COMPARISON OF FORAGE OR CO-PRODUCT SUPPLEMENTS ON THE PERFORMANCE AND REPRODUCTION OF BEEF COWS

By

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To my family, if you hadn't been there I wouldn't be here.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

ADG	Average Daily Gain
BCS	Body Condition Score
BW	Body Weight
CP	Crude Protein
DM	Dry Matter
DMI	Dry Matter Intake
IVDMD	In Vitro Dry Matter Digestibility
IVOMD	In Vitro Organic Matter Digestibility
NPN	Non-protein Nitrogen
OM	Organic Matter
RDP	Rumen Degradable Protein
RR	Rye-ryegrass
RUP	Rumen Undegradable Protein
TDN	Total Digestible Nutrients
WCS	Whole Cottonseed
WWT	Weaning Weight

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The objective of this study was to compare the effects of supplementing gestating and lactating beef cows with winter annual pasture compared to whole cottonseed on overall performance and reproduction characteristics. Eighty cows were assigned to one of two supplementation treatments, limit grazing rye-ryegrass pasture (RR) for 2 h/day or whole cottonseed (WCS) fed at 0.5% of mean pen BW, with two replications per treatment. Cows were maintained on dormant bahiagrass (*Paspalum notatum)* pastures. All cows had *ad libitum* access to Coastal bermudagrass (*Cynodon dactylon* L.) hay throughout the study. Supplement treatments were fed from December 19, 2010 to April 19, 2011. Cows were stratified by BW, BCS, breed, and expected calving date. Cow BW was greater (P = 0.02) for RR on January 13, 2011 and at conclusion of the supplementation period (P = 0.04). Cow BCS was greater (P= 0.03) for WCS in January however, at the conclusion of the supplementation period cow BCS for RR was greater (P = 0.02). Estimated hay DMI was greater (P < 0.001) for WCS in December, though hay DMI did not differ at any other time. Calf birth weight tended (P = 0.09) to be heavier for RR as did calf BW at conclusion of the supplementation period (P = 0.11)

and at weaning (P = 0.13). Adjusted 205-day weights were greater (P = 0.05) for RR calves compared to WCS calves. Additionally, calf ADG from birth to conclusion of the supplementation period was greater (P = 0.05) for RR and tended (P = 0.13) to be from birth until weaning. Weight per day of age also tended (P = 0.10) to be greater for RR calves. Thirty-day and breeding season pregnancy rates did not differ between supplementation treatments. Supplementation cost per cow for RR was $14.10 less compared to WCS. The results from this study indicate that using rye-ryegrass winter pasture as a supplement for mature cows may improve cow and calf performance as effectively as or better than supplementation with WCS.

CHAPTER 1
INTRODUCTION

Beef production in Florida primarily consists of cow/calf production. The majority of nutrition comes from forage sources. Bahiagrass is the most common forage planted and utilized in Florida (Chambliss and Sollenberger, 1991). Due to the seasonal production of warm-season grasses such as bahiagrass it is important to have a proper supplementation program during the winter period when forage quantity and quality are limiting.

Most winter cow feeding programs in the Southeast still consist of feeding hay and a high protein concentrate (Gunter et al., 2002). There are many types of concentrate supplements available such as manufactured and commodity byproducts. These supplements improve animal performance by providing added nutrients that can be lacking during the winter period. However, supplementation of cows with cool-season annual forages in place of concentrate has shown promise for supplementation. Possible benefits of supplementation with cool-season annuals include decreases in amount of hay fed along with increased body weights (BW) of cows and calves. In order to maximize profitability producers must meet the nutrient requirements of the animal as economically as possible.

The purpose of this study was to compare a traditional winter supplementation system to one utilizing cool-season annual forage as a supplement. Determining the differences in animal performance and comparing the economic feasibility of each system allows for the maximization of profit.

CHAPTER 2
REVIEW OF LITERATURE

Beef Cow Nutrient Requirements

Nutrient requirements of beef cows can be divided into several categories: maintenance, gestation and lactation. From these categories, requirements for energy, protein, vitamins, minerals, and water can be calculated (NRC, 2000). The nutritional requirements for beef cows at these different stages can vary greatly within and between categories due to a number of factors.

Energy Requirements

Maintenance

The maintenance requirement for energy is the amount of feed energy intake that will result in no net loss or gain of energy from the tissues of the animal body (NRC, 2000) and is considered the most important requirement to be met before nutrients are used for production. There are many factors which affect the maintenance energy requirements such as environment, breed type, BW, state of production, and age (NRC, 2000). Ferrell and Jenkins (1984) stated that approximately 70% of the energy required by the cow herd can be attributed to energy costs for cow maintenance. Therefore it is important to understand how different factors affect these requirements so production efficiency can be maximized.

Environmental conditions can affect maintenance energy requirements, especially with concern given to a combination of temperature and humidity. Extreme temperatures can alter the energy needed for the animal to increase body heat or to dissipate body heat depending on the climate. In the Southeastern U.S., especially Florida, heat stress will be the most common environmental concern. In a study by Fox and Tylutki (1998) it was reported that milk production of dairy cows in a 30°C environment with 20 and 80% humidity decreased by 2.6 and 11.9 kg/day, respectively. This illustrates the increased amount of energy needed to meet the base requirements of the animal when under environmental stress due to the higher energy cost associated with getting rid of the excess heat. Therefore it in order to sustain an equal level of production compared to cows not heat stressed more energy must be provided. Declines in dry matter intake (DMI) have also been associated with heat stress (Holter et al., 1996; West, 2003) and DMI decline has also been related to declines in milk yield (West, 2003). The decrease in DMI leads to less energy consumption by the cow which in itself decreases milk production. The added cost of dissipating heat further increases the maintenance energy requirement, thus lowering production further. Fox et al. (1988) predicted decreases in energy intake of beef cattle as ambient temperature increased. At a temperature of 10°C energy intake was estimated to be 8% greater than at 20°C. In a cow-calf system this could lead to inadequate calf growth due to low milk yielded by the dam as a result of decreased nutrients available for production.

Breed type can also possibly have an effect on maintenance requirements. Dairy breeds have an estimated 20% greater maintenance requirements in comparison to beef breeds due to higher milk production potential (NRC, 2000). Within beef cattle types there are also differences. According to the NRC (2000), *Bos indicus* breeds have a maintenance energy requirement 10% less than *Bos taurus* breeds. Differences in maintenance energy requirement is attributed to the low quantities of internal fat and smaller metabolically active organs commonly found in *Bos indicus* cattle compared to *Bos taurus* cattle. Butler et al. (1956) and Lunt et al. (1986) both reported lower internal metabolically active (liver, intestines) organ tissue mass in Brahman cattle compared to Angus and Hereford cattle. In a study evaluating 8 breed groups for differences in ME for maintenance, Reid et al. (1991), reported that Brahman x Hereford and Brahman x Angus cows tended to require less daily ME for maintenance (138.58 and 142.95 kcal/kg$^{0.75}$, respectively) than straightbred and crossbred British and Continental breeds. In agreement, Ledger and Sayers (1977) reported that *Bos indicus* steers required 37.3% less feed than *Bos taurus* steers to maintain a constant BW of 185 kg.

There is conflicting research as to the effect of BW on maintenance energy requirements. According to findings reported by Lofgreen and Garrett (1968) maintenance requirements of beef cows within similar production systems is primarily dependent on BW. The NRC (2000) uses the metabolic BW equation reported by Lofgreen and Garrett (1968) as an indicator to calculate nutrient requirements. This equation has been disputed however. Thompson et al. (1988) evaluated the influence of BCS on energy requirements in gestating Angus x Hereford and Angus x Holstein cows. According to the equation proposed by Lofgreen and Garrett (1968) cows with greater BW and of similar type would have increased maintenance energy requirements. However, Thompson et al. (1983) reported that in Angus x Hereford cows, fatter cows had 6.1% lower energy requirements than thinner cows in the same breed group. Conversely, thinner Angus x Holstein cows had lesser energy requirements (2.7%) than fatter cows of the same breed group. Also in contrast to the NRC (2000) equation, Klosterman et al. (1968) reported that cows with increased BCS did not have any significantly greater maintenance requirements than thinner cows. However, in agreement with the equation proposed by Lofgreen and Garrett (1968), Houghton et al.

(1990b) reported that cows with greater BW (578.9 kg) had a greater daily maintenance energy requirement (10.59 Mcal) than cows weighing 506 kg (8.74 Mcal). Due to discrepancies in the literature, it is important to not use just BW as a sole predictor of nutrient requirements of cattle.

Age of the animal is another variable in determining maintenance energy requirements, though the primary factor influencing this seems to come from whether or not the animal has reached maturity. According to the NRC (2000), the maintenance requirements of young, growing animals is greater than that of older mature animals. Equations proposed by Graham et al. (1974) and Corbett et al. (1985) have predicted the decrease in maintenance requirements for each year of age as 8 and 5%, respectively. However, Blaxter and Wainman (1966) did not report significant differences in maintenance requirements due to age in steers ranging from 15 to 81 weeks of age. Most research agrees that maintenance requirements decrease per unit of BW as age increases however, total maintenance requirements are often still greater for mature animals due to increased size (Reiling, 1998).

Gestation

Maintenance energy requirements during gestation are greater than those for non-pregnant, dry cows (NRC, 2000). This is due to increased heat production associated with anabolic process related to fetal growth. The energy requirement associated with gestation in beef cows increases gradually over the length of gestation (Hersom, 2012). Hersom (2012) reported that at the third month postpartum the energy required for gestation is only 0.1% of the total energy requirement. However, at one month prior to parturition the gestation energy requirement is approximately 56% of the total energy requirement. Likewise, Warrington et al. (1988) reported that the energy requirement for two-year old heifers increased by 25% as gestation lengthened and efficiency of ME use decreased by 35% during the same time period.

Montano-Bermudez et al. (1990) conducted two separate trials to examine the differences in energy requirement for maintenance required during gestation compared to lactation maintenance energy requirement. The two trials used 71 and 77 crossbred cows from Milking Shorthorn, Hereford, and Red Poll sires and Angus dams, with the findings that the total energy requirements during gestation were 86.5 and 78% of the total energy requirements during lactation in trials one and two, respectively. The results of these studies would suggest that energy requirements for maintenance are similar to non-pregnant cows early in gestation, however requirements increase rapidly during mid to late gestation. However, maintenance requirements during gestation are less than those of lactation.

