastures across sampling months with hand-clipped samples 5% greater in ADF concentration during the study.   There was a trend for a month effect (*P*=0.10) on ADF concentration. Acid detergent fiber concentrations are lowest in young, immature forage and will increase with increasing maturity as winter and spring progress to the summer season (Barnes et al., 2007). Hand-collected forage sample ADF concentration was greatest in February (37%) while the remaining months had a mean ADF concentration of 31%, suggesting a prevalence of senescent material in February. In contrast, Davis et al. (1987) reported no change in ADF concentration of limpograss from December to April, which may have been due to the lack of growth during the winter, since limpograss is a warm-season perennial grass. While bahiagrass is also a warm-season perennial grass, the differences between the results of this study and those of Davis et al. (1987) may have been influenced by the anatomical differences of the forages such as leam:stem ratios. Masticate ADF concentrations were lowest in February, March, and May (mean=26.6%), whereas December, January, and April had the greatest concentrations of ADF (mean=30.5%). These results indicate that although there was an abundance of dead forage material in the pastures during the winter months, as demonstrated by the hand-clipped forage samples, the steers were still able to select forage material that was lower in ADF concentration compared to clipped forage samples during the winter and spring. Similarly, in a study comparing hand-clipped tall fescue samples to masticate samples, Dubbs et al. (2003) concluded that hand-clipped samples had greater ADF concentrations (*P*<0.01) compared to masticate samples during April and May.

The SI for ADF concentration was affected by month (*P*=0.001). There was also a trend for a difference in SI between FA for ADF concentration (*P*=0.07). The steers selected forage material that was lowest in ADF concentration during February and March with the remaining months not differing from each other and eliciting less of a selection response. Norman et al. (2004) concluded sheep that grazing saltbushes will not show preference for forage material based on ADF concentration. The negative SI values for February and March indicate that steers selected forage that was lower in ADF concentration.

Implications

Results of this study indicate that steers grazing bahiagrass forage during the winter and spring selected forage with greater digestibility and CP concentration compared to hand-collected forage samples. These results imply that cow-calf producers need to properly evaluate the nutritive value of their pastures in order to correctly supplement their herd during the winter.

Table 3-1. Effect of forage availability and month on overall mean forage mass (kg/ha).

	Month							*P*-value		
FA[a]	Dec	Jan	Feb	Mar	Apr	May	SEM[d]	FA	Month	FA*Month
H[b]	2,808	2,050	2,140	1,215	996	2,276	464	0.10	0.001	0.73
L[c]	1,298	936	1,050	1,541	1,474	3,023				

[a]FA= Forage availability.
[b]H = High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of mean, n=192.

Table 3-2. Effect of sampling type and month on chemical composition of bahiagrass.

		Month							*P*-value		
Analysis	Type[a]	Dec	Jan	Feb	Mar	Apr	May	SEM[e]	Type	Month	Type*Month
IVDOM[b]	F[c]	44.2	37.5	42.2	49.6	50.8	50.5	1.98	<0.001	<0.001	<0.001
	M[d]	55.6	56.3	62.6	60.6	59.8	60.5				
CP	F	7.8	9.5	10.8	11.9	11.7	11.3	0.58	<0.001	<0.001	0.02
	M	10.6	11.9	13.4	11.9	13.6	12.5				
NDF	F	62.9	62.2	59.9	54.5	57.5	58.7	1.77	<0.001	<0.001	0.13
	M	59.0	60.7	49.7	48.7	52.6	53.7				
ADF	F	31.1	31.8	37.4	33.3	29.5	28.7	1.39	<0.001	0.10	<0.001
	M	30.1	31.5	25.8	27.4	29.9	26.6				
DM	F	91.2	91.3	90.7	90.7	90.5	90.7	0.29	<0.001	0.01	<0.001
	M	91.0	91.1	90.9	91.9	91.6	93.1				
OM	F	94.7	94.3	94.6	93.8	93.8	94.3	1.17	<0.001	0.02	0.03
	M	83.9	83.3	87.8	86.7	86.6	90.1				

[a]Type= Forage sampling type.
[b]IVDOM= In vitro digestible organic matter.
[c]F= Hand-sampled forage.
[d]M= Masticate.
[e]SEM= Standard error of the mean, n=192.

Table 3-3. Effect of forage availability on chemical analysis of bahiagrass.

	FA[a]			
Analysis	H[b]	L[c]	SEM[d]	*P*-value
Forage				
IVDOM[e]	46.2	45.4	1.54	0.75
CP	11.3	9.6	0.45	0.08
NDF	59.1	59.5	0.66	0.72
ADF	32.0	31.9	0.55	0.91
DM	91.0	90.7	0.13	0.24
OM	94.0	94.4	0.14	0.24
Masticate				
IVDOM	57.9	60.4	0.95	0.19
CP	12.3	12.3	0.33	0.99
NDF	52.8	55.6	1.00	0.18
ADF	27.9	29.2	0.80	0.35
DM	91.8	91.5	0.23	0.49
OM	85.3	87.6	0.08	0.19

[a]FA= Forage availability.
[b]H= High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of the mean, n=48.
[e]IVDOM= In vitro digestible organic matter.

Table 3-4. Effect of forage availability and month on steer selection index[a] of bahiagrass forage.

	FA[b]				Month							
Analysis	H[c]	L[d]	SEM[e]	*P*-value	Dec	Jan	Feb	Mar	Apr	May	SEM[e]	*P*-value
IVDOM[f]	125.78	135.9	3.40	0.04	120.7[i]	151.8[gh]	151.1[g]	121.2[i]	119.9[i]	120.3[i]	5.73	<0.001
CP	112.2	131.5	5.10	0.01	136.5[h]	131.0[h]	130.1[h]	100.2[g]	116.4[gh]	112.8[gh]	8.59	0.03
NDF	88.8	93.1	2.11	0.16	93.6	98.2	82.5	89.0	91.1	91.2	3.56	0.10
ADF	85.6	95.3	3.65	0.07	98.8[h]	101.7[h]	66.1[g]	80.7[g]	101.9[h]	93.7[gh]	6.17	0.001

[a]{[(Masticate concentration – forage concentration) / forage concentration] * 100} + 100.
[b]FA= Forage availability.
[c]H= High forage availability.
[d]L= Low forage availability.
[e]SEM= Standard error of the mean, n=48.
[f]IVDOM= In vitro digestible organic matter.
[g,h,i]Within a row, means with a different superscript differ, P<0.05.

Table 3-5. Precipitation data (cm) - Winter 2006 and spring 2007.

	Month						
Location	Nov	Dec	Jan	Feb	Mar	Apr	May
Ona	1.7	7.0	3.7	5.1	1.6	4.2	1.0
30-yr average	5.3	4.5	5.4	6.2	7.9	4.7	9.8
Brooksville	5.1	6.3	3.2	7.0	2.9	4.9	3.0
30-yr average	6.1	6.2	8.3	8.2	10.7	6.7	8.6
Santa Fe	1.9	8.7	8.9	4.5	3.9	2.7	6.4
30-yr average	5.8	7.0	11.1	9.4	11.0	8.3	9.2
Marianna	8.7	13.9	15.4	6.3	2.8	2.6	5.7
30-yr average	10.5	9.8	15.5	12.2	15.5	9.8	10.7

Table 3-6. Temperature data (^{0}C) - Winter 2006 and spring 2007.

	Month					
Location	Dec	Jan	Feb	Mar	Apr	May
Ona	19.1	17.1	15.3	19.0	20.1	23.1
30-yr average	17.0	15.9	16.5	18.8	21.1	24.4
Brooksville	17.4	15.6	13.9	18.0	19.2	22.9
30-yr average	16.3	15.4	16.3	19.1	21.4	24.6
Santa Fe	14.8	12.9	12.0	16.3	17.8	21.5
30-yr average	13.4	14.1	12.6	17.2	19.9	23.6
Marianna	12.6	11.2	10.5	17.0	18.0	23.7
30-yr average	10.8	9.6	11.4	15.2	18.5	22.7

CHAPTER 4
EFFECTS OF FORAGE SAMPLING METHOD ON NUTRITIVE VALUE OF BAHIAGRASS DURING THE SUMMER AND FALL

Introduction

Florida pastures are comprised primarily of tropical and subtropical forages, which are typically low in quality, yet will yield high quantities of DM (Skerman and Riveros, 1990). Bahiagrass (*Paspalum notatum*) occupies approximately one million hectares within Florida and is the primary component of diets of grazing cattle in Florida (Chambliss and Sollenberger, 1991). Bahiagrass has a primary seasonal production from April to October (Ball et al., 2002). Advantages to providing bahiagrass in a cattle grazing system are persistence under little to no management, and moderate quality during most of the year. However, a consistently high-quality bahiagrass is rarely achieved, regardless of management or fertilization and may not be a good forage choice for cattle with greater nutritional requirements, such as lactating or pregnant cattle (Pate, July 1992). As with many tropical grasses, bahiagrass has been reported to be low in nutritive value, especially during the summer and fall months, as determined by hand-harvested samples (Brown and Mislevy, 1988); however, this data does not account for the ability of cattle to selectively graze within a pasture.

According to the NRC (2000), bahiagrass contains no more than 8.9% CP and 54.0% TDN on a DM-basis. However, if cattle are able to select a diet that is greater in nutritive value than hand-harvested forage samples, supplementation strategies for producers may be affected. Previous research has shown an inverse relationship between maturity and quality of grasses during the summer months (Connor et al., 1963), while other studies have shown that when adequate forage is available for grazing, ruminants will selectively graze (Weir and Torrell, 1959; Fontenot and Blaser, 1965; Jung et al., 1989; Russell et al., 2004). Other research has illustrated that hand-sampled forage is inaccurate in its estimation of a grazing animal's selected diet (Kiesling et al., 1969; Coleman and Barth, 1973; Skerman and Riveros, 1990). During the summer and fall, bahiagrass forage is in its greatest production phase; however, forage quality declines significantly as the growing season progresses. Also, due to temperature and environmental differences, the chemical composition and forage mass of bahiagrass varies widely across Florida. The purpose of this study was to characterize the chemical composition of bahiagrass from four locations across the state of Florida during the summer and fall by comparing sampling techniques, either by hand-sampling or collection of masticate sample, within pastures of varying levels of forage availability (**FA**).