Lactation

Cow total energy requirements during lactation are greater than those at maintenance. Based upon a 500 kg cow yielding 4.5 kg/day of milk, the maintenance energy requirements during peak lactation are approximately 31% greater than those during gestation while not lactating (NRC 2000). Similarly, Neville (1974) reported an increase in maintenance energy requirements for lactating cows (0.172 mcal/kg $BW^{0.75}$ of ME) compared to non-lactating cows (0.125 mcal/kg $BW^{0.75}$ of ME) resulting in a 38% increase. These results are in agreement with Moe et al. (1970) and Neville and McCullough (1969) who reported increases in maintenance energy requirements for lactating cows compared to non-lactating cows of 22 and 30%, respectively. The increase was in requirements was likely lessened in Moe et al. (1970) due to the study utilizing dairy cows which as previously discussed have greater maintenance requirements than beef cows. It can be concluded based upon these research findings that maintenance energy requirements during gestation are greater than those of non-lactating, non-pregnant cows, and that maintenance energy requirements during lactation are greater than those during gestation or at maintenance.

Protein Requirements

Maintenance

Maintenance protein requirements for ruminants are relatively low due to the fact that protein is only needed to insure proper microbial growth and to replace nitrogen lost in tissue turnover (Ørskov, 1982). As a result mature, non-lactating, non-pregnant cows can subsist on a diet with protein as low as 7% (Hersom, 2012). Metabolizable protein is defined as the true protein that is absorbed by the intestine. Metabolizable protein is supplied by the microbial protein and from rumen undegraded protein (NRC, 2000). The maintenance requirement for protein is represented by the amount needed to offset metabolic fecal, urinary, and scurf losses (NRC, 2000). While it has been suggested that the rumen microbial environment can subsist with ammonia-nitrogen concentrations as low as 0.3 mg/dL (Owens and Zinn, 1993), dietary protein is needed in much greater concentrations to support metabolism during different stages of production including gestation and lactation.

Gestation

During gestation protein requirements increase gradually with the largest increase occurring during the last trimester of pregnancy when the majority of fetal growth takes place (Winters et al., 1942). Late gestation crude protein (CP) requirements are approximately 27% greater than those at maintenance.

Diets deficient in protein, especially during late gestation have been found to negatively affect both cow rebreeding rates (Mobley et al., 1983; Garmendia et al., 1984) and subsequent calf vigor (Bull et al., 1974). In a study conducted by Sasser et al. (1989) 40 Hereford first-calf beef cows were allotted to two isocaloric diets that provided 100% of the NRC recommended requirements for energy but contained either adequate (0.96 kg CP/day) or inadequate (0.32 kg CP/day) levels of protein. The cows fed adequate protein had greater rates of first service conception (71 vs. 25%) and greater overall pregnancy rates (74 vs. 32%) compared to cows provided inadequate protein. Likewise, Clanton (1982) reported decreases in overall pregnancy rates for cows fed a prepartum diet deficient in protein (91 vs. 80%). Research by Koritnik et al. (1981) reported that ewes underfed protein during late gestation (last 50-60 days) produced lambs that had a 24% lower birth weight than lambs from control ewes provided adequate protein. Underfed ewes also had a greater decline in BW from 90 days of gestation until 24 hr. after parturition (14 kg vs. 2.7 kg) than control ewes. This decline in BW was believed to be from the ewes mobilizing lean body tissue to maintain pregnancy due to the diet being deficient in total protein and nitrogen. The research clearly shows that the increased protein requirements during gestation, especially late gestation, are important to meet in order to not jeopardize subsequent dam and progeny performance.

Lactation

Just as with energy requirements during lactation, protein requirements during lactation are greater than those at maintenance or gestation (NRC, 2000). According to calculation from the NRC the CP requirement for a mature cow during peak lactation is approximately 31% greater than at maintenance (NRC, 2000).

Just as with diets that are deficient in protein during gestation, diets deficient in protein during lactation have a negative effect on subsequent cow pregnancy rates (Hancock et al., 1984; Rakestraw et al., 1986). In a study by Cantrell et al. (1982) 101 Angus x Hereford cows were assigned to either an adequate or inadequate protein supplementation program and fed from calving until the start of the breeding season after which all cows were managed the same. Cows supplemented the adequate protein level had a greater conception rate (96 vs. 82%) than those supplemented the inadequate level. Likewise, Kropp et al. (1983) reported increased pregnancy rates in cows supplemented with a moderate level of nutrition (energy and protein to maintain BCS of 6) compared to cows receiving 10% less nutrients (90.8 and 71.4, respectively). It can be concluded from the research that a diet deficient in protein during gestation and lactation is detrimental to animal performance.

Nutritional Management

The basis of nutrition in the Florida cow/calf herd comes from the primarily forage diet they consume. During the summer growing season perennial grasses and legumes can be grazed with little labor required. During the winter period however, it is important to provide conserved forage due to perennial grasses and legumes becoming dormant and unproductive. Though there are many types of forages grown throughout Florida the two most common types which provide the basis for cow nutrition are bahiagrass and bermudagrass. While bahiagrass is commonly grazed, bermudagrass is often grown to be cut and conserved which can be fed during the dormancy period.

Perennial Pasture

Bahiagrass

Bahiagrass (*Paspalum notatum* Flugge) is a seed propagated warm-season perennial grass that is commonly grown throughout Florida and the Gulf Coast region (Chambliss and Sollenberger, 1991). Bahiagrass is the most widely used forage in the Florida beef industry due to its adaptability to low fertility soils, high grazing tolerance, and resistance to encroaching species (Chambliss and Sollenberger, 1991). Bahiagrass is planted on over 2 million acres in Florida (Newman et al., 2012a) and is most productive from April to October; though with proper management can be utilized into December (Chambliss and Sollenberger, 1991). Bahiagrass has annual production yields between 3,350 and 11,200 kg/ha with most of this during the warm, growing season (Newman et al., 2012a). In a study by Inyang et al. (2010) yields of nitrogen fertilized bahiagrass (150 kg N/ha) were measured in two different years during the summer growing season. In year one, the average production from May to September was 3,100 kg/ha; while in year two, the average yield was 4,900 kg/ha. The contrast in yields was attributed to the below average rainfall in year one. Hughes and Hersom (2009a) reported unfertilized bahiagrass yields at four locations throughout Florida that represented the entire state. During the summer and fall growing season the state average yield from June to November was 5,950 kg/ha. As stated previously however, due to its seasonal production, herbage mass of bahiagrass is limited during the fall and winter season from November to March. Hughes and Hersom (2009b) utilizing the same representative locations as in Hughes and Hersom (2009a) reported yields of bahiagrass during the winter and spring from December to May with a reported state mean of 1,827 kg/ha. Gates et al. (2001) measured herbage accumulation of three bahiagrass cultivars (Pensacola, Tifton 9, and RRPS Cycle 18) during from October to March at two different locations (Tifton, GA and Ona, FL). The results of Tifton 9 and RRPS Cycle 18 were averaged because RRPS Cycle 18 was derived from the same line as Tifton 9. The two-year average of the herbage accumulation rates was greater for Tifton 9 and RRPS Cycle 18 compared to Pensacola at Tifton (9.6 vs. 4.3 kg/ha/day) and Ona (19.95 vs. 8.5 kg/ha/day).

Although bahiagrass produces adequate forage mass during the growing season, the nutritive value is often low (Newman et al., 2012a). Arthington and Brown (2005) reported CP concentration of approximately 9% at four weeks of growth and in vitro OM digestibility (IVOMD) concentration of 52.3% during the growing season. Hughes and Hersom (2009a) reported for bahiagrass an average Florida state mean of 9.64% CP and IVOMD of 51.68%. Sollenberger et al. (1988) conducted a two year study utilizing crossbred steers (average BW =242 kg), in which animal performance on Pensacola bahiagrass was evaluated. The two year average daily gain (ADG) for these steers was 0.38 kg/day with forage nutritive value of 8.9% CP, and IVOMD of 46%. While these levels are adequate to support mature animals with decreased nutrient requirements when there is adequate forage mass availability (Chambliss and Sollenberger, 1991) the quality is not sufficient to maintain animals with greater nutritional requirements such as growing calves or lactating dairy animals (Newman et al., 2012a).

Bermudagrass

Bermudagrass (*Cynodon dactylon*) is the second most planted perennial grass in Florida with approximately 141,640 hectares in production, mostly in North Florida for stored forage production (Newman et al., 2012b). Bermudagrass is popular for both hay and grazing due to its tolerance to grazing, and highly efficient response to fertilization, and increased forage yields that are important in hay production (Newman et al., 2012b). As with bahiagrass, bermudagrass is a warm-season perennial grass that is most productive from May to October with yields of 11,000 to 22,500 kg/ha during the productive season and 5,600 to 11,000 kg/ha during the winter season depending on N fertilization application rates (Newman et al., 2012b). A summary of research reports that CP concentrations can range from 16% at 2 weeks of regrowth to 8% at 10 weeks of regrowth (Newman et al., 2012c). In a study by Prine and Burton (1956) the effect of N fertilizer on yields of Coastal Bermudagrass was evaluated during the summer growing season. The N application rates were 0, 112, 336, 672, and 1,008 kg/ha with two year average DM yields of 2,443, 7,397, 13,450, 17,284, and 18,282 kg/ha, respectively. There was a quadratic response to N fertilization at the 336 kg/ha application with yields leveling off after that. There are reported differences in both forage yield and quality among bermudagrass cultivars however. Mandebvu et al. (1999) compared dry matter yields and In vitro dry matter digestibility (IVDMD) of Tifton 85 and Coastal bermudagrass under equal fertilization rates. Tifton 85 had greater DM yield (4.5 vs. 4.2 tons/ha) and IVDMD (58.7% vs. 54.8%) than the Coastal cultivar, respectively. In a study by Burns and Fisher (2007) masticate samples of steers were evaluated. The steers were fed Tifton 85 and Coastal bermudagrass hay harvested at 4 weeks of regrowth. Tifton 85 had greater CP concentrations than Coastal bermudagrass (18.9 vs. 7.3 %) in masticate samples taken. Jolliff et al. (1979) reported that as the growing season and maturity increased in Coastal and Coastcross-1 bermudagrass cultivars there were declines in IVDMD and CP associated with increases in acid detergent fiber (ADF) and neutral detergent fiber (NDF). This would indicate that as with bahiagrass, bermudagrass chemical composition is significantly negatively affected with advancing maturity.

Conrad et al. (1981) compared steer performance on Coastal and Callie bermudagrasses under grazing and reported greater ADG for the Callie variety (0.6 vs. 0.5 kg/hd/day) compared to Coastal. In addition Callie supported a greater average stocking density (9.68 vs. 8.68 steers/ha) than Coastal did. In an effort to determine the economic benefits of different fertilization rates of Coastal bermudagrass, Neville and McCormick (1976) evaluated the profitability of two different fertilization rates over two years. The higher fertilization rate was approximately double the lower rate. While the higher fertilization rate provided both greater ADG per unit of land area for cows and calves (2.44 vs. 1.88 kg/ha) and total saleable calf weight (5,502 vs. 3,919 kg) compared to the lower fertilization rate, respectively. The average return per cow however, was greater for the low ($53.66) fertilization rate compared to the high ($29.38) rate due to the much greater costs associated with the increased fertilization rate.