Materials and Methods

Locations and Collections

Four locations were utilized to represent variation in the Florida pasture landscape, the locations included: Range Cattle Research and Education Center, Ona; USDA- Subtropical Agricultural Research Station, Brooksville; Santa Fe River Ranch Beef Unit, Alachua; and North Florida Research and Education Center, Marianna. The soils of the research site in Ona are a sandy, siliceous, hyperthermic Alfic Alaquod (EauGallie sand). At the Brooksville research site, the soils are a loamy, siliceous, semiactive, hyperthermic Grossarenic Paleudult (Arredondo fine sand). The soils of the research site in Alachua are a hyperthermic, uncoated Typic Quartzipsamment (Tavares sand). At the Marianna research site, the soils are a loamy, kaolinitic, thermic Arenic Kanhapludult (Chipola loamy sand), fine-loamy, kaolinitic, thermic Typic Kandiudult (Orangeburg loamy sand), and loamy, kaolinitic, thermic Grossarenic Kandiudult (Troup sand). The pasture sizes at each location were: 1.0 ha (Ona), 1.0 ha (Brooksville), 0.8 ha (Alachua), and 1.5 ha (Marianna). Bahiagrass (*Paspalum notatum)* was the primary forage of interest for this trial. However, there were different cultivars at each location. At the Ona research site, the bahiagrass cultivar used for the trial was Pensacola (*Paspalum* *notatum* cv. Suarae Parodi), while the cultivar found in Brooksville was primarily Argentine bahiagrass, which is similar to Pensacola, but may be more palatable. At the Alachua research site, the bahiagrass cultivar was Pensacola, while Marianna contained Pensacola bahiagrass. The selected pastures were managed at each location either by grazing or mowing to allow for differences in available forage mass. Pastures were not fertilized prior to or during the trial.

Samples were collected over a six-mon period from June to November 2007. Eight ruminally-cannulated Angus or Brangus steers were used for this experiment (mean BW=500 kg); two steers (one Angus and one Brangus) were placed at each location one-mon before the start of the trial. Steer fistulation surgery and daily care were approved by the University of Florida Institutional Animal Care and Use Committee (E#105). Forage and masticate samples were collected monthly (approximately every 30 days) from two pastures at each location. Forage availabilities were visually assigned to the selected pastures, as either HIGH or LOW, at each location to represent differences in forage quantity. Within each pasture, two individuals hand-collected three forage samples each for a total of six samples per pasture. Hand shears were used to cut the forage to an approximate height of 3.5-cm within a 0.25-m^2 quadrat. Samples were placed in paper bags, transported to the lab, and weighed. Forage samples were dried for 48 h in a 55^oC forced-air oven to determine DM concentration and forage mass.

Simultaneously, masticate samples were collected using two ruminally fistulated steers. At sunrise, the steers were removed from the pasture and penned for rumen evacuation; rumen contents were removed by hand as described by Lesperance et al. (1960), except that the rumen walls were also wiped with sponges to remove adherent particles. Both steers were allowed to graze either the HIGH or LOW designated pasture for approximately one h. The masticate was removed from the rumen and excess liquid drained. Samples were stored in individual, labeled plastic cups, placed on ice for transport, and frozen in the lab (-20^{0}C). The masticate sample collection process was repeated for the other forage availability pasture. At the conclusion of the masticate collections, ruminal contents were returned to the steers.

Laboratory Analysis

Masticate samples were lyophilized to a constant DM content. Hand-collected forage and masticate samples

were ground to pass through a 1-mm screen with a Wiley mill. Each individually collected sample, forage or masticate, was composited by person or steer, and pasture availability and subsampled. All samples were analyzed for DM and OM (AOAC, 2007). Concentrations of NDF and ADF were determined using an Ankom 200 Fiber Analyzer (Ankom Technology Corp., Fairport, NY) without the use of sodium sulfite or decalin (Van Soest et al., 1991). Crude protein concentration was determined by the combustion method using the Elementar Vario Max CN (Elementar Americas Inc., Mt. Laurel, NJ). In vitro digestible organic matter, (**IVDOM**) was determined according to Tilley and Terry (1963), as modified by Marten and Barnes (1980), for all samples using rumen fluid inoculum obtained from a ruminally fistulated dry Holstein cow consuming a basal, daily diet of ad libitum bermudagrass hay (*Cynodon dactylon*) and 450 g of soybean meal. The selection index (**SI**) for chemical composition was determined using the following equation: SI= {[(Masticate concentration – hand-collected forage concentration) / hand-collected forage concentration] * 100} + 100.

Statistical Analysis

Data were analyzed as a split plot design with the whole plot completely randomized using the MIXED procedure of SAS (SAS Inst., Inc., Cary, NC). The experimental unit was steer or person for sample collection. Fixed effects in the model included FA, month, sampling type (masticate or hand-collection), and their interactions. Repetition (steer or person) within each

FA was used for the repeated measures and random effect. The least squares means were determined. Means were separated using the P-diff option when protected by a significant F-value ($P<0.05$).

Results and Discussion

Forage Mass

Forage mass (Table 4-1) was affected by month ($P<0.001$) and FA ($P=0.03$), while there was a tendency for a FA x month effect ($P=0.06$). Overall, September had the greatest forage mass (8,474 kg/ha), followed by August, October, and November (mean=7,024 kg/ha), while July forage mass (4,077 kg/ha) was only greater than the lowest forage mass, which occurred in June (2,100 kg/ha). Both HIGH and LOW FA increased in forage mass from June to September, when yields began to decline. Forage mass of the HIGH FA increased from a minimum in June (2,567 kg/ha) to a maximum in September (12,032 kg/ha) and declined to 9,292 kg/ha in November. Forage mass of the LOW FA increased by approximately 5,000 kg/ha from June to a maximum value of 5,401 kg/ha in October thereafter a moderate decrease occurred in November (3,333 kg/ha). During the months with the greatest forage mass (August, September, October, and November), the LOW FA had a mean of approximately 5,000 kg/ha, while the HIGH FA averaged 11,000 kg/ha during the months with the greatest forage mass (September and October). Similar to the results of this study, Brown and Mislevy (1988) noted that tropical grasses had greater forage mass during the summer compared to spring growth, with a decrease in IVDOM and CP concentration, and increase in NDF and ADF concentration as maturity increased. In a study by Bertrand and Dunavin (1985) comparing bahiagrass in North Florida over three consecutive summer and fall seasons, mean forage mass was 8,824 kg/ha, which is greater than our seasonal mean forage mass of nearly 6,000 kg/ha.

The FA x month trend was likely influenced by the simultaneous gains and losses of forage mass for the HIGH and LOW FA during the trial. Seasonal growth patterns for bahiagrass have been shown to decline in late summer and fall due to declining temperature and decreasing day length (Gates et al., 1999). Previous research conducted by Williams et al. (1994) observed that bahiagrass forage mass increased from June to an approximate maximum forage mass in August or September, depending on the stocking density and cultivar being utilized, while forage mass decreased through November. The results of Williams et al. (1994) correspond to the results of this study, with increased forage mass from June to September and decreased forage mass from September to November. Bahiagrass growth and forage availability is affected by seasonality and rainfall, which can limit animal performance when adequate forage is not available for meeting nutritional requirements (Williams and Hammond, 1999). However, as long as bahiagrass forage mass is accumulating, cattle can selectively graze for the highest quality forage material (Williams and Hammond, 1999).

In Vitro Digestible Organic Matter

Masticate samples were consistently greater (Table 4-2; $P<0.001$) in IVDOM concentration compared to hand-collected forage samples, averaging 9% greater IVDOM during the summer and fall. In a study conducted by Fisher et al. (1991), steers grazing either flaccidgrass *(Pennisetum flaccidum)*, switchgrass *(Panicum virgatum)*, bermudagrass, or tall fescue (*Festuca arundinacea)* pastures during the summer and fall selected forage material consistently greater in IVDMD concentration (mean difference=16.9%) compared to the hand-harvested forage samples. Cattle grazing fescue-lespedeza (*Festuca arundinacea-Lespedeza stipulacea*) and orchardgrass-ladino clover (*Dactylis glomerata-Trifolium repens*) pastures selected forage material greater in digestible dry matter (mean=64.3%) compared to samples collected by hand (**DDM**; mean=62.2%) from May to November (Coleman and Barth, 1973).

Concentration of IVDOM of hand-collected forage samples was affected by month (*P*<0.001). The IVDOM concentration of the hand-collected forage samples was lowest in August and November, while October had the greatest IVDOM concentration with a mean of 55.0% (55.6% TDN; Fike et al., 2003). As reported by the Beef Cattle NRC (2000), a 1,200 lb cow with 20 lb peak milk production requires a mean TDN concentration of 49.2% from five to 11 mon after calving, corresponding to the summer and fall months. This indicates that the hand-collected forage samples have greater TDN than the beef cattle require, thus supplementation of energy is not required. Previous research by Williams et al. (1994) indicated rotationally-grazed bahiagrass pastures increased in forage IVDOM concentration from June to either August or September, depending on the grazing system utilized, before decreasing in IVDOM concentration from September to November. In the current study, as forage mass increased from June to September, hand-collected forage digestibility decreased and forage maturity increased; however, IVDOM concentration increased again in September and October until reaching its minimum in November likely because of the influence of colder temperatures and shorter day length, which have negative effects on nutritive value of warm-season grasses (Barnes et al., 2007).