Conserved Forage

The conservation of forage has been defined by Gallaher and Pitman (2001) as "the preservation of forage plant material to provide feed for livestock at a time after the primary period of growth of these plants". As stated previously due to the seasonal growth patterns of perennial grass species in Florida it is important to provide supplemental forage to what is available in pastures during the winter dormancy period. This is most commonly done with hay in beef cattle systems. The objective of hay production is to minimize yield and nutritive value losses by drying and storing as quickly as possible (Sollenberger et al., 2004). Hay is the most widely grown and mechanically harvested agronomic crop in the United States with over 24.3 million hectares harvested to produce over 150 million tons of hay (Ball et al., 1998). It is of great importance to minimize losses associated with hay production in order to maintain as much profitability as possible (Ball et al., 1998). The losses associated with hay can be broken into field, storage,feeding losses.

Field and storage losses

The two losses that occur in the field and in storage are DM and nutritive value and can both vary widely depending upon forage management decisions. The greatest factor affecting forage losses is drying time of the cut forage. Due to this it is imperative to have the forage dry as quickly as possible in order to halt plant respiration so that losses are kept to a minimum (Sollenberger et al., 2004). Respiration is the process in which plant cells metabolize sugars to produce energy for the plant to use. However, because this process uses sugars in the forage it effectively lowers the nutritive value of the hay, hence the importance of halting it as quickly as possible (Sollenberger et al., 2004). In order to increase the speed at which the cut forage dries there are several management options available. Conditioning of cut forage is the process by which a mechanical device crimps or crushes the stem of the plant which allows moisture to escape more easily through the broken stem. Tedding of forage is the stirring action that moves the wetter forage at the bottom of the windrow to the top of the windrow so that drying can occur more quickly. Chemical treatments can also be used to aid in the drying process.

Losses during storage are the result of respiration as well, and can vary depending on where and how hay bales are kept. Huhnke (2003) reported percent DM losses for different storage conditions of hay. Round bales stored outside on the ground and uncovered have DM losses of up to 20%. In comparison round bales stored in the same manner but off the ground have 5% less loss in DM%. Round bales stored under a roof have much less DM losses (less than 5%) due to not being subjected to the weather conditions of sun and rain during the storage period. The consequence of being subjected to the elements is called weathering. Weathering occurs on the outer portion of the bale and results in decreases in digestibility and increases in fiber (Guerrero, 2006). To determine forage quality losses due to weathering, Lechtenberg et al. (1979) compared weathered and unweathered round bales of grass hay. The weathered round bales had decreased in vitro digestibility values (42.5%) compared to non-weathered bales (58.8%) and an increased dollar loss of $9.72/ton. For alfalfa bales, weathered bales (34.2%) also had decreased digestibility compared to unweathered bales (56.5%) and resulted in a loss of $22.68/ton.

Feeding losses

Losses during feeding occurs from hay being wasted by animals. This can happen due to trampling, refusal, and contamination (Ball et al., 1998). These losses are influenced by feeding method, feeding frequency, and forage quality (Ball et al., 1998). The amount of waste can be as small as 2-3% up to over 50% (Ball et al., 2007). Some methods to decrease trampling and contamination include feeding the hay in an enclosed area such as a hay ring or hay cone (Kallenbach, 2012). This minimizes the ability of the animals to spread they hay around or bed down in it or defecate on it. Buskirk et al. (2003) evaluated four types of hay feeders (ring, cone, trailer, and cradle) to determine which allowed for greatest intake and greatest waste. Cows feeding from a cradle and trailer wasted the greatest amount per day (1.9 and 1.6 kg/day, respectively) followed by those feeding from a ring (0.7 kg/day) and cone (0.4 kg/day). Feeding high quality hay or grinding low quality hay can decrease the amount of refusal from animals by taking away the ability to select against longer stem and weathered material (Ball et al., 1998). One management tool that can be used to decrease all feeding losses is to only feed a one day supply at a time (Ball et al., 2007) or restrict hay access time (Miller et al., 2007). Miller et al. (2007) evaluated the difference in hay wastage and cow performance when feeding access to hay was restricted in two trials. In trial 1 cows in the last trimester of pregnancy were given access to high quality hay (17.6% CP, 45% NDF, 62.3% total digestible nutrients [TDN]) for either 3, 6, 9 hrs/day, or *ad libitum* access. Hay wastage tended to increase linearly as access time was increased. Total hay disappearance per cow was least for animals allowed access to hay for 3 hrs (8.0 kg/day) and greatest for those allowed ad libitum access (15.6 kg/day). In addition all cows gained BCS during the course of the trial. Trial 2 consisted of cows in the last trimester of pregnancy allowed access to adequate quality hay (15.4% CP, 57.1% NDF, 61.2% TDN) for 6 or 9 hrs/day, or *ad libitum*. In agreement with the first trial, hay disappearance increased linearly as access time increased (10.7 kg/day vs. 12.9 kg/day for *ad libitum* access) while BCS increases were still observed. These two trials indicate that limiting access time to hay can decrease feeding costs while still maintaining an acceptable increase in BCS prior to calving and lactation. In conclusion, feeding losses associated with feeding of conserve forage in round bales can be greatly decreased with proper management.

Supplementation Strategies

In the Southeastern U.S. and especially Florida, the beef cattle industry is almost completely dependent on forage-based systems for production (Burns, 2006). During periods of low forage quality it is often necessary to provide supplemental nutrients to cows in order to maintain adequate nutritional status. Concentrates are a common form of supplements fed to cattle and can provide energy and/or protein to nutrient deficient animals. Concentrates are characterized as nutrient dense feeds providing large amounts of nutrients in smaller form. Though less widely used, high-quality forages also have the ability to provide supplemental nutrients to the cow herd during periods of nutrient deficiencies.

Forage Sources

High quality grasses

Intake. Villalobos et al. (1997) evaluated the effects of supplementing gestating beef cows grazing native range with high-quality meadow regrowth hay during the period of November through February for two consecutive years. Cows were allotted to four treatments consisting of 1) native range only; 2) native range plus 2.2 kg/day of meadow hay (15.5% CP); 3) native range plus 1.2 kg/day of a 70:30 wheat grain: soybean meal supplement (36% CP); and 4) native range with treatments 2 and 3 supplements fed on alternating days. Native range intake and total intake (kg/100 kg BW) were similar between the native range only treatment and the three suplemental treatments and between hay and soybean meal treatments. However, native range intake (1.96 vs. 1.64 kg/100 kg BW) and total intake (2.24 vs.1.91 kg/ 100 kg BW) were greater for the average of treatments 2 and 3 compared to treatment 4. These results imply that feeding of supplemental hay elicits a similar intake response as soybean meal.

Gunter et al. (2002) evaluated the feasibility of supplementing gestating cows with winter annual pasture. An experiment was conducted over two years using 120 cows. All cows were kept on common bermudagrass pastures, received *ad libitum* bermudagrass hay and were either; 1) supplemented with a concentrate based supplement (33% corn, 67% corn gluten feed) at 1.2 kg/day 3 days/week; 2) allowed to graze winter annual pasture for 7 hrs/day twice a week or 3) allowed to graze winter annual pasture for 7 hrs/day 3 days/week. Winter annual pasture consisted of a mixture of wheat, rye, and annual ryegrass and was grazed from January to the end of April each year. Dry matter intake of hay was greater for cows receiving a concentrate based supplement (11.5 kg/day)compared to those grazing winter annual pasture (9.9 kg/day). The decrease in hay fed to cows grazing winter-pasture could be attributable to the increased gut fill associated with intake of forage.

Utley and McCormick (1978) evaluated two systems for maintaining a cow-calf herd through the winter for two years during the period of February to April. One treatment group was maintained on dormant coastal bermudagrass with annual ryegrass sod-seeded into the pasture and fed *ad libitum* coastal bermudagrass hay while the second treatment was maintained on dormant coastal bermudagrass and fed *ad libitum* coastal bermudagrass hay and supplemented with 0.45 kg/head/day of cottonseed meal. Total hay DMI was increased for the treatment fed cottonseed meal (1.62 metric tons) as a supplement in both years when compared to the winter grazing treatment (1.13 metric tons). As stated previously this is likely due to the increased gut fill as a result of having a forage supplement. The results from these studies imply that supplementation with high quality forages decreases intake of hay (Gunter et al., 2002; Utley and McCormick, 1978) without decreasing total intake (Villalobos et al., 1997).

Digestibility. Villalobos et al. (1997) reported decreased digestibility of native range forage in supplemented cows (59.0% of DM) compared to non-supplemented cows (60.48% of DM). Total diet digestibility was not different between the non-supplemented and the supplement treatments however, the wheat-soybean meal supplemented cows (61.5% of DM) had greater total diet digestibility than did cows supplemented with meadow hay (59.2% of DM). This is likely due to the differences between the digestibility of the two supplements themselves (60.8 and 83.8% for meadow hay and wheat-soybean meal, respectively). While digestibility of low-quality forage was decreased with supplementation, the similarity in intake and total digestion imply that these would not have negative effects on production.

Performance. Villalobos et al. (1997) reported BW losses of non-supplemented cows in both years of the study (11 and 38 kg loss in year 1 and 2, respectively) compared to BW gains of the supplemental treatments (48 and 22 kg gain in year 1 and 2, respectively). In year 1, the wheat-soybean meal supplement cows (50 kg) had greater BW gains than the meadow hay supplemented cows (41 kg), but in year 2 the meadow hay supplemented (33 kg) cows had greater BW gains compared to wheat-soybean meal supplemented cows (3 kg). Additionally, in year 2, the cows fed both of the supplements on alternate days had greater BW gains (29 kg) compared to the average of the two individual supplement treatments (8 kg), this was due to the very low gains of the wheat-soybean meal supplemented cows. Non-supplemented cows had lower BCS at conclusion of the trial in both years (4.7 and 4.2, respectively) than the supplemented cows did (5.8 and 5.5, respectively). Additionally in year 1, cows supplemented with wheat-soybean meal had greater BCS (6.1) at conclusion of the trial than did cows supplemented with meadow hay (5.7). In year 2, the meadow hay treatment cows had greater BCS (5.7) at conclusion of the trial than wheat-soybean meal supplemented cows (5.3), though this difference was not significant. The increased performance of supplemented cows is likely due to the increased protein consumed, while the protein requirements of the un-supplemented cows were not met by the native range forage.

Gunter et al. (2002) reported that cow BW did not differ between cows limit grazed on winter annual pasture or supplemented with a corn-corn gluten meal concentrate at any point in either year of the experiment. However, BCS was greater for cows grazing winter pasture at the end of the trial period in year 1 (6.7) compared to those receiving a concentrate based supplement (6.1). In year 2, BCS of cows was not different during the trial period and at no point in either year was BCS different between cows grazing winter pasture either 2 or 3 days a week. Additionally BCS at calving was similar for all treatment groups (6.0). Utley and McCormick (1978) reported greater ADG for cows grazing sod-seeded ryegrass from February to April in both year 1 (0.35 vs. 0.01 kg/day) and year 2 (0.52 vs. 0.10 kg/day) when compared to cows receiving a supplement of cottonseed meal. Supplementation with high-quality forages yields gains that are greater than those of non-supplemented animals. Additionally, forage supplementation results in comparable or increased animal gains and condition scores when compared to traditional concentrate supplementation during the winter feeding period.

Reproduction. Villalobos et al. (1997) reported no differences in pregnancy rates (95.5%) or calf birth (42 kg) and weaning (253 kg) weights between treatments for both years in the experiment. Though non-supplemented cows lost condition, it was apparently not enough to have adverse effects on pregnancy rate. Cows starting the winter period in poorer condition could possibly experience lower pregnancy rates if not supplemented.

Likewise, Gunter et al. (2002) reported no differences in pregnancy rates between cows offered a concentrate based supplement or those allowed to limit graze winter annual pasture for 2 or 3 days/week, though there was a tendency for cows grazing winter pasture 3 days/week to have lower pregnancy rates than those grazing 2 days/week (85 vs. 93%). High plasma urea nitrogen concentrations (> 16.5 mg/100mL) caused by intake of feeds with high CP concentrations have been reported to inhibit fertility (Elrod and Butler, 1993). Though total CP of the diets were not calculated in this study, cows grazing winter annual pasture likely consumed a diet high in CP concentration due to hours spent grazing winter annual pasture which regularly exceeds 16% CP (West et al., 1988). Calf birth weights, weaning weights, and ADG were not affected by treatment.

In agreement with both Villalobos et al. (1997) and Gunter et al. (2002), Utley and McCormick (1978) reported similar pregnancy rates for cows grazing winter forage and cows receiving a concentrate based supplement. In year 1 pregnancy rates were 100% and 92% for cows grazing sod-seeded ryegrass and cows receiving cottonseed meal, respectively. Similarly in year 2 pregnancy rates were 95% and 96%, respectively. Calf birth weights were not different between treatments in either year but in contrast to Villalobos et al. (1997) and Gunter et al. (2002), ADG of calves from the period of February to April was greater for calves grazing ryegrass in year 1 (0.94 vs. 0.69 kg/day) and year 2 (0.94 vs. 0.65 kg/day) compared to those receiving a concentrate based supplement. This increase in ADG led to greater weaning weights in both years of the experiment. Additionally Utley and McCormick (1978) conducted an economic analysis to determine the return on costs of each treatment. The sod-seeded ryegrass treatment returned $9.44 more in year 1 and $46.26 in year 2 compared to the cottonseed meal treatment. The increased disparity for returns in year 2 was largely due to an increase in cottonseed meal price. Increased calf gains associated with nursing cows grazing winter pasture can lead to increased revenue which in combination with lower costs associated with winter supplementation compared to traditional concentrate supplementation can yield greater profitability for producers.

Legumes

Intake. DelCurto et al. (1990) compared the use of a soybean meal/sorghum grain (0.48% of BW), alfalfa hay (0.70% of BW), or dehydrated alfalfa pellets (0.67% of BW) as a source of supplemental protein to provide equal amounts of CP and metabolizable energy (ME) for beef cattle grazing dormant range forage. To determine the effect of the different treatments on intake and digestibility an experiment was conducted using 16 ruminally cannulated steers fed the different supplements for 36 days. Range forage intake was dramatically increased for all treatments compared to the control steers only consuming range forage (0.49% of BW). Range forage DMI was greatest for steers fed dehydrated alfalfa pellets (1.21% of BW) while forage DMI was similar for the steers fed concentrate (1.07% of BW) or alfalfa hay (1.05% of BW). Total DMI was also different between treatments however, this was expected due to differing amounts of supplement fed. The increase in range forage intake due to supplementation is likely a result of the increased CP in the diet. Range forage by itself contained 2.67% CP and 80.8% NDF which would slow rate of passage, thus restricting intake.

Vanzant and Cochran (1994) conducted two experiments to determine the performance and forage utilization by beef cattle of alfalfa hay supplemented at an increasing rate in the diet. Intake and digestibility was determined using 16 ruminally cannulated steers fed supplemental alfalfa hay at a rate of 0.23, 0.47, 0.70, and 0.94% of BW per day. Voluntary range forage intake decreased linearly with increasing levels of alfalfa hay supplementation (1.44, 1.32, 1.37, and 1.11% of BW, respectively); however, total DMI increased linearly with increasing levels of alfalfa supplementation (1.67, 1.79, 2.08, and 2.05% of BW) as did digestible OM intake (0.75, 0.85, 0.98, and 0.96% of BW). While there was a substitution of alfalfa at the expense of range forage, this substitution was beneficial for the animal due to the increased CP and ME intake. This substitution most likely occurred as a result of the lowest level of supplementation providing adequate CP to alleviate the depression in intake associated with low-quality forages.

Foster et al. (2009) compared the use warm-season legume hays or soybean meal as a supplement on intake and digestibility of DM in lambs. Forty-two lambs were fed *ad libitum* bahiagrass hay alone or bahiagrass hay supplemented with either annual peanut, cowpea, perennial peanut, pigeonpea, or soybean hays at 50% of diet DM for two 21-day periods. Soybean meal was fed at 4.25% of the total diet DM to match the average CP concentration of the legume supplemented diets. Total DMI was increased with supplementation of all legume hays except for pigeonpea which was likely due to its high NDF and ADF from its woody stems. Intake was increased the most for perennial peanut hay followed by annual peanut hay. However, supplementation with soybean meal did not increase total DMI. Increases in intake reported with feeding of annual or perennial peanut hay are a result of the lower NDF and ADF concentrations in addition to the increased IVDMD of these two hays in comparison to the other supplements.

Digestibility. DelCurto et al. (1990) reported that steers fed either a soybean meal/sorghum grain mixture, alfalfa hay, or dehydrated alfalfa pellets had similar total tract DMD (46.3, 49.6, and 44.2%, respectively). Control steers consuming only native range forage also had similar total tract DMD (42.7%). Similarly, Vanzant and Cochran (1994) reported similar DMD in steers consuming native range forage plus either 0.23, 0.47. 0.70 or 0.94% of BW/day of alfalfa hay (45.4, 48.6, 48.4, and 48.3%, respectively). The similarities in total DMD between treatments reported by DelCurto et al. (1990) and Vanzant and Cochran (1994) are attributable to the increased passage rate associated with alfalfa supplementation. This increase in passage rate limits the amount of time that DM is digested. While diet digestibility was greater for alfalfa supplemented diets there was less time for the diet to be digested in the animal resulting in similar total DMD between all treatments. In evaluating DMD in lambs consuming bahiagrass hay or bahiagrass hay plus warm season legumes or SBM, Foster et al. (2009) reported that only perennial and annual peanut hay increased DMD with perennial peanut hay providing the most benefit. As stated previously, this is likely a result of the increased IVDMD of these two hays in comparison to other supplements.

Performance. In a second experiment conducted by DelCurto et al. (1990) to compare the effect of three different supplemental protein sources on cattle performance and reproduction, 82 mature, pregnant cows were maintained on dormant tallgrass prairie pastures and fed one of the previously described three treatments.

Supplements were fed at a rate to provide 69% of the CP and 36% of the ME requirement for gestating cows, mature cows weighing 499 kg. Cow BW loss from the initiation of the trial to calving (d 127) was the least for cows fed dehydrated alfalfa pellets (-26.5 kg) while BW loss during the same period was similar for cows fed soybean meal/sorghum grain (-50.2 kg) or alfalfa hay (-54.8 kg). From the start of the trial to the start of the breeding season (d 182) cows supplemented with alfalfa hay had the greatest BW loss (-60.8 kg) followed by soybean meal/sorghum grain (-49.8 kg) and dehydrated alfalfa pellets (-38.1 kg). During the period following the breeding season to the end of the trial cows fed alfalfa hay and soybean meal/sorghum grain displayed increased growth so that total BW change among treatments only tended to be different with dehydrated alfalfa pellets (19.0 kg) and soybean meal/sorghum grain (14.9kg) gaining the most BW and cows fed alfalfa hay gained a total of 4.6 kg. Cow BCS was only moderately influenced by source of protein supplementation. Cows supplemented with alfalfa hay tended to have the lowest BCS at both calving (5.13) and at the start of the breeding season (5.52) compared to soybean meal/sorghum grain (5.26 and 5.67 for calving and breeding, respectively) and dehydrated alfalfa pellets cows (5.2 and 5.71 calving and breeding, respectively). All of these BCS are within an acceptable range for adequate rebreeding rates (Dzuik and Bellows, 1983). Total BCS change over the entire trial was not different among treatments. The slight increase in performance with dehydrated alfalfa pellets could be due to increased intake as previously discussed in the first experiment resulting in better maintenance of BW and BCS.

In agreement with DelCurto et al. (1990), Cochran et al. (1986) reported similar responses in BW and BCS in cows supplemented with cubed alfalfa hay. In addition to evaluating the use of cubed alfalfa hay as a supplement for cows grazing winter range, a cottonseed meal/barley concentrate was also compared to control cattle receiving no supplement. Supplements were fed at a rate of 1.2 kg/day for alfalfa cubes and 0.9 kg/day for the concentrate. These supplements were fed to provide ~50% of the CP requirements of the grazing cows. There were no differences in total BW change over the trial between treatments (24 and 14 kg gain, for alfalfa cubes and concentrate respectively) but both supplementation strategies resulted in more favorable changes than control cows who lost 11 kg. Cow BCS change also did not differ between alfalfa cubes (0.2) and concentrate (0.0), and both maintained BCS better than control cows (-0.5). Though performance was similar between cows fed alfalfa cubes and a cottonseed meal/barley concentrate, Cochran et al. (1986) reported that feeding alfalfa cubes cost less ($0.11/hd/day) than the concentrate ($0.23/hd/day). This could change from year to year depending on alfalfa and grain prices.