Masticate sample IVDOM concentration was also affected by month (*P*<0.001). The masticate IVDOM concentration was similar in June and November with a mean IVDOM concentration of 57% (54.2% TDN), while during the remaining months masticate samples had greater IVDOM concentration (mean=62%; 57.8% TDN). The sample type and month effects led to a type x month (*P*=0.08) trend for IVDOM concentration during the summer and fall. Masticate and hand-collected forage samples had adequate TDN to meet nutritional requirements of grazing cattle. In a study by Johnson et al. (1998), mixed-grass prairie decreased in IVDOM from June to November indicating that as the season progressed, forage quality as determined by IVDOM declined.

Masticate IVDOM concentration (Table 4-3) was not affected by FA (*P*=0.39) during the summer and fall, while FA only tended (*P*=0.09) to have an effect on hand-collected forage IVDOM concentration. However, there was a FA x month effect for masticate and hand-collected forage IVDOM concentration (*P*<0.001 and *P*=0.04, respectively) indicating the forage selected by hand and by the steers was different between the HIGH and LOW FA, as well as between months. Anderson et al. (1988), compared the digestibility of different strains of switchgrass and concluded that although increased FA can enhance selective grazing, the overall nutritive value of the forage may have a negative influence on selection of forage material, particularly if the forage is low in IVDMD. Thus steers grazing switchgrass with HIGH (4,972 kg/ha) and LOW FA (2,990 kg/ha) may select forage material with greater IVDMD concentrations (Anderson et al., 1988). This is similar to the results of the current study in which masticate IVDOM concentration was not affected by FA as maturity of the forage increased.

Selection indices (Table 4-4) did not differ between FA (*P*=0.48) or month (*P*=0.43) for IVDOM concentration. During this study, regardless of forage mass, steers selected forage material that was about 19% greater in IVDOM concentration on average compared to hand-collected forage samples. Jung et al. (1989) reported that masticate IVDMD from lambs grazing bromegrass *(Bromus inermis)* were 12% greater than hand-sampled forage IVDMD concentrations taken from May to August during a three-yr trial. Similar to the results of this study, Fisher et al. (1991) demonstrated that steers grazing bermudagrass, switchgrass, flaccidgrass, or tall fescue from May to September selected forage that had 16.9% greater IVDMD compared to hand-collected forage samples. The lack of a difference in SI among FA and month indicates that month or FA did not affect forage selection. Thus selection did not change during the summer and fall seasons. Although selection of forage material occurred, hand-collected forage IVDOM concentrations were adequate to meet TDN requirements of lactating cows during the summer and fall, thus an energy supplementation program would not be needed.

Crude Protein

Month affected CP concentration of hand-collected forage and masticate samples (Table 4-2; $P<0.001$) during the summer and fall, resulting in a type x month interaction ($P<0.001$). The type x month interaction was likely influenced by the intersection of the hand-collected forage and masticate CP values in June and the lower reductions in CP concentrations of masticate versus hand-collected forage samples as the season progressed. The lack of rainfall in May and June may have influenced forage mass, as well as hand-collected forage chemical composition variation between months. At most locations, precipitation was less than the 30-yr average for all locations from May to November (Table 4-5). Forage CP concentration was greatest in June (13.93%), whereas November had the lowest hand-collected forage CP concentration (8.29%). According to the 2000 Beef Cattle NRC (2000), a 1,200 lb cow with 20 lb peak milk production requires a mean CP concentration of 7.02% five to11 mon post-calving, which corresponds to the summer and fall season. The results from this study indicate that hand-collected forage CP values were in excess of cow requirements (NRC, 2000), thus protein supplementation would not be needed during the summer and fall. Johnson et al. (1998) reported that steers grazing range grasses in the Northern Great Plains selected forage that decreases in CP concentration from June (13.6%) to December (6.2%). The results of Johnson et al. (1998) are similar to those of this study in which CP concentration of hand-collected forage and masticate samples decreased as the season progressed and forage maturity increased. Williams et al. (1994) concluded that CP concentration of continuously and rotationally stocked bahiagrass pastures decreased linearly from May to November. Chambliss and Sollenberger (1991) reported that as weeks of regrowth between bahiagrass cuttings increase during the summer and fall, CP concentration decreases by nearly 7% CP from June to August, which is similar to the almost 6% decrease in hand-collected forage CP during this trial. Arthington and Brown (2005) reported that with increasing maturity (4- vs. 10-wk regrowth) of tropical grasses, a 38% decrease in CP concentration can be expected. In the current study, FA did not affect CP concentration (Table 4-3) of either hand-collected forage or masticate samples (P=0.24 and P=0.17, respectively). The similarities in CP concentration between FA for hand-collected forage and masticate samples may have been due to greater forage mass seen in the summer and fall. Thus the forage mass was great enough to provide similar CP concentration within both FA as selected by person or steer.

Similar to IVDOM, CP concentration (Table 4-2) of masticate samples were consistently greater (P<0.001) than those of the hand-collected forage samples except in June. Masticate samples averaged 1.4% greater CP concentration than the hand-collected forage samples during the summer and fall, thus the steers selected a diet that was slightly greater in CP concentration compared to hand-clipped forage samples. Dubbs et al. (2003) reported that CP concentrations of tall fescue samples were approximately 4.5 % greater than hand-collected forage samples from April to September. Also, Jung et al. (1989) found that wethers grazing smooth bromegrass selected forage material that was 10% greater in CP concentration compared to pasture samples. Masticate CP concentrations were greatest in June and July with a mean of 12.5%, while the other months had similar, lower CP concentration (mean=10.3%). These data are similar to the summer results of Connor et al. (1963), who reported declining CP concentration of steer masticate samples of Nevada range grass from May (12.9%) to August (11.0%) with a slight increase in concentration in September (11.7%) followed by a decrease in October (9.7%). In a study conducted by Waterman et al. (2007) using ruminally fistulated cows grazing range grasses in the Northern Great Plains, CP concentration of extrusa samples were greatest in May (12.1%) and decreased through August (7.6%), which is similar to the results of this study. Bailey (1995) concluded that in heterogeneous areas of forage, cattle will develop preferences for patches of grass with greater CP concentration regardless of forage quantity.

The SI (Table 4-4) for CP concentration was not affected by FA or month (P=0.72 and P=0.89, respectively). The SI for the HIGH and LOW FA indicated that the steers were able to select forage that was 20% greater in CP compared to hand-collected forage samples. While there were no differences between month (P=0.16) in SI for CP concentration, there was no selection in June (-3%), while the other summer and fall months had a mean SI of 25%. As in this study, Weir and Torrell (1959) reported that esophageal extrusa samples of native range, as well as temperate grasses and legumes were greater in CP concentration (mean=18.0%) than forage samples collected by hand-clipping (mean=14.7%). According to a study conducted by Bennett et al. (1999), when forage mass is not limiting, the principle factor driving selection is the chemical composition of the available forage. During the current trial, while forage mass was abundant and while hand-collected forage CP concentration decreased to a minimum of 8.3%, the steers were still able to select forage material 25% greater in CP concentration compared to hand-clipped samples. However, the CP concentrations of hand-collected forage and masticate samples were greater than the CP requirement for a lactating cow (NRC, 2000; 7.02% CP), thus supplementation would not be necessary during the summer and fall seasons.

Neutral Detergent Fiber

There was an effect of sampling type (Table 4-2; P<0.001) and month (P=0.04), thus resulting in a type x month interaction (P<0.001) for NDF concentration. Forage samples had greater NDF concentration across all months except June and July for NDF (mean=62%) compared to masticate samples (mean=58%). The NDF concentrations of hand-collected forage and masticate samples in June and July may have been influenced by the lack of rainfall, thus slowing growth and subsequent increase in fiber as seen during the summer. The similarity in hand-collected forage NDF concentration between August, September, October and November, which is the primary growing season for bahiagrass, would be attributed to the greater deposition of cell wall constituents as the forage matured (Barnes et al., 2007). Similar to the results of Brown and Mislevy (1988) reported consistent NDF concentration from June to September (mean=80.4%). Research has shown the influence of month and stage of maturity, especially during the summer and fall, on NDF concentration. Karn et al. (2006) examined the chemical composition of four perennial grasses, bromegrass and three species of wheatgrass (*Tritcum aestivum*) and concluded that while the rate of NDF accumulation within plant tissues differed between the species, the concentration of NDF increased by 10% in all forages as maturity advanced. Previous research by Wilson and ‘t Mannetje (1978) reported that the cell wall content of buffelgrass (*Pennisetum ciliare*) and green panic (*Panicum maximum*) in Australia was lowest in spring, and greatest in summer and autumn. Cuomo et al. (1996) reported that bahiagrass increased in NDF concentration during mid- to late-summer (mean=66.0%) compared to early summer harvests (63.1%).

Masticate NDF concentration was greatest ($P<0.001$) in June (61%) and remained relatively constant until October, and then decreased considerably in November (51%). During the summer and early fall, cell wall concentrations of bahiagrass are greatest due to the advancing maturity of the forage, which is also reflected in the masticate samples. The hand-collected forage samples had a mean NDF concentration that was 3.5% greater ($P<0.001$) during the trial compared to masticate samples implying the steers were able to select forage material with lower NDF concentration compared to hand-clipped forage samples. There are also indications that even as forage mass decreased in November as compared to the mid-summer months, the steers were still consuming forage with decreased NDF concentrations compared to hand-clipped samples. There were also no differences between NDF concentrations of HIGH and LOW FA for hand-collected forage or masticates samples (*P*=0.37 and *P*=0.93, respectively). This may have been due to the increased forage mass during the summer and fall thus the opportunity for selection of NDF concentration was similar between FA.