In the second experiment conducted by Vanzant and Cochran (1994), 113 pregnant cows grazing winter native range were fed three levels (0.48, 0.72, and 0.96% of BW) of alfalfa hay to determine the effects supplemental alfalfa hay had on cow performance and reproduction from November 27 to calving (approximately March 7). Cow BW increased linearly with increasing levels of alfalfa during the first month of supplementation. During the remaining months leading up to calving, cow BW change was not affected by level of alfalfa fed, though cows fed the greatest amount of alfalfa maintained greater BW due to the increased gain during the first month of supplementation. Over the length of the experiment, cows fed the two lesser levels of alfalfa demonstrated increased BW gain, subsequently there were no treatment differences in BW change over the entire trial. Cow BCS change was not affected during the first month by treatment, however cows fed the least amount of alfalfa tended to lose more condition during this period. Cows fed the highest level of alfalfa maintained greater BCS from the start of the trial until calving. The differences in BCS were non-significant by the start of the breeding season and BCS change from breeding until weaning was not affected by level of alfalfa hay supplementation. The results of these studies implies that supplementation of cows with some form of supplementation increases performance over non-supplemented animals. Increases in levels of alfalfa supplementation tend to increase overall BW and BCS as does providing alfalfa in a pelleted form so as not to limit intake.

Reproduction. DelCurto et al. (1990) reported that cows fed either alfalfa hay (66.7%) or dehydrated alfalfa pellets (59.3%) tended to have a greater percentage of cows cycling than cows fed soybean meal/sorghum grain (31.9%). These differences in cyclicity did not affect final pregnancy rates however (88.4, 96.3, and 96.7%, respectively for soybean meal/sorghum grain, alfalfa hay, and dehydrated alfalfa pellets). Calf birth weights and calf ADG from calving date to 140 days of age were not different between treatments. Vanzant and Cochran (1994) reported no differences in conception rates between the three levels of alfalfa supplementation. Calf birth weights were greatest for cows fed alfalfa at 0.72% of BW (37.9 kg). Though this was statistically significant there was only a 2.7 kg difference between birth weights which may not be practically significant. Calf weaning weights were greatest for cows supplemented at 0.96% of BW (234.8 kg) while weaning weights for cows fed alfalfa at 0.48 or 0.72% of BW were similar (223.2 and 223.1, respectively). Supplementation of cows with alfalfa is comparable or better to supplementation with a concentrate for reaching acceptable pregnancy rates. Additionally, greater levels of alfalfa supplementation can lead to increased BW of calves leading to greater revenue at weaning.

In conclusion, the use of high-quality forages, whether grass or legume, allow levels of performance and reproduction that are comparable to traditional concentrate supplements and can in some cases provide increased performance in both cows and calves. Additionally, supplementation with high quality-forage can be an economically beneficial nutritional management due to reported decreases in hay intake and decreases in feed costs associated with the use of forage supplements. Lastly, care should be taken when managing animals grazing high-quality winter forage in order to ensure that intake of nitrogen does not have a deleterious effect on pregnancy rates due to the high CP content of winter annual forages.

Concentrates

Energy

Intake. Energy based supplementation of cows can come from both cereal grains and byproducts of processes such as cotton ginning, brewing, and distillation. Cereal grains are generally characterized by low-protein and high-starch concentrations which provide additional energy in the animal diet (Jurgens and Bregendahl, 2007). When cattle are fed energy-based supplements in the form of grains it has been reported that there is often an observed decrease in grazed forage intake (Caton and Dhuyvetter, 1997.) Chase and Hibberd (1987) reported linear decreases in forage intake when cows offered low-quality hay were fed increasing levels of corn. Hay intake was 8.8 and 5.1 kg/day at supplementation rates of 0 and 3 kg/day of corn respectively. Likewise, Pordomingo et al. (1991) observed a 7.8 g/kg BW decrease in OM intake of native range by forage by cows when fed a supplement of corn at 0.6% of BW as compared to cows not supplemented. The decreased intake of forage when corn is fed as a supplement has been attributed to its high starch content. Sanson et al. (1990) reported a decrease in forage intake of 2.1 kg when level of cornstarch supplementation was increased in steer diets from 0 to 4g/kg of BW. Mould et al. (1983) concluded that this is due to a shift in ruminal microflora or a decrease in ruminal pH due to the increase in VFA production associated with increase of starch in the diet. When the pH of the rumen is decreased the ruminal bacteria population is altered to more amylolytic bacteria and less cellulolytic bacteria (Mould et al., 1983). This shift in bacterial population results in lower fiber digestion (Caton and Dhuyvetter, 1997.) When compared to corn several other cereal grains such as wheat, oats, and barley have been found to have less of a negative effect on forage intake but still decrease intake. Conversely, Henning et al. (1980) reported that at low levels of supplementation (7.8%), corn can actually increase the intake of forage in grazing sheep. This is also supported by the work of Matejovsky and Sanson (1995) in sheep. Most often the reports of low levels of energy supplementation increasing forage intake occur in sheep and not cattle.

Bodine and Purvis (2003) reported that an adequate balance of TDN:RDP can offset the negative effects often reported when feeding a high level of starch to ruminants whose basal diet consists of low-quality forage. Moore et al. (1999) reported that a TDN:CP ratio > 7 (nitrogen deficient) could result in an increase in forage intake while a ratio < 7 (adequate nitrogen) could result in a decrease. Garces-Yepez et al. (1997) also observed that feeding a highly digestible fiber source such as soybean hulls had less of a negative effect on forage intake when supplemented at high levels compared to high starch supplements (.8 to 1% of BW). While energy supplementation often causes a decrease in forage intake, total intake is generally unchanged or slightly increased (Caton and Dhuyvetter, 1997).

Digestibility. The addition of energy with high starch energy supplements at high levels (> 0.2% of BW) often causes a decrease in the digestibility of forage but an increase in total digestibiity. Cordes et al. 1988 reported that corn reduced IVDMD of grass hay at 24 (12% decrease) and 48 hrs (6% decrease) of incubation time. However, corn increased total tract OM digestibility by 22% in comparison to total tract OM digestibility of hay alone. Likewise, Leventini et al. (1990) reported an increase in DM digestibility when barley was fed at an increasing rate of 10, 20, and 30% of diet DM (67.7, 68.4, and 70.8%, respectively) though there was a linear decrease in NDF digestibility (65.1, 61.0, and 59.7%, respectively). The decrease in NDF digestibility would thus inhibit forage digestion. The detrimental effects on forage digestibility associated with high-starch supplementation can be lessened by utilizing high-fiber supplements. Martin and Hibberd (1990) reported linear increases in organic matter digestibility (48.6 vs. 45.8%) and acid detergent fiber (ADF) digestibility (44.1 vs. 41.6%) when supplementing cows offered low-quality hay with soybean hulls at a rate of 3 vs. 0 kg/day, while neutral detergent fiber (NDF) digestibility was not affected. The increase in OM and NDF digestibility represent a more efficient utilization of the total diet. Anderson et al. (1988) evaluated the feasibility of using soybean hulls as an alternative to corn for energy supplementation and reported all energy supplemented groups (corn or soybean hulls supplemented at 12.5, 25, and 50% of DMI) had increased DM digestibility over animals not supplemented and there were no differences in DM digestibility between animals supplemented corn or soybean hulls at each respective level of the diet DM thus implying that soybean hulls are a viable alternative to grains for energy supplementation. While most studies report an increase or no effect on overall digestibility of the diet when an energy supplement is offered, there are instances where total diet digestibility was decreased (Vanzant et al., 1990; Hannah et al., 1989) Hannah et al. (1989) utilized both corn and corn gluten feed as energy supplements and only corn decreased OM digestibility. This is attributable to corn gluten feed having a large amount of highly digestible fiber in place of starch as its source of energy. Vanzant et al. (1990) evaluated the use of sorghum grain as an energy supplement. As reported in Nocek et al. (1991) the starch in sorghum has the lowest digestibility of the commonly used grains, which may explain the decrease in total OM digestibility reported by Vanzant et al. (1990). Supplementation of grazing ruminants with an energy source leads to increased diet and OM digestibility however, digestibility of forage may be reduced.

Performance. Most research reports that energy supplementation has a positive effect on production characteristics (Caton and Dhuyvetter, 1997) by decreasing BW and BCS loss of beef cows during the period of supplementation. Marston et al. (1995) supplemented cows during late gestation beginning on November 1 with either 2.44 kg/day of an energy supplement (soybean hulls) or 1.22 kg/day of a protein supplement (soybean meal) until calving at which point they remained on the same supplement or were switched to the opposite supplement. The new supplements were fed until the start of the breeding season on April 20. Cows fed energy during gestation had greater

BW gains during gestation than those fed protein (24 vs. 15 kg, respectively). Additionally, cows fed the energy supplement had decreased BCS loss (0.2 less) compared to cows fed the protein supplement. The greater BCS of cows fed energy during gestation carried on through breeding and tended to maintain the advantage until weaning. Most importantly, cows fed energy during gestation had greater pregnancy rates than cows fed a protein supplement (90 vs. 80%, respectively). However, energy supplementation during the postpartum period did not have a significant effect on BW gains. This could be due to the short postpartum supplementation period. In agreement with Marston et al. (1995), Huston et al. (1993) reported that cows fed an energy supplement from early December to late March lost less BW from fall to spring (59 kg loss) compared to cows fed no energy supplement. Body weight losses over 10 months were also less for energy supplemented cows compared to cows receiving no supplement (27 vs. 48 kg loss). Additionally, BCS losses were less for cows supplemented with energy (0.8 less) during the fall to spring period however, BCS changes were not different among treatments over 10 months. Whereas, Marston et al. (1995) reported no differences in calf weaning weights between energy and protein treatments, Huston et al. (1993) reported increased weaning weights for calves nursing cows supplemented with energy compared to calves nursing cows with no supplement (235 vs. 220 kg). The differences between the studies are likely due to the cows not fed an energy supplement in Marston et al. (1995) were still receiving a supplement that provided protein and a small amount of energy, while those in Huston et al. (1993) were receiving no supplement. In addition energy supplementation has been reported to increase gains in growing animals. Horn et al. (1995) conducted a study over a 3-yr period that assigned growing steers grazing winter wheat pasture to either a high-starch supplement (corn-based), high-fiber energy supplement (soybean hull/wheat middlings based), or no supplement (control) and target intake for supplements was 0.75% of BW. Feeding an energy supplement increased ADG of calves compared to control calves (1.07 vs. 0.92 kg/day) though type of energy supplement did not affect ADG. These studies would suggest that the feeding of an energy supplement to cows during periods of low-forage quantity and quality can minimize BW and BCS loss while also possibly enhancing pregnancy rates and calf weaning weights. In growing animals ADG can be increased by the addition of energy supplementation.

Reproduction. Wiltbank et al. (1962, 1964) reported that pre- and postpartum energy intake is linked to subsequent reproductive performance. Additionally, a review by Randel (1990) reported that inadequate energy intake postpartum extends the postpartum period to first estrous and decreases subsequent pregnancy rates. Dunn et al. (1969) fed 240 pregnant yearling heifers either a low (8.7 Mcal/day) or high (17.3 Mcal/day) level of energy for 135 days prior to calving after which the low group was divided into a low-moderate (27.3 Mcal/day) or low-high (48.2 Mcal/day) group. The high pre-calving feed level was divided into three groups which were high-low (14.2 Mcal/day), high-moderate (27.3 Mcal/day) or high-high (48.2 Mcal/day). These postpartum diets were fed for 120 days. Heifer pregnancy rates were directly related to the postpartum energy level fed. Heifers fed the high energy level postpartum had 87% pregnancy rates compared to 72% for those fed the moderate level and 64% for those fed the low level. In concurrence with the review by Randel (1990) pre-calving energy level affected the pregnancy rates of heifers during the first 100 days after parturition.

Heifers fed high energy pre-calving had 68% pregnancy rates compared to 60% for heifers fed low energy pre-calving. This is likely due to the increased occurrence of estrus in heifers fed the high level of energy pre-calving compared to those fed low energy. By 60 days after parturition only 44% of those fed low energy pre-calving had shown estrus compared to 69% of those fed high energy during the pre-calving period. Since BW and BCS score are more easily manipulated during the prepartum period, it is best to utilize a supplementation program that ensures cows to calve at a BCS of at least 5 (Randel, 1990) and avoid severe BW losses from parturition to breeding (Cantrell et al., 1981).

In summary, energy supplementation can often have negative effects on the forage utilization of animals consuming low-quality forage but can increase performance and reproductive measurements. This is likely due to the increase in digestible energy intake. To decrease the negative effects on intake and digestibility of forage associated with high-starch the use of high-fiber energy sources may be warranted. As stated by Bodine and Purvis (2003) it is more appropriate to supplement for a proper ratio of TDN:CP in order to ensure adequate available protein in the rumen to complement energy intake and ensure greatest production.

Protein

Low-quality forages are the most common found type found in Florida. In a study analyzing 637 samples of typical Florida grasses, Moore et al. (1991) reported that the average CP in these grasses was between 5 and 7% on a DM basis. According to the NRC (2000), a mature 1100 pound cow needs between 8-10% CP in her diet during lactation to sustain desirable weight and body condition. In situations when quantity of low-quality forages being fed are not limiting, protein is the most beneficial supplement

(Campling, 1970). Protein supplementation of cattle grazing low quality forages has been reported to increase intake and digestion (Bandyk et al., 2001), and overall animal performance (Willms et al., 1998). Bandyk et al. (2001) reported that supplementation of protein (400g/d of sodium caseinate) to beef steers increased hay OM intake (77.4 vs. 47.8 g/kg BW) and OM digestibility (44.7 vs. 39.5%) compared to steers receiving no supplement. Additionally, Willms et al. (1998) reported decreased BW loss of pregnant cows grazing native grassland from November 1 to January 31 receiving a canola meal supplement at a rate of 1.2 kg/day compared to cows receiving no supplement (19.5 vs. 35.1 kg loss, respectively). A key contributor to the difference in animal performance is due to the improved TDN:CP ratio in the diet that is achieved with protein supplementation (Bodine et al., 2001). Moore et al. (1991) reported that TDN:CP ratios that are low (less than 8), have adequate protein to compliment the energy in the diet. When this ratio is too high there may not be adequate protein in relation to energy and cause the negative associative effects that can appear with high level energy supplementation. Moore et al. (1991) recommends a TDN to CP ratio of 7 as a goal so as to ensure a proper amount of protein to match the energy available in the diet.

Crude protein can be further divided into two separate categories. Rumen degradable protein (RDP) can be broken down in the rumen by the microbes that will eventually convert the RDP to microbial protein which can be easily digested in the small intestine (NRC, 2000). The other CP portion is rumen undegradable protein (RUP), which cannot be broken down by the rumen microbes and is digested and absorbed in the small intestine as free amino acids and peptides. The absorbed amino acids and peptides are either used directly by the animal or deaminated by the liver into urea N which is then cycled through the rumen to be broken down (Bohnert et al., 2002). RDP and RUP requirements must be met in order for the animal to have acceptable performance. According to the NRC (2000) only about 50% of the animal's protein requirement is met by microbial protein produced in the rumen form RDP. Additionally, microbial protein synthesis is related to forage quality, therefore as a result in low-quality forage systems microbial protein will be less (NRC, 2000). In order to ensure adequate animal performance supplemental protein must be provided.

To determine if the type of supplemental protein offered would affect the productivity of beef cows Alderton et al. (2000) used 36 primiparous beef cows on a basal diet of low-quality native grass hay and placed them on one of three supplementation treatments from 3 days postpartum to 120 days postpartum. The treatments were RDP only (0.82 kg corn and 0.23 kg soybean meal), RDP+ RUP (RDP plus 0.12 kg blood meal and 0.13 kg corn gluten meal), or RUP (0.82 kg corn, 0.07 kg blood meal, and 0.08 kg corn gluten meal) only. Total OM intake was greater for cows supplemented with RDP+RUP (9.5 kg/day) than cows supplemented with only RUP (8.7 kg/day). At 60 days post-partum the RDP+RUP and RDP only cows had greater milk production (9.1 kg/day) than RUP only cows (7.5 kg/day). Body condition score was also greater for RDP+RUP than for RUP only cows at days 60 (5.0 vs. 4.5), 90 (4.9 vs. 4.5), and 120 (5.0 vs. 4.5) days PP. Though the combination treatment resulted in greater intake and BCS scores, post-partum interval to first estrus, conception rate, and subsequent calf weaning bodyweight was unaffected by treatment so the type of supplemental protein would seem to not impact productivity of primiparous beef cows.

Hafley et al. (1993) conducted two experiments to determine the effects of supplementing differing amounts of RDP and RUP to growing animals. In the first experiment yearling steers grazing native range were assigned to a control treatment of no supplement, an energy control supplement (cornstarch-molasses mix), an energy control plus 0.1 kg/day of RUP (blood meal-corn gluten meal), or an energy control plus 0.2 kg/day of RUP. Greater ADG was reported for steers supplemented with 0.2 kg/day of RUP (1.01 kg/day) compared to those steers receiving no supplement (0.86 kg/day), an energy control (0.91 kg/day), or an energy control plus 0.1 kg/day of RUP (0.93 kg/day). In the second experiment, yearling heifers were assigned to treatments including a no supplement control, an energy control (same as Exp. 1), energy plus RDP (0.18 kg/day), energy plus RUP (0.18 kg/day), or an RDP+RUP combination (0.36 kg/day). The combination treatment tended to increase BW gains compared to the heifers fed energy only or energy plus RUP and also had an increased numerical BW gain (0.05 kg/day) over the energy plus RDP treatment. Hafley et al. (1993) suggested that this increased performance could be from the additional RDP that occurred with the RUP source (25% of total RUP source) or be an indicator that more protein is needed for digestion at the small intestine.

Köster et al. (1996) conducted an experiment to determine the effects of differing levels of supplemental RDP on DMI and digestion of low-quality hay fed to beef cows. Cows were assigned to levels of 0, 180, 360, 540, or 720 g/day of RDP from sodium caseinate (90% CP). A quadratic increase was reported for OM intake with the peak intake occurring at 540 g/day of RDP (69.6 g/kg of BW). A tendency for an increase in total tract digestibility was observed with supplementation of RDP with the greatest digestibility at 180 g/day of RDP (54.3 %). Likewise, Scott and Hibberd (1990) reported a plateau in increasing intake of low-quality forages when feeding differing levels of RDP. Cows were fed RDP (soybean hull-soybean meal) at a level of either 0.18, 0.30, 0.43, or 0.55 kg/day. Feeding 0.43 kg/day resulted in the greatest intake of low-quality forage (7.5 kg/day). Additionally, total tract OM disappearance rate was greatest for cows supplemented with 0.43 kg/day of RDP digestibility (5.3 kg/day). This implies that protein supplementation has a limit in terms of increasing intake and digestion of low-quality forages.

Excessive supplementation of dietary protein can have negative effects on reproduction. Elrod and Butler (1993) reported lower conception rates (61%) for heifers fed a 50% excess of RDP requirements compared to heifers fed a ration to provide the required RDP (82%). The plasma urea nitrogen (PUN) levels were also greater (23.6 mg/dL) for heifers fed excessive RDP when compared to heifers fed RDP to meet the requirement (14.8 mg/dL). Other research suggests that PUN concentrations over 19 mg/dL have a negative effect on fertility (Butler et al., 1996) which could explain the decrease in conception rates observed by Elrod and Butler (1993). Likewise excessive supplementation of RUP can increase PUN concentrations due to the excess protein being deaminated in the liver and recycled into the bloodstream in the form of urea (Dhuyvetter et al., 1993). Butler (1998) suggests that the decreases in conception rate could be due to the decreased uterine pH caused by the increase in PUN concentrations observed when excess protein is fed.

Nitrogen can also be supplied to ruminants via non-protein nitrogen (NPN). Non-protein nitrogen differs from natural proteins in that it does not contain amino acids that are broken down by microbes in the rumen. Non-protein nitrogen is dissolved at a high rate in the rumen into ammonia allowing ruminal microbes to utilize it in the production of amino acids which are subsequently synthesized into microbial protein that will eventually be absorbed in the small intestine. The ammonia formed from the NPN can also be absorbed through the rumen wall and deaminated into urea in the same way excess protein can be. Just as excess protein can have negative effects, excess ammonia from too high a supplementation rate of NPN can also have negative effects. Excess ammonia can cause ammonia toxicity that if left untreated can lead to death. There are several types of NPN supplement sources (urea, biuret, ammonia) though urea is the most commonly utilized in beef cattle nutrition.