There was a month effect (Table 4-4; *P*=0.001) on SI for NDF concentration. However there were no differences (*P*=0.16) in SI between HIGH and LOW FA indicating the steers were selecting forage material similar in NDF concentration at both FA. The greatest SI was observed in July (12%), however there was little indication of a selection response from August to October (mean=-7%) and the lowest SI occurred in November (-19%). The low SI in November indicates that when forage mass was abundant the steers selected forage material with nearly 20% less NDF concentration compared to hand-collected forage samples, while the other months elicited less of a selection response. Therefore, although plant physiological processes resulted in increasing NDF concentration with maturity, steers selected forage with less NDF concentration. Bahiagrass has been classified as extremely fibrous and low in feeding value when mature (Chambliss and Sollenberger, 1991). However, cattle are less selective of NDF concentration (Reid et al., 1990) because of their ability to maintain greater levels of intake of cell wall constituents compared to other ruminant species, which may explain the variability of the SI between months. The results indicate that steers are less selective of NDF concentration during the summer and fall when forage mass is greatest, there was still selection for IVDOM and CP concentration. Thus steers may be able to meet energy and protein requirements even while bahiagrass has greater NDF concentration by selecting forage with lower NDF concentration.

Acid Detergent Fiber

Acid detergent fiber concentration of hand-collected forage and masticate samples (Table 4-2) was affected by sampling type and month (P=0.002 and P<0.001, respectively) resulting in a type x month interaction (P<0.001). There were no differences between hand-collected forage ADF concentration between HIGH and LOW FA (P=0.83). Overall, masticate samples were 1.5% lower in ADF concentration than hand-collected forage samples during the summer and fall. The exceptions were the lower ADF concentrations of hand-collected forage versus masticate samples in June (1.3%) and August (0.02%). As in the July and October data from this study, Dubbs et al. (2003) reported that hand-clipped samples of fescue pastures were 3.0% greater in ADF concentration from April to September. Forage sample ADF concentration was lowest in June (29%) and increased to 33% in October and November. Acid detergent fiber concentrations are generally less in young, immature forage and would increase with increasing maturity as the growing season progress (Barnes et al., 2007). Brown and Mislevy (1988) reported that ADF concentration of bahiagrass increased from June (41.8%) to July (46.3%), then remain constant through September (47.1%). Cuomo et al. (1996) examined the chemical composition of bahiagrass at different harvest frequencies during the summer and concluded that ADF concentrations increased from early (mean=29.9%) to mid-summer (mean=34.0%) at all harvest frequencies.

Masticate ADF concentrations were lowest in November (27%), followed by June, July and September (30%), while August and October had the greatest mean concentration of ADF (33%). As for NDF concentration, the lowest ADF concentration occurred in masticate samples in November, when forage mass began to decrease after the summer. This indicates the steers were selecting forage that was lower in cell wall components compared to other available forage. Duble et al. (1971) concluded that ADF concentration of warm-season perennial grasses would increase from late spring (April to May; mean=34.0%) to early summer (June; mean=35.9%), and remain consistent through mid-summer (July; mean=40.6%). There were no differences between masticate ADF concentration (*P*=0.86) for both FA.

The SI for ADF concentration was affected by month (*P*=0.01), but was not affected by FA (*P*=0.99). With the exception of November (-20%), the SI values indicate that the steers were not selecting forage based on the ADF concentration (mean=-0.3%). Norman et al. (2004) concluded that sheep grazing river saltbush (*Atriplex amnicola*) and old man saltbush (*Atriplex nummularia*) would not show preference for forage material on the basis on ADF concentration. The saltbush species are typically low in nutritive value and grazed only because of proliferance on saline land, not because of palatability or nutritive value of the forage. However, the results of Norman et al. (2004) indicate that the sheep may have been selecting forage material based on palatability. During November, the low SI indicate that the steers were selecting forage 20% less in ADF concentration compared to the hand-clipped samples. This implies that as forage mass was greatest in the summer and fall, the steers selected forage material with less senescence and lower ADF concentration.

Implications

Results from the summer and fall indicate that while bahiagrass matures and its forage mass increases, grazing steers will select forage material with greater IVDOM and CP concentrations, and less NDF and ADF concentrations. However, hand-collected forage and masticate samples were in excess of cow requirements (NRC, 2000) for energy and protein during the summer and fall months. The implications of the summer and fall trial are that producers will not need to supplement the cow herd with additional protein or energy.

Table 4-1. Effect of forage availability and month on overall mean forage mass (kg/ha).

	Month							*P*-value		
FA[a]	June	July	Aug	Sept	Oct	Nov	SEM[d]	FA	Month	FA*Month
H[b]	2,567	4,689	9,117	12,032	10,106	9,292	1,152	0.03	<0.001	0.06
L[c]	1,634	3,465	4,897	4,916	5,401	3,333				

[a]FA= Forage availability.
[b]H = High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of mean, n=192.

Table 4-2. Effect of sampling type and month on chemical composition of bahiagrass.

		Month							*P*-value		
Analysis	Type[a]	June	July	Aug	Sept	Oct	Nov	SEM[e]	Type	Month	Type*Month
IVDOM[b]	F[c]	54.5	51.2	48.1	54.9	55.0	46.2	1.47	<0.001	<0.001	0.08
	M[d]	58.4	61.1	60.7	64.5	63.4	56.5				
CP	F	13.9	9.7	8.6	8.6	8.6	8.3	0.62	<0.001	<0.001	<0.001
	M	12.9	12.1	11.0	9.6	10.7	10.1				
NDF	F	59.1	55.4	61.3	65.8	64.8	63.6	1.72	<0.001	0.04	<0.001
	M	61.4	59.2	57.9	59.0	60.9	51.4				
ADF	F	28.7	31.1	32.8	31.3	34.0	33.0	0.75	0.002	<0.001	<0.001
	M	30.1	29.7	32.8	30.2	32.7	26.6				
DM	F	90.4	91.7	90.1	90.2	92.3	90.8	0.36	0.03	<0.001	<0.001
	M	92.1	92.8	90.7	91.0	91.1	90.3				
OM	F	94.4	94.5	94.7	94.3	94.0	93.0	0.80	<0.001	0.01	0.07
	M	91.2	91.5	91.8	92.5	93.6	89.0				

[a]Type= Forage sampling type.
[b]IVDOM= In vitro digestible organic matter.
[c]F= Hand-sampled forage.
[d]M= Masticate.
[e]SEM= Standard error of the mean, n=192.

Table 4-3. Effect of forage availability on chemical analysis of bahiagrass.

	FA[a]			
Analysis	H[b]	L[c]	SEM[d]	*P*-value
Forage				
IVDOM[e]	50.5	52.9	0.56	0.09
CP	9.4	9.9	0.20	0.24
NDF	60.4	62.6	1.35	0.37
ADF	31.9	31.8	0.45	0.83
DM	90.8	91.0	0.14	0.49
OM	94.2	94.0	0.24	0.57
Masticate				
IVDOM	60.1	61.5	0.90	0.39
CP	10.8	11.6	0.27	0.17
NDF	58.4	58.2	0.76	0.93
ADF	30.4	30.3	0.43	0.86
DM	91.3	91.4	0.63	0.82
OM	92.0	91.0	0.44	0.25

[a]FA= Forage availability.
[b]H= High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of the mean, n=96.
[e]IVDOM= In vitro digestible organic matter.

Table 4-4. Effect of forage availability and month on steer selection index of bahiagrass forage.

	FA[b]				Month							
Analysis	H[c]	L[d]	SEM[e]	*P*-value	June	July	Aug	Sept	Oct	Nov	SEM[e]	*P*-value
IVDOM[f]	120.7	117.1	3.60	0.48	108.4	119.6	126.4	120.4	116.5	122.2	6.08	0.43
CP	118.9	121.6	5.33	0.72	97.1	122.7	128.4	120.6	128.3	124.6	8.99	0.16
NDF	98.7	93.4	2.60	0.16	103.5	112.3	94.8	90.0	94.5	81.5	4.37	0.001
ADF	96.2	96.2	2.69	0.99	105.0	95.4	99.9	98.3	98.1	80.4	4.53	0.01

[a]{[(Masticate concentration – forage concentration) / forage concentration] * 100} + 100.
[b]FA= Forage availability.
[c]H= High forage availability.
[d]L= Low forage availability.
[e]SEM= Standard error of the mean, n=48.
[f]IVDOM= In vitro digestible organic matter.

Table 4-5. Precipitation data (cm) - Summer and fall 2007.

	Month						
Location	May	June	July	Aug	Sept	Oct	Nov
Ona	1.0	10.5	9.1	21.2	17.1	5.2	0.2
30-yr average	9.8	19.8	19.4	17.8	17.2	7.3	5.3
Brooksville	3.0	10.8	22.6	16.1	9.4	16.8	1.1
30-yr average	8.6	18.4	18.2	20.9	11.6	7.5	5.8
Santa Fe	6.4	16.0	12.7	11.3	11.6	8.0	1.5
30-yr average	9.2	17.5	19.1	20.1	11.6	7.5	5.8
Marianna	5.7	5.8	7.0	10.8	3.4	12.7	5.0
30-yr average	10.7	13.3	17.6	13.7	12.1	7.4	10.5

Table 4-6. Temperature data (^{0}C) - Summer and fall 2007.

	Month					
Location	June	July	Aug	Sept	Oct	Nov
Ona	25.1	26.0	26.0	26.7	24.7	18.6
30-yr average	26.7	27.3	27.3	26.6	23.7	19.9
Brooksville	25.4	26.1	27.0	25.5	23.6	17.1
30-yr average	26.7	27.3	27.2	26.6	23.2	19.7
Santa Fe	24.5	25.9	26.6	24.4	21.8	14.5
30-yr average	26.3	27.2	27.1	25.6	21.1	17.0
Marianna	26.7	26.9	28.3	25.7	21.3	14.0
30-yr average	25.9	27.3	26.9	24.83	19.3	14.7

CHAPTER 5
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Results of this study indicate that steers grazing bahiagrass forage during the winter and spring selected forage with greater IVDOM and CP concentrations compared to hand-collected forage samples. The summer and fall results indicate that while bahiagrass matures and its forage mass increases, grazing steers will select forage material with greater IVDOM and CP concentrations, and less NDF and ADF concentrations.