To examine the effects of increasing the amount of urea (an NPN) provided in place of RDP as a source of ruminally available N, Köster et al. (1997) fed growing steers grazing low-quality forage an increasing level of urea in place of RDP from natural plant sources. Treatment levels were 0, 25, 50, 75, and 100% of the N provided in the supplement. Köster et al. (1997) reported no differences in total forage OM intake between treatments but digestibility of OM (5.7% decrease from 0 to 100%) and NDF (11.8% decrease from 0 to 100%) tended to decrease with increasing levels of urea. This led to a significant linear decrease in digestible OM intake. Whereas total OM intake was not different among treatments, OM and NDF digestion and total DOMI were lowest when all the RDP was supplied by urea. However, even though there was a linear decrease in OM and NDF digestibility, these changes were marginal up to the 50% inclusion rate. Likewise, Köster et al. (2002) reported no differences in intake or digestibility in beef steers consuming low-quality forage while receiving supplemental

RDP containing urea at a rate of 0, 20, or 40%. This concurs with Minson (1990) in a review where it was reported that while both natural protein and NPN are able to stimulate forage intake, the response to urea seems to be less than for natural proteins. These differing responses to urea and natural proteins are minimized as long as urea inclusion is not extreme. In summary NPN supplementation of cattle can be a feasible alternative to feeding a completely natural protein supplement when substituted at low levels. Non-protein nitrogen supplementation will also increase performance over no supplementation of cattle being fed low-quality forage.

Concentrate supplementation of cattle can be a beneficial management tool for cattle being maintained on low quality forage. In most of these cases protein is the most beneficial supplement as high energy supplements can have negative performance effects. These negative effects can be minimized by providing energy with highly digestible fiber in place of grain starch. When supplementing low-quality roughages, RDP is generally the first limiting nutrient. However, RUP can cause increased gains over just RDP, as long as the RDP requirement of the animal is met. In most scenarios over supplementation of either energy or protein have negative effects and be economically unwise.

Effect of Maternal Nutrition on Calf Characteristics

The maternal plane of nutrition during gestation has been implicated in developmental programming that can affect subsequent calf characteristics (Caton and Hess, 2010). Nutritional management of the dam can affect BW measurements of calves along with having an instrumental part in the proper formation of organs and body tissues. Depending on supplementation strategy, nutrition provided to the gestating dam can be either restrictive or excessive if not managed correctly. Both extremes can have negative effects on the progeny (Caton and Hess, 2010).

Restricted Nutrition

Body weight

Corah et al. (1975) conducted two experiments to determine the effects of energy restriction during late gestation on beef heifers and cows. In the first experiment 59 Hereford first-calf heifers were assigned to either a low or high energy (65 vs. 100% of NRC requirements) level for the last 100 days of gestation. Birth weights of calves from the high energy treatment were 2 kg greater than those from the low energy treatment. In experiment 2, Corah et al. (1975) evaluated whether a period of nutrient restriction could be mitigated with a high plane of energy prior to parturition. Forty-three cows were fed an energy deficient diet (50% of NRC requirements) from 100 days prepartum to 30 days prepartum. At this point cows were assigned to a high energy diet (117% of NRC requirements) or kept on the deficient diet. After parturition all cows received 100% of NRC requirement for energy. Calves from continuously restricted cows were lighter at both birth (26.7 vs. 34.4 kg) and weaning (147.6 vs. 160.6kg). Likewise, Houghton et al. (1990a) evaluated the effects of restricted energy intake during the late prepartum period on calf BW at birth and thereafter. A total of 160 Charolais x Angus cows were assigned to either a maintenance energy diet (100% NRC) or a low energy diet (70% NRC) at day 190 of gestation. Low energy intake prior to parturition produced calves with lower BW (34.7 vs. 39 kg) and lower BW at 105 days of age (127.9 vs. 144.6 kg). This decrease in calf weight can lead to decreased revenue when calves are sold resulting in an economic loss. These findings are in agreement with others as to the effect of restricted energy intake during the late gestation period (Hight, 1966; Bellows, 1972).

Though the effects of energy restriction during late gestation are well established the effects of protein restriction are less so. Carstens et al. (1987) conducted an experiment to determine the effects of restricted protein nutrition during late gestation. On day 190 of gestation, 22 cows were assigned to one of two isocaloric diets. One contained 91% of NRC requirement for protein and the other contained 55% of the NRC requirement. Although there were no differences in calf birth weight, calves from protein restricted dams had lower heat production (43.7 vs. 49.3 kcal/kg/day) than calves from control dams. Decreased heat production in young calves has been hypothesized as a symptom of nutritional stress that could affect calf mortality (Alexander, 1962a,b).

In other experiments protein supplementation during late gestation data has come in the form of winter grazing systems. Funston et al. (2008) reported that calves born to cows grazing winter range with protein supplementation tended to be heavier than calves from cows which did not receive protein supplementation. At weaning however, both actual BW (235.5 vs. 220.5 kg) and 205-day adjusted BW (220.5 vs. 211.4 kg) were greater for calves from protein supplemented cows. Similarly, Larson et al. (2009) reported that calves born to protein supplemented cows on winter range during late gestation tended to have heavier birth weights than calves from non-supplemented cows and had heavier weaning weights. As stated previously, calf BW at weaning is important due to increased revenue realized from heavier calves. Additionally, the heavier weaning weights of heifers kept for breeding could lead to earlier puberty and subsequently earlier pregnancies.

Long et al. (2012) evaluated the effects of restricted energy and protein restriction during early and mid-gestation utilizing 36 Angus x Gelbvieh cows fed one of three treatments. The treatments consisted of a control diet which contained 100% of energy and protein requirements, a nutrient restricted diet which was 70% of the control diet, and a nutrient restricted plus supplemental protein diet which contained 70% of control energy and 100% of essential amino acid supply. Cows were fed the respective diets from day 45 to day 185 of gestation. After day 185 cows were commingled and fed the control diet. Calf birth weights and weaning weights were similar among all three treatments. The results from this experiment are in agreement with Long et al. (2010) and Cooper et al. (1998) in which nutrient restriction before the last trimester of pregnancy did not influence birth weight of calves

Body composition

While the effects of maternal undernutrition during late gestation are clearly reflected in differences in BW the effects of undernutrition during early gestation are less easily observed. Maternal undernutrition during early gestation can influence subsequent body composition of the calf due to restriction of fetal growth. Zhu et al. (2006) evaluated the effects of nutrient restriction from day 28 to 78 of gestation in pregnant ewes on the skeletal muscle characteristics of their lambs. Control animals were fed 100% of recommended nutrients and restricted ewes were given only 50% of the recommendation. From day 78 to parturition all ewes were fed the control diet. Lambs from nutrient restricted ewes tended to have reduced muscle mass at 8 months of age compared to those from control ewes. This tendency for nutrient restricted lambs to have decreased muscle mass is a result of the tendency for nutrient restricted lambs to have a decreased number of muscle fibers. In addition, lambs from nutrient restricted ewes had greater percentages of kidney and pelvic fat compared to control lambs (2.18 vs. 1.66%). Reed et al. (2007) evaluated the effects of maternal diet restriction from d 64 to d 135 on organ weights of lamb fetuses. Fetuses from restricted ewes had reduced liver (82.1 vs. 101.5 g), pancreas (3.2 vs. 3.8 g), perirenal fat (20.0 vs. 23.8 g), and spleen (5.0 vs. 6.3 g) weights compared to fetuses from adequately fed ewes.

Overall, nutrient restriction of the dam leads to negative effects on the progeny. Maternal undernutrition during early to mid-gestation can affect the development of fetal tissues which may not influence growth performance but can affect subsequent health (Caton and Hess, 2010). Undernutrition during late gestation has negative effects on weight measurements due to the majority of fetal growth occurring during this time period (Winters et al., 1942).

Excessive Nutrition

Body weight

Boyd et al. (1987) conducted an experiment to compare the effects of differing energy intakes on calf birth weight when 37 Angus cows were fed one of two treatments for 50 days prior to calving. The control treatment was a moderate-energy intake (approximately 100% of NRC recommended intake) and the other treatment was a high-energy intake (over 100% NRC recommended intake). After parturition all cows were combined and fed identically. Calf weights were greater for calves from the high energy treatment at birth (36.7 vs. 33.1 kg) and at weaning (236.4 vs. 223.6 kg). Laster (1974) also compared the effects of high-energy intake to moderate-energy intake during the last 90 days of gestation on subsequent calf weights. Utilizing 358 Angus and Hereford heifers that were assigned to either a low, moderate, or high energy intake, Laster (1974) reported increased birth weights for calves from dams fed the high energy treatment (29.0 kg) when compared to both the low and moderate energy intakes (27.9 and 26.3 kg, respectively).

Bond and Wiltbank (1970) evaluated the effects of feeding differing energy and protein levels for the entirety of gestation utilizing heifers. Heifers supplemented with a high level of protein produced calves that had similar birth weights as calves from moderately supplemented heifers. Calves from heifers fed a high energy supplement produced calves of similar weight as those from moderately supplemented heifers, however there was greater death loss of calves from the heifers fed high energy. At birth only 75% of calves were born live on the high energy supplement while 88% born were alive for those heifers supplemented with a moderate level of energy. The difference in live calf birth weight was due to dystocia problems in which the calf was born backwards or in another abnormal position. Furthermore, while 100% calves from the moderately supplemented heifers were alive two weeks after birth only 50% were still alive from the high energy heifers. The large death loss after 2 weeks was a result of many of the calves that were born live died within a few minutes, also likely due to dystocia problems.

In research utilizing adolescent ewes, Wallace et al. (1996, 1999, 2001) reported that feeding nutrition in excess of animal requirements throughout gestation resulted in premature delivery of low-birth weight lambs when compared to lambs from adolescent ewes fed at the proper level of nutrition. This was attributed to the rapid growth of the dam at the expense of the gravid uterus which led to placental growth restriction. In agreement, Swanson et al. (2008) reported decreased birth weights (4.21 vs. 4.64 kg) of lambs from adolescent ewes fed 140% of energy requirements during the last two thirds of gestation when compared to control ewes. In addition, overnourished ewes yielded less colostrum. This drop in colostrum due to excess nutrition was also reported by Wallace et al. (2005) who utilized adult ewes. This drop in colostrum can have negative effects on progeny health and survival during the early periparturient period.

Excess nutrition of the bovine can lead to increased BW of calves however, this can lead to dystocia problems which can then affect overall health of the calf. Conversely in adolescent ewes excess nutrition can lead to decreased lamb weights along with decreased colostrum yield which can negatively impact lamb health. Feeding nutrition in excess of dam requirements during gestation can be costly and have negative impacts on production.

CHAPTER 3
COMPARISON OF FORAGE OR CO-PRODUCT SUPPLEMENTS ON THE PERFORMANCE AND REPRODUCTION OF BEEF COWS

Story in Brief

Florida cow/calf producers most commonly utilize perennial warm-season grasses as the foundation for cow herd nutrition. Bahiagrass (*Paspalum notatum*) and Bermuda grass (*Cynodon dactylon*) are the two most commonly utilized improved forages in Florida. Bahiagrass and bermudagrass have primary seasonal production from April to October and are dormant from November to March with insufficient quantity or quality to support the nutrient requirements of the cow herd (NRC, 2000). During the cool-season from November to March is when the majority of cows in Florida are in late gestation and early lactation. In this period the nutrient requirements of cows increase greatly (NRC, 2000). In order to meet the nutritional requirements of cows during the period of warm-season forage dormancy it is important to design a supplementation program to optimize both production and profitability.