Figure 5-1 illustrates the differences in hand-collected forage and masticate values for TDN and CP compared to cow requirements for lactation (NRC, 2000). The cow nutrient requirements in Figure 5-1 are based on the NRC (2000) values for a 544 kg cow with 9 kg peak milk with December as the month of parturition. During early lactation, bahiagrass forage collected by hand-sampling, as well as bahiagrass selected by cattle did not meet cow energy requirements; however, masticate and hand-collected forage values indicate that CP concentration was not limiting thus cow CP requirements during the first 4 months of lactation were met by both sampling types. Though later in lactation, both TDN and CP requirements were met by bahiagrass regardless of selection of forage material by either sampling method. When approaching calving (month 11 and 12), bahiagrass was deficient in TDN, but had CP great enough to meet cow requirements during that time period. Intake of TDN is central to the energy status of lactating cattle, which is important in maintaining BCS throughout the cow's production cycle. This in turn affects reproductive performance of the cow and further influences the number of calves born, and the financial outlook for the cattle producer.

When given the opportunity, cattle grazing bahiagrass forage will select a diet that is greater in nutritive value compared with hand-collected samples, which are normally gathered for estimation of available forage quality. The data collected in this study imply that forage samples collected by hand may under-estimate the nutritive value of the actual selected forage by cattle. The implications of this study indicate the opportunity to more closely match cow requirements with forage resources, based on available bahiagrass nutritive value and cow selection within those forage opportunities. If less supplement is needed to meet cattle requirements, then the excess supplement currently being provided is excreted by the animal into the environment causing unnecessary nutrient inputs into land and water systems. If energy and protein supplementation can be more closely matched to cow requirements, then less N and other nutrient inputs would be added to the environment thus improving land and water quality, which is an important concern for Florida cattle producers.

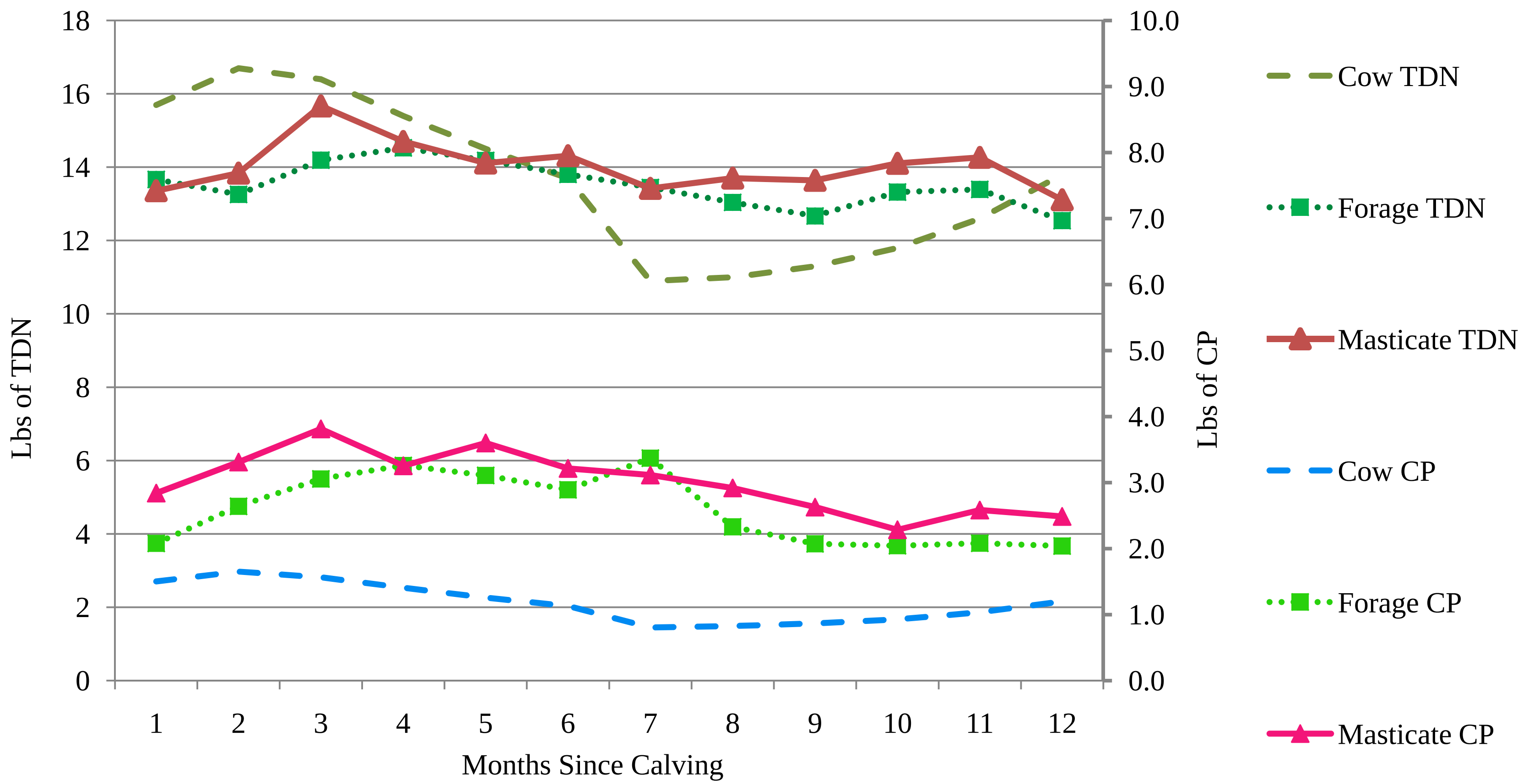

Figure 5-1. Nutrient requirement cycles and pasture characteristics

APPENDIX A
WINTER / SPRING

Table A-1. Effect of forage availability and month on overall mean forage mass (kg/ha) at Ona.

	Month							*P*-value		
FA[a]	Dec	Jan	Feb	Mar	Apr	May	SEM[d]	FA	Month	FA*Month
H[b]	5,805	3,840	3,537	2,971	2,060	7,008	663	0.09	<0.001	0.17
L[c]	2,081	1,339	1,408	1,501	1,095	4,498				

[a]FA= Forage availability.
[b]H = High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of mean, n=48.

Table A-2. Effect of sampling type and month on chemical composition of bahiagrass at Ona.

		Month							*P*-value		
Analysis	Type[a]	Dec	Jan	Feb	Mar	Apr	May	SEM[e]	Type	Month	Type*Month
IVDOM[b]	F[c]	38.56	34.94	39.09	42.83	43.70	51.29	2.05	<0.001	<0.001	<0.001
	M[d]	47.80	51.17	58.41	56.45	65.25	58.72				
CP	F	7.57	9.22	10.93	12.05	11.70	10.84	0.62	<0.001	<0.001	<0.001
	M	9.57	10.56	13.49	11.92	15.72	12.24				
NDF	F	62.23	63.22	62.43	58.63	61.04	58.25	1.23	0.006	<0.001	0.18
	M	59.41	64.40	58.22	53.28	56.53	57.05				
ADF	F	32.03	30.87	38.30	45.82	29.52	29.38	0.89	<0.001	<0.001	<0.001
	M	33.23	32.29	28.08	27.60	28.71	26.33				
DM	F	90.81	91.27	90.90	91.15	90.69	90.68	0.53	0.01	0.27	0.24
	M	91.64	91.22	90.93	91.87	92.92	91.88				
OM	F	94.50	93.32	94.27	93.78	93.64	94.27	1.02	<0.001	<0.001	0.004
	M	84.64	84.68	88.42	84.82	90.03	91.07				

[a]Type= Forage sampling type.
[b]IVDOM= In vitro digestible organic matter.
[c]F= Hand-sampled forage.
[d]M= Masticate.
[e]SEM= Standard error of the mean, n=48.

Table A-3. Effect of forage availability on chemical analysis of bahiagrass at Ona.

	FA[a]			
Analysis	H[b]	L[c]	SEM[d]	*P*-value
Forage				
IVDOM[e]	43.62	39.89	2.49	0.39
CP	11.74	9.06	0.50	0.06
NDF	61.18	60.95	0.80	0.86
ADF	32.87	35.81	0.52	0.05
DM	91.81	91.68	0.40	0.83
OM	85.13	89.45	0.77	0.06
Masticate				
IVDOM	53.10	59.25	1.42	0.09
CP	11.44	13.00	0.57	0.19
NDF	55.33	60.73	0.10	0.06
ADF	26.95	31.76	0.68	0.04
DM	91.32	90.47	0.35	0.22
OM	93.69	94.26	0.39	0.27

[a]FA= Forage availability.
[b]H= High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of the mean, n=24.
[e]IVDOM= In vitro digestible organic matter.

Table A-4. Effect of forage availability and month on steer selection index of bahiagrass forage at Ona.

	FA[b]				Month							
Analysis	H[c]	L[d]	SEM[e]	*P*-value	Dec	Jan	Feb	Mar	Apr	May	SEM[e]	*P*-value
IVDOM[f]	146.81	125.58	10.95	0.23	122.73	146.45	153.78	129.85	149.22	115.12	18.96	0.65
CP	143.53	98.94	14.40	0.08	124.98	118.66	134.53	99.91	136.43	112.88	24.93	0.89
NDF	94.58	95.38	3.45	0.87	93.32	101.86	93.35	90.69	92.75	97.81	5.98	0.78
ADF	98.05	80.29	5.90	0.09	103.64	104.94	74.73	63.79	97.87	90.07	10.21	0.15

[a]{[(Masticate concentration – forage concentration) / forage concentration] * 100} + 100.
[b]FA= Forage availability.
[c]H= High forage availability.
[d]L= Low forage availability.
[e]SEM= Standard error of the mean, n=12.
[f]IVDOM= In vitro digestible organic matter.

Table A-5. Effect of forage availability and month on overall mean forage mass (kg/ha) at Brooksville.

	Month							*P*-value		
FA[a]	Dec	Jan	Feb	Mar	Apr	May	SEM[d]	FA	Month	FA*Month
H[b]	2,344	1,430	2,521	2,211	1,488	2,002	399	0.23	0.15	0.50
L[c]	1,603	933	1,065	1,530	1,248	1,410				

[a]FA= Forage availability.
[b]H = High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of mean, n=48.

Table A-6. Effect of sampling type and month on chemical composition of bahiagrass at Brooksville.

		Month							*P*-value		
Analysis	Type[a]	Dec	Jan	Feb	Mar	Apr	May	SEM[e]	Type	Month	Type*Month
IVDOM[b]	F[c]	40.43	39.69	38.73	44.36	50.26	50.10	1.42	<0.001	<0.001	<0.001
	M[d]	52.44	60.08	58.78	56.62	57.89	57.78				
CP	F	6.78	8.02	8.06	10.20	10.06	10.89	0.49	<0.001	<0.001	<0.001
	M	10.19	12.90	11.47	10.39	11.63	11.63				
NDF	F	65.19	62.31	64.96	61.19	61.48	61.03	2.40	<0.001	0.004	0.13
	M	65.89	55.10	54.89	56.64	58.05	49.00				
ADF	F	34.64	32.73	41.13	35.60	29.14	26.51	1.81	0.003	0.001	<0.001
	M	28.32	28.53	28.46	33.49	35.49	25.65				
DM	F	90.99	91.64	91.00	91.14	90.67	90.85	0.58	0.03	0.50	0.08
	M	90.91	90.66	91.33	92.65	91.92	92.97				
OM	F	95.56	94.87	95.22	94.46	94.56	94.74	1.42	<0.001	<0.001	0.004
	M	84.09	88.60	89.83	83.96	76.47	88.66				

[a]Type= Forage sampling type.
[b]IVDOM= In vitro digestible organic matter.
[c]F= Hand-sampled forage.
[d]M= Masticate.
[e]SEM= Standard error of the mean, n=48.

Table A-7. Effect of forage availability on chemical analysis of bahiagrass at Brooksville.

	FA[a]			
Analysis	H[b]	L[c]	SEM[d]	*P*-value
Forage				
IVDOM[e]	41.95	45.90	0.72	0.06
CP	9.57	8.43	0.32	0.13
NDF	62.39	63.00	1.11	0.73
ADF	33.48	33.11	0.54	0.67
DM	91.21	90.87	0.14	0.23
OM	94.87	94.96	0.16	0.70
Masticate				
IVDOM	54.24	60.29	0.91	0.04
CP	10.82	11.92	0.47	0.24
NDF	52.08	61.11	3.28	0.19
ADF	26.55	33.43	1.99	0.13
DM	92.35	91.14	0.77	0.38
OM	80.77	89.69	1.40	0.05

[a]FA= Forage availability.
[b]H= High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of the mean, n=24.
[e]IVDOM= In vitro digestible organic matter.

Table A-8. Effect of forage availability and month on steer selection index of bahiagrass forage at Brooksville.

	FA[b]				Month							
Analysis	H[c]	L[d]	SEM[e]	*P*-value	Dec	Jan	Feb	Mar	Apr	May	SEM[e]	*P*-value
IVDOM[f]	137.82	126.61	3.88	0.10	129.68	151.72	151.79	127.67	115.74	116.70	6.72	0.04
CP	147.20	116.05	11.29	0.11	150.24	167.84	147.56	101.84	115.55	106.71	19.55	0.24
NDF	89.89	90.52	5.38	0.94	101.08	88.96	84.44	92.53	94.01	80.22	9.33	0.67
ADF	87.56	96.19	11.11	0.61	81.77	87.67	69.17	94.26	121.61	96.77	19.25	0.58

[a]{[(Masticate concentration – forage concentration) / forage concentration] * 100} + 100.
[b]FA= Forage availability.
[c]H= High forage availability.
[d]L= Low forage availability.
[e]SEM= Standard error of the mean, n=12.
[f]IVDOM= In vitro digestible organic matter.

Table A-9. Effect of forage availability and month on overall mean forage mass (kg/ha) at Santa Fe.

	Month							*P*-value		
FA[a]	Dec	Jan	Feb	Mar	Apr	May	SEM[d]	FA	Month	FA*Month
H[b]	1,821	1,120	1,507	1,468	1,310	3,974	429	0.09	0.02	0.19
L[c]	1,052	.	971	1,041	1,059	1,642				

[a]FA= Forage availability.
[b]H = High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of mean, n=48.

Table A-10. Effect of sampling type and month on chemical composition of bahiagrass at Santa Fe.

		Month							*P*-value		
Analysis	Type[a]	Dec	Jan	Feb	Mar	Apr	May	SEM[e]	Type	Month	Type*Month
IVDOM[b]	F[c]	43.66	.	39.32	55.84	51.81	50.42	2.62	<0.001	<0.001	0.01
	M[d]	51.46	.	63.27	63.63	57.08	61.57				
CP	F	7.70	.	11.91	15.20	13.75	13.27	0.89	0.18	<0.001	0.43
	M	9.83	.	14.56	14.72	15.07	13.55				
NDF	F	64.98	.	61.20	49.67	52.51	56.27	1.98	<0.001	<0.001	0.05
	M	60.87	.	46.89	43.82	47.08	54.20				
ADF	F	31.83	.	39.34	27.95	27.94	25.43	2.27	0.02	0.01	0.004
	M	35.14	.	23.91	23.18	28.47	25.56				
DM	F	91.80	.	90.47	89.72	90.80	90.37	0.39	<0.001	0.007	0.002
	M	92.10	.	90.81	91.50	91.73	93.62				
OM	F	95.51	.	95.39	92.85	93.68	94.72	2.04	<0.001	0.30	0.05
	M	80.63	.	86.44	87.20	91.36	88.19				

[a]Type= Forage sampling type.
[b]IVDOM= In vitro digestible organic matter.
[c]F= Hand-sampled forage.
[d]M= Masticate.
[e]SEM= Standard error of the mean, n=48.

Table A-11. Effect of forage availability on chemical analysis of bahiagrass at Santa Fe.

	FA[a]			
Analysis	H[b]	L[c]	SEM[d]	*P*-value
Forage				
IVDOM[e]	48.02	48.40	2.32	0.92
CP	12.82	11.91	0.76	0.49
NDF	54.34	59.51	1.32	0.11
ADF	29.47	31.52	2.47	0.43
DM	90.54	90.72	0.19	0.57
OM	94.33	94.52	0.39	0.77
Masticate				
IVDOM	59.04	59.76	1.26	0.73
CP	13.29	13.81	0.79	0.69
NDF	50.48	50.66	0.73	0.87
ADF	27.23	27.27	1.43	0.98
DM	92.27	91.63	0.58	0.51
OM	86.51	87.01	1.45	0.83

[a]FA= Forage availability.
[b]H= High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of the mean, n=24.
[e]IVDOM= In vitro digestible organic matter.

Table A-12. Effect of forage availability and month on steer selection index of bahiagrass forage at Santa Fe.

	FA[b]				Month							
Analysis	H[c]	L[d]	SEM[e]	*P*-value	Dec	Jan	Feb	Mar	Apr	May	SEM[e]	*P*-value
IVDOM[f]	122.28	133.31	4.22	0.12	108.78	149.30	161.63	114.36	110.47	122.25	6.18	0.02
CP	120.52	110.09	14.58	0.62	136.06	124.90	122.17	96.84	109.80	102.08	21.34	0.79
NDF	94.78	84.15	4.31	0.13	91.04	92.87	76.80	88.46	90.69	96.92	6.31	0.47
ADF	101.86	85.52	7.01	0.15	110.71	102.83	60.95	82.96	102.21	102.49	10.27	0.14

[a]{[(Masticate concentration – forage concentration) / forage concentration] * 100} + 100.
[b]FA= Forage availability.
[c]H= High forage availability.
[d]L= Low forage availability.
[e]SEM= Standard error of the mean, n=12.
[f]IVDOM= In vitro digestible organic matter.

Table A-13. Effect of forage availability and month on overall mean forage mass (kg/ha) at Marianna.

	Month							*P*-value		
FA[a]	Dec	Jan	Feb	Mar	Apr	May	SEM[d]	FA	Month	FA*Month
H[b]	1,263	1,810	995	818	1,038	2,096	308	0.12	0.04	0.42
L[c]	455	535	753	787	581	1,552				

[a]FA= Forage availability.
[b]H = High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of mean, n=48.

Table A-14. Effect of sampling type and month on chemical composition of bahiagrass at Marianna.

		Month							*P*-value		
Analysis	Type[a]	Dec	Jan	Feb	Mar	Apr	May	SEM[e]	Type	Month	Type*Month
IVDOM[b]	F[c]	54.68	35.04	50.80	54.88	54.49	50.19	2.23	<0.001	<0.001	0.06
	M[d]	66.34	54.56	69.51	61.99	60.15	63.65				
CP	F	9.03	9.75	12.16	10.36	11.47	9.83	0.56	<0.001	<0.001	0.08
	M	12.00	11.70	14.24	10.57	11.89	12.61				
NDF	F	56.82	61.99	51.83	46.63	55.00	61.47	1.85	<0.001	<0.001	0.004
	M	50.70	66.35	39.29	39.92	48.01	55.36				
ADF	F	25.97	32.20	38.30	29.50	31.31	34.06	1.04	<0.001	<0.001	<0.001
	M	25.64	34.80	22.92	24.90	27.08	28.96				
DM	F	91.18	91.01	90.21	90.68	89.86	91.03	0.32	0.06	<0.001	<0.001
	M	89.47	91.46	90.49	91.54	89.83	93.96				
OM	F	93.09	95.01	93.05	94.09	92.85	93.99	0.97	<0.001	<0.001	<0.001
	M	85.99	77.57	86.37	91.03	88.69	92.34				

[a]Type= Forage sampling type.
[b]IVDOM= In vitro digestible organic matter.
[c]F= Hand-sampled forage.
[d]M= Masticate.
[e]SEM= Standard error of the mean, n=48.

Table A-15. Effect of forage availability on chemical analysis of bahiagrass at Marianna.

	FA[a]			
Analysis	H[b]	L[c]	SEM[d]	*P*-value
Forage				
IVDOM[e]	52.78	48.25	1.92	0.23
CP	11.60	9.27	0.40	0.03
NDF	54.15	57.09	1.59	0.32
ADF	31.51	32.27	0.83	0.58
DM	90.52	90.80	0.18	0.40
OM	93.59	93.77	0.51	0.83
Masticate				
IVDOM	63.52	62.18	1.47	0.57
CP	13.61	10.73	0.40	0.04
NDF	48.49	51.38	0.87	0.14
ADF	25.82	28.95	0.69	0.09
DM	91.28	91.01	0.11	0.23
OM	88.99	85.00	0.73	0.06

[a]FA= Forage availability.
[b]H= High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of the mean, n=24.
[e]IVDOM= In vitro digestible organic matter.

Table A-16. Effect of forage availability and month on steer selection index of bahiagrass forage at Marianna.

	FA[b]				Month							
Analysis	H[c]	L[d]	SEM[e]	*P*-value	Dec	Jan	Feb	Mar	Apr	May	SEM[e]	*P*-value
IVDOM[f]	123.94	128.94	4.65	0.49	121.72	155.43	137.30	112.87	104.30	126.98	8.11	0.05
CP	113.87	120.90	5.18	0.38	134.69	118.00	116.28	102.07	103.91	129.38	8.96	0.21
NDF	88.81	88.80	4.24	0.99	89.17	107.08	75.44	84.30	87.06	89.77	7.34	0.23
ADF	83.00	90.25	9.20	0.60	98.22	108.30	59.52	81.74	85.92	85.35	15.83	0.46

[a]{[(Masticate concentration – forage concentration) / forage concentration] * 100} + 100.
[b]FA= Forage availability.
[c]H= High forage availability.
[d]L= Low forage availability.
[e]SEM= Standard error of the mean, n=12.
[f]IVDOM= In vitro digestible organic matter.

APPENDIX B
SUMMER / FALL

Table B-1. Effect of forage availability and month on overall mean forage mass (kg/ha) at Ona.

	Month							*P*-value		
FA[a]	June	July	Aug	Sept	Oct	Nov	SEM[d]	FA	Month	FA*Month
H[b]	4,298	6,042	11,773	19,404	14,680	17,762	1,880	0.02	0.005	0.03
L[c]	3,020	4,081	5,576	6,124	5,588	3,798				

[a]FA= Forage availability.
[b]H = High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of mean, n=48.

Table B-2. Effect of sampling type and month on chemical composition of bahiagrass at Ona.

		Month							*P*-value		
Analysis	Type[a]	June	July	Aug	Sept	Oct	Nov	SEM[e]	Type	Month	Type*Month
IVDOM[b]	F[c]	48.69	50.91	44.33	43.67	51.63	45.11	1.31	<0.001	<0.001	<0.001
	M[d]	54.90	56.59	56.96	68.13	69.53	59.74				
CP	F	9.83	8.86	6.87	8.77	7.25	7.53	0.45	<0.001	<0.001	0.004
	M	10.08	8.69	8.57	12.57	11.10	10.65				
NDF	F	60.18	61.18	61.52	67.56	64.78	63.49	1.67	<0.001	0.01	<0.001
	M	64.14	64.68	57.40	54.30	52.58	51.24				
ADF	F	30.17	31.48	33.58	35.94	35.07	34.47	1.03	<0.001	0.12	<0.001
	M	31.23	34.13	32.47	28.08	29.94	27.80				
DM	F	90.26	91.92	91.04	91.76	92.28	91.11	0.85	0.18	0.08	0.04
	M	92.14	93.22	89.25	91.43	88.97	89.47				
OM	F	95.29	94.29	94.85	93.74	93.76	89.00	0.98	<0.001	<0.001	0.008
	M	94.34	91.81	88.43	93.00	92.35	81.98				

[a]Type= Forage sampling type.
[b]IVDOM= In vitro digestible organic matter.
[c]F= Hand-sampled forage.
[d]M= Masticate.
[e]SEM= Standard error of the mean, n=48.

Table B-3. Effect of forage availability on chemical analysis of bahiagrass at Ona.

	FA[a]			
Analysis	H[b]	L[c]	SEM[d]	*P*-value
Forage				
IVDOM[e]	43.62	51.17	0.44	0.007
CP	8.00	8.38	0.14	0.20
NDF	62.40	63.83	0.33	0.09
ADF	33.41	33.59	0.76	0.88
DM	91.30	91.49	0.15	0.48
OM	94.10	92.87	0.39	0.16
Masticate				
IVDOM	59.46	62.49	0.88	0.13
CP	9.81	10.74	0.26	0.13
NDF	56.89	57.98	2.50	0.79
ADF	30.04	31.17	0.82	0.43
DM	90.08	91.41	0.65	0.29
OM	91.75	88.89	0.58	0.07

[a]FA= Forage availability.
[b]H= High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of the mean, n=24.
[e]IVDOM= In vitro digestible organic matter.

Table B-4. Effect of forage availability and month on steer selection index of bahiagrass forage at Ona.

	FA[b]				Month							
Analysis	H[c]	L[d]	SEM[e]	*P*-value	June	July	Aug	Sept	Oct	Nov	SEM[e]	*P*-value
IVDOM[f]	137.24	122.68	4.66	0.08	113.76	111.15	129.22	157.49	136.13	132.01	8.06	0.07
CP	123.67	132.18	10.80	0.60	103.50	97.23	123.75	148.46	153.15	141.47	18.71	0.31
NDF	91.64	91.24	2.68	0.93	105.61	105.72	93.36	80.39	81.57	80.88	4.96	0.03
ADF	90.79	93.93	4.92	0.67	103.90	109.04	96.80	78.14	85.65	80.63	8.54	0.20

[a]{[(Masticate concentration – forage concentration) / forage concentration] * 100} + 100.
[b]FA= Forage availability.
[c]H= High forage availability.
[d]L= Low forage availability.
[e]SEM= Standard error of the mean, n=12.
[f]IVDOM= In vitro digestible organic matter.

Table B-5. Effect of forage availability and month on overall mean forage mass (kg/ha) at Brooksville.

	Month							*P*-value		
FA[a]	June	July	Aug	Sept	Oct	Nov	SEM[d]	FA	Month	FA*Month
H[b]	1,088	.	9,730	9,458	12,830	11,918	1,741	0.05	0.009	0.33
L[c]	1,073	.	5,796	4,164	6,458	4,522				

[a]FA= Forage availability.
[b]H = High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of mean, n=48.

Table B-6. Effect of sampling type and month on chemical composition of bahiagrass at Brooksville.

		Month							*P*-value		
Analysis	Type[a]	June	July	Aug	Sept	Oct	Nov	SEM[e]	Type	Month	Type*Month
IVDOM[b]	F[c]	54.18	.	48.07	54.64	49.65	45.59	2.08	<0.001	0.009	0.42
	M[d]	61.39	.	59.74	62.33	61.31	51.21				
CP	F	12.24	.	8.39	6.93	7.69	6.89	0.42	<0.001	<0.001	0.17
	M	13.34	.	10.92	9.86	10.37	9.49				
NDF	F	60.90	.	61.80	66.59	68.28	63.90	1.10	<0.001	<0.001	<0.001
	M	59.64	.	57.89	57.28	63.68	47.86				
ADF	F	27.98	.	34.09	33.07	37.94	33.72	0.41	<0.001	<0.001	<0.001
	M	29.16	.	34.15	30.73	36.68	26.75				
DM	F	90.73	.	90.18	90.24	93.42	90.94	0.14	0.01	<0.001	<0.001
	M	91.82	.	91.27	91.27	91.22	91.26				
OM	F	94.80	.	94.41	94.74	93.97	94.25	1.26	0.001	0.51	0.38
	M	92.07	.	91.73	91.29	95.23	89.79				

[a]Type= Forage sampling type.
[b]IVDOM= In vitro digestible organic matter.
[c]F= Hand-sampled forage.
[d]M= Masticate.
[e]SEM= Standard error of the mean, n=48.

Table B-7. Effect of forage availability on chemical analysis of bahiagrass at Brooksville.

	FA[a]			
Analysis	H[b]	L[c]	SEM[d]	*P*-value
Forage				
IVDOM[e]	50.84	50.74	0.85	0.94
CP	8.27	8.58	0.34	0.58
NDF	63.98	64.61	0.20	0.15
ADF	33.53	33.19	0.23	0.46
DM	90.91	91.29	0.08	0.08
OM	94.20	94.66	0.14	0.14
Masticate				
IVDOM	60.01	58.75	1.57	0.61
CP	11.06	10.50	0.31	0.32
NDF	54.81	59.87	1.65	0.16
ADF	30.65	32.37	0.75	0.14
DM	91.47	91.34	0.15	0.58
OM	90.91	93.11	0.90	0.21

[a]FA= Forage availability.
[b]H= High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of the mean, n=24.
[e]IVDOM= In vitro digestible organic matter.

Table B-8. Effect of forage availability and month on steer selection index of bahiagrass forage at Brooksville.

	FA[b]				Month							
Analysis	H[c]	L[d]	SEM[e]	*P*-value	June	July	Aug	Sept	Oct	Nov	SEM[e]	*P*-value
IVDOM[f]	118.33	115.11	1.20	0.32	113.29	.	124.29	110.38	123.32	112.33	3.16	0.09
CP	137.77	123.92	6.44	0.20	108.97	.	129.94	142.12	135.50	137.70	10.18	0.32
NDF	85.75	92.36	1.42	0.03	97.95	.	93.68	86.01	92.85	74.18	2.25	0.01
ADF	91.89	97.42	3.08	0.27	104.18	.	100.31	93.02	96.48	79.29	4.87	0.11

[a]{[(Masticate concentration – forage concentration) / forage concentration] * 100} + 100.
[b]FA= Forage availability.
[c]H= High forage availability.
[d]L= Low forage availability.
[e]SEM= Standard error of the mean, n=12.
[f]IVDOM= In vitro digestible organic matter.

Table B-9. Effect of forage availability and month on overall mean forage mass (kg/ha) at Santa Fe.

	Month							*P*-value		
FA[a]	June	July	Aug	Sept	Oct	Nov	SEM[d]	FA	Month	FA*Month
H[b]	3,579	4,947	5,338	9,882	3,830	3,634	439	0.02	<0.001	<0.001
L[c]	1,507	3,951	4,027	2,964	3,716	2,524				

[a]FA= Forage availability.
[b]H = High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of mean, n=48.

Table B-10. Effect of sampling type and month on chemical composition of bahiagrass at Santa Fe.

		Month							*P*-value		
Analysis	Type[a]	June	July	Aug	Sept	Oct	Nov	SEM[e]	Type	Month	Type*Month
IVDOM[b]	F[c]	59.23	52.23	49.02	57.98	62.64	47.99	1.84	<0.001	<0.001	<0.001
	M[d]	53.46	59.09	61.87	63.45	61.73	55.67				
CP	F	15.35	9.70	10.62	10.62	10.16	8.69	0.29	0.004	<0.001	<0.001
	M	11.64	13.70	12.00	8.98	11.49	9.98				
NDF	F	57.31	61.57	61.15	67.33	63.58	63.63	0.58	<0.001	<0.001	<0.001
	M	60.28	61.32	61.50	60.36	65.96	47.51				
ADF	F	27.85	32.01	30.47	29.43	32.05	31.92	0.68	0.36	<0.001	<0.001
	M	31.49	29.39	33.27	30.81	33.55	23.04				
DM	F	89.66	91.87	89.48	90.67	91.51	91.08	0.26	0.008	<0.001	<0.001
	M	91.43	92.73	91.31	90.76	91.66	89.29				
OM	F	94.27	95.06	94.62	94.58	94.13	94.13	0.26	<0.001	<0.001	<0.001
	M	86.08	92.08	93.35	92.82	94.30	92.20				

[a]Type= Forage sampling type.
[b]IVDOM= In vitro digestible organic matter.
[c]F= Hand-sampled forage.
[d]M= Masticate.
[e]SEM= Standard error of the mean, n=48.

Table B-11. Effect of forage availability on chemical analysis of bahiagrass at Santa Fe.

	FA[a]			
Analysis	H[b]	L[c]	SEM[d]	*P*-value
Forage				
IVDOM[e]	54.58	55.11	1.07	0.76
CP	10.88	10.83	0.22	0.90
NDF	63.07	61.80	0.56	0.25
ADF	30.62	30.62	0.65	0.99
DM	90.65	90.78	0.15	0.61
OM	94.55	94.37	0.03	0.06
Masticate				
IVDOM	57.85	60.58	0.99	0.19
CP	11.33	11.27	0.14	0.80
NDF	60.59	59.48	0.50	0.26
ADF	30.00	30.52	0.29	0.33
DM	91.57	90.82	0.19	0.11
OM	92.59	91.02	0.16	0.02

[a]FA= Forage availability.
[b]H= High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of the mean, n=24.
[e]IVDOM= In vitro digestible organic matter.

Table B-12. Effect of forage availability and month on steer selection index of bahiagrass forage at Santa Fe.

	FA[b]				Month							
Analysis	H[c]	L[d]	SEM[e]	*P*-value	June	July	Aug	Sept	Oct	Nov	SEM[e]	*P*-value
IVDOM[f]	107.78	110.36	3.84	0.65	90.79	113.14	126.00	109.53	98.78	116.17	6.64	0.09
CP	110.60	105.27	8.80	0.69	79.07	140.93	112.21	86.90	113.05	115.47	15.24	0.21
NDF	96.38	96.25	2.48	0.97	105.08	99.54	100.49	94.53	103.73	74.50	4.30	0.03
ADF	98.43	100.02	3.02	0.72	113.15	91.75	109.17	104.60	104.68	72.00	5.22	0.02

[a]{[(Masticate concentration – forage concentration) / forage concentration] * 100} + 100.
[b]FA= Forage availability.
[c]H= High forage availability.
[d]L= Low forage availability.
[e]SEM= Standard error of the mean, n=12.
[f]IVDOM= In vitro digestible organic matter.

Table B-13. Effect of forage availability and month on overall mean forage mass (kg/ha) at Marianna.

	Month							*P*-value		
FA[a]	June	July	Aug	Sept	Oct	Nov	SEM[d]	FA	Month	FA*Month
H[b]	1,304	3,079	9,603	9,382	9,082	3,856	979	0.05	<0.001	0.18
L[c]	936	2,363	4,192	6,414	5,842	2,478				

[a]FA= Forage availability.
[b]H = High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of mean, n=48.

Table B-14. Effect of sampling type and month on chemical composition of bahiagrass at Marianna.

		Month							*P*-value		
Analysis	Type[a]	June	July	Aug	Sept	Oct	Nov	SEM[e]	Type	Month	Type*Month
IVDOM[b]	F[c]	55.82	50.41	50.87	61.49	56.15	46.09	1.43	<0.001	<0.001	<0.001
	M[d]	63.97	67.69	64.12	64.12	61.33	59.33				
CP	F	17.30	10.58	8.82	8.48	9.41	10.00	0.43	<0.001	<0.001	<0.001
	M	16.72	13.65	12.87	8.83	10.62	10.49				
NDF	F	59.12	45.01	60.15	59.54	62.12	61.04	4.38	0.84	0.15	0.61
	M	61.54	53.80	54.93	58.95	61.92	58.39				
ADF	F	28.80	29.73	33.15	26.81	30.76	31.93	0.79	0.39	<0.001	<0.001
	M	28.49	25.48	30.93	31.55	32.14	28.77				
DM	F	90.95	91.45	89.79	88.04	92.12	89.90	0.25	<0.001	<0.001	0.004
	M	93.13	92.46	90.84	90.44	92.31	91.17				
OM	F	92.89	94.25	94.44	94.42	93.88	94.13	0.26	<0.001	<0.001	<0.001
	M	92.03	90.74	93.35	92.95	93.35	92.67				

[a]Type= Forage sampling type.
[b]IVDOM= In vitro digestible organic matter.
[c]F= Hand-sampled forage.
[d]M= Masticate.
[e]SEM= Standard error of the mean, n=48.

Table B-15. Effect of forage availability on chemical analysis of bahiagrass at Marianna.

	FA[a]			
Analysis	H[b]	L[c]	SEM[d]	*P*-value
Forage				
IVDOM[e]	52.66	54.28	0.90	0.33
CP	10.24	11.28	0.26	0.10
NDF	54.88	60.78	3.29	0.33
ADF	30.20	30.20	0.91	0.99
DM	90.37	90.38	0.13	0.98
OM	93.96	94.04	0.16	0.75
Masticate				
IVDOM	62.93	63.92	0.91	0.52
CP	10.92	13.48	0.32	0.29
NDF	60.24	56.28	1.41	0.19
ADF	31.29	27.83	0.37	0.02
DM	91.81	91.64	0.11	0.37
OM	92.82	92.21	0.31	0.30

[a]FA= Forage availability.
[b]H= High forage availability.
[c]L= Low forage availability.
[d]SEM= Standard error of the mean, n=24.
[e]IVDOM= In vitro digestible organic matter.

Table B-16. Effect of forage availability and month on steer selection index of bahiagrass forage at Marianna.

	FA[b]				Month							
Analysis	H[c]	L[d]	SEM[e]	*P*-value	June	July	Aug	Sept	Oct	Nov	SEM[e]	*P*-value
IVDOM[f]	119.68	118.09	7.41	0.96	115.83	134.53	126.02	104.03	107.78	128.12	12.84	0.55
CP	106.99	124.53	5.85	0.09	96.82	130.03	147.61	104.75	111.63	103.71	10.13	0.09
NDF	114.64	92.62	6.57	0.06	104.29	131.63	91.44	98.86	99.92	95.63	11.37	0.31
ADF	103.85	92.93	4.56	0.15	98.91	85.48	93.46	117.30	105.42	89.80	7.90	0.21

[a]{[(Masticate concentration – forage concentration) / forage concentration] * 100} + 100.
[b]FA= Forage availability.
[c]H= High forage availability.
[d]L= Low forage availability.
[e]SEM= Standard error of the mean, n=12.
[f]IVDOM= In vitro digestible organic matter.

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BIOGRAPHICAL SKETCH

Ashley Lynn Hughes was born in 1984, in Tampa, FL. She lived in Miami, FL, until the age of 14, and then moved to a beef cattle ranch in Okeechobee, FL. While living and working on the ranch, she developed an interest in the beef cattle industry. This prompted her to begin an undergraduate degree in animal sciences at the University of Florida in 2002 after graduating from Okeechobee High School. Midway through her tenure at UF, Ashley decided to change her major to food and resource economics, since she wished to attend culinary school after graduation. However, her employment in the dairy and ruminant nutrition labs as an undergraduate influenced her to remain in the animal science industry. After graduating with her B. S. degree in 2006, she immediately began working toward a master's degree in beef cattle nutrition. During her studies, Ashley was involved with Gator Collegiate Cattlewomen, Dairy Science Club, Agricultural and Life Sciences College Council, Board of College Councils, and the Animal Science Graduate Student Association. As a University of Florida student, Ashley cultivated a love of the Florida Gators and has been proud to celebrate their football and two basketball national championships. Upon completion of her master's degree, Ashley will begin a career at the Georgia Beef Board.