A common base for winter feeding programs is conserved forages. The majority of conserved forage in Florida is fed as hay made from warm-season perennial grasses. Due to the relative low quality of tropical warm-season grasses conserved forage from this source alone cannot meet the elevated nutrient requirements of late gestating and early lactating animals. This results in the majority of winter feeding programs for the cow herd in Florida consisting of feeding hay and a concentrate based supplement with high protein and/or energy to provide the additional nutrients. However, research has reported that there may be benefits to utilizing cool-season annual forages in place of the traditional concentrate based supplements including a decrease in hay fed. The purpose of this study was to compare the utilization of a winter pasture grazing system to a traditional hay-supplement system on cow performance, stored forage use, calf performance, and economics.

Materials and Methods

This experiment was conducted at the University of Florida Santa Fe Beef Research Unit, Alachua, Florida during the period of December 2010 to April 2011. The experiment was divided into four periods with d 0 being the start of the treatments and d 118 being the final treatment day. The experiment was conducted in accordance with acceptable practices as outlined by Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1999) and University of Florida IFAS Non-regulatory Research system protocol number F065.

Field Preparation and Pastures

A 12.14 ha field was v-ripped, disked, and seeded with a mixture of rye (*Secale cereal*) and ryegrass (*Lolium multiflorum* Lam.) on November 8-12, 2010 using a grain drill. The seeding rates were 90 and 28 kg/ha for rye and ryegrass, respectively. Fields were initially fertilized on November 12, 2010 with 44.8 kg/ha of actual N from ammonium nitrate and 22.4 kg/ha of K_2O_5 and re-fertilized on February 6, 2011 with 64.4 kg/ha of actual N from ammonium nitrate. The field was irrigated on November 15, 2010 with 2.54 cm of water and again on December 6, 2010 with 1.9 cm of water. Prior to initiation of the experiment the field was divided with temporary electric fence into two paddocks of 6.07 ha. Two 6.07-ha dormant bahiagrass (*Paspalum notatum*) pastures adjacent to the rye-ryegrass field were utilized to compliment the cool-season annuals. Additionally, two 6.07-ha dormant bahiagrass pastures were utilized for grazing and concentrate supplement treatment. These bahiagrass pastures received no fertilizer during the experiment. All pastures contained automatic water sources.

Cow BW were taken on d 0, 29, and 118 and these were used to calculate BW change. Body condition scores (1 = severely emaciated; 5 = moderate; 9 = very obese; Wagner et al., 1988) were taken monthly by two individuals. Calf BW were taken within 24 h of birth and on d 118. These measurements were used to calculate calf ADG and total BW change.

Animals and Treatments

The treatments utilized in this experiment consisted of limit-grazing on rye-ryegrass pasture (RR) for 2 hr daily or supplemented 3 d/wk with whole cottonseed (WCS) at a rate of 0.5% of the pen mean BW per day (3.3 kg DM/day). Additionally, all cows had *ad libitum* access to Coastal bermudagrass (*Cynodon dactylon* L.) hay throughout the study. Angus (n = 40) and Brangus (n = 40) multiparous cows with initial BW of 579 $\pm$ 55 and 602 $\pm$ 54 kg, respectively were utilized. A full BW was taken December 8, 2010 before the start of the experiment, and cows were stratified by BW, BCS, and breed, and expected calving date and assigned to either the rye-ryegrass or WCS treatment. Two pens for each treatment were utilized; equal numbers of cows from each breed were allocated by expected calving date (early calving and late calving). All pens received ad libitum access to large round bales of bermudagrass hay delivered as needed. The quantity of supplement offered to WCS cows was adjusted on d 29. Cows were offered ad libitum water and loose vitamin-mineral mix throughout the experiment.

Feed Sampling and Analysis

Samples of WCS and core samples of hay were collected monthly throughout the experiment. Pasture samples were also taken monthly from each bahiagrass pasture and the rye-ryegrass pasture to estimate forage quantity and chemical composition by hand clipping three 0.25 m^2 areas. Hay, WCS, and pasture samples were dried at 60°C in a forced air oven for approximately 72 h. Dried samples were ground using a Wiley mill (Arthur H. Thomas Company, Philadelphia, PA, USA) to pass through a 1-mm screen. After grinding samples were analyzed for organic matter (OM), dry matter (DM), CP, and in vitro dry matter digestibility (IVDMD). Crude protein was determined by obtaining total nitrogen using a macro N analyzer (Elementar, vario MAX CN, Elementar Americas, Mount Laurel, NJ, USA) (CP = N x 6.25). In vitro dry matter digestibility was determined by a commercial laboratory (Dairy One Forage Laboratory, Ithaca, NY). Chemical composition and DM yield for bahiagrass pastures is listed in Table 3-1. Chemical composition of supplements is listed in Table 3-2.

Breeding

On April 12, 2011 all cows over 23 d post-partum were assigned to either a 5-day Select Synch-CIDR and Timed-AI (5D) or a Modified 7-day Select Synch-CIDR and Timed-AI (7D) synchronization program by breed and days postpartum. On April 12, 7D cows had a CIDR (Eazibreed CIDR, Pfizer Animal Health) inserted and given a 25 mg shot of Prostaglandin $F_{2\alpha}$ (PGF) (Lutalyse Sterile Solution, Pfizer Animal Health). On April 14, 5D cows had a CIDR inserted and all cows in 5D and 7D treatments received a 500 µg shot of gonadotropin releasing hormone (GnRH) (Fertagyl, Pfizer Animal Health). On April 19, at 0 and 12 hrs after CIDR removal from 5D and 7D cows, all cows were given a shot of PGF. For 72 h cows were observed for estrus and if estrus was observed cows were bred to via artificial insemination (AI) 8-12 hrs later. After 72 h all cows that did not exhibit estrus received GnRH (500 µg, Fertagyl) and bred to timed-AI on April 22. Subsequently, cows from the study were placed in predetermined breeding groups with cleanup bulls on May 2 and removed July 8. Estrous cycling status, estrous response, conception rate, timed-AI pregnancy rate, synchronized pregnancy rate, 30-d pregnancy rate, and breeding season pregnancy rate were recorded. Estrous cycling status was determined with blood samples taken at -7 and 0 days relative to CIDR insertion. Cows with plasma urea nitrogen levels greater than 1.0 ng/mL at either -7 or 0 days were classified as cycling while those less than 1.0 ng/mL were classified as not cycling. Estrous response was the number of cows displaying estrus for 60 h after CIDR removal and inseminated divided by the total number of cows treated. Conception rate was the total number of cows that displayed estrus, were inseminated, and became pregnant, divided by the total number of cows that displayed estrus and were inseminated. Timed-AI pregnancy rate was the total number of cows that failed to display estrus, were timed-inseminated and became pregnant, divided by the total number of cows failed to display estrus and were timed-inseminated. Synchronized pregnancy rate was the number of cows that became pregnant to the synchronized breeding, divided by the total number of cows treated. Thirty-day pregnancy rate was the number of cows pregnant during the first 30 d of the breeding season divided by the total number of cows treated. Breeding season pregnancy rate was the number of cows pregnant at the end of the 80 d breeding season, divided by the total number of cows treated. Pregnancy was detected using ultrasonography (Aloka 500 V, Corometrics Medical Systems, Wallingford, CT) at 28 and 56 d after AI and 30 d after the end of the breeding season. Due to the period of 9 days where no cows were exposed to natural service sires, differences in fetal size were used to determine whether a pregnancy resulted from synchronized AI or natural service. Additionally, pregnancy determinations were verified during the 2012 calving season.

Statistical Analysis

The MIXED procedure of SAS^{TM} (SAS Inst. Inc., Cary, NC) was used for the analysis of cow and calf performance measurements. The model statement for cow BW, BW change, BCS, BCS change, estimated hay offered, calf birth weight, April 19 weight, weaning weight, adjusted 205-day weight, average daily gain from birth to April 19, average daily gain from birth to weaning, and weight per day of age included the effect of winter supplement system. Cow was considered the experimental unit.

The GLIMMIX procedure of SAS (SAS Inst. Inc., Cary, NC) was used for the analysis of reproduction measurements. The effects of winter supplementation system, synchronization treatment, breed and their interactions were evaluated for estrous cycling status, estrous response, conception rate, timed-AI pregnancy, thirty-day pregnancy, and breeding season pregnancy rates. Cow BW, BCS, were included as covariates. No synchronization treatment, breed or interaction effects were observed so they were removed from the model and only winter supplementation system effects were reported.

Results and Discussion

Cow Performance

At the initiation of the experiment cow BW did not differ ($P = 0.36$, mean = 590 kg, Table 3-3). However, cow BW were greater ($P < 0.05$) for cows grazing RR compared to cows supplemented with WCS on January 13th prior to the initiation of calving. Likewise cows grazing RR had greater BW ($P = 0.04$) compared to those supplemented with WCS at the conclusion of the trial in April, just prior to the initiation of the breeding season. However, cow BW change over the course of the experiment was similar ($P = 0.43$) between RR and WCS cows. Villalobos et al. (1997) reported greater BW in the second year of their experiment at the conclusion of the winter supplementation period for cows supplemented with high-quality meadow hay at a rate of 2.2 kg/day (566 kg) compared to those fed a concentrate of soybean meal and wheat at a rate of 0.9 kg/day (524 kg). However in the first year of the experiment ending BW for cows was not different. Likewise, Gunter et al. (2002) reported similar ending BW for cows limit-grazed on winter annual pasture or supplemented with 1.2 kg/d of a corn-corn gluten meal (17% CP, 80% TDN) concentrate. Differences observed in the current study and Gunter et al. (2002) could possibly be due to the base pasture provided to the cows. Gunter et al. (2002) kept cows on bermudagrass pastures which generally have greater yields early in the spring season compared to bahiagrass pastures (Montgomery et al., 1979), which were used in this study. Hill et al. (1985) reported no differences however, in cows grazing ryegrass sod-seeded into Pensacola bahiagrass and those maintained on Pensacola bahiagrass and receiving a supplement of cottonseed meal. In addition, Utley and McCormick (1978) reported similar BW at the conclusion of the winter supplementation period between cows grazing ryegrass and those receiving a concentrate of cottonseed meal at a rate of 0.45 kg/d.

Initial cow BCS was similar ($P = 0.93$) between supplement treatments (Table 3-3). In contrast, January BCS prior to the beginning of calving season was greater ($P = 0.03$) for WCS cows. February and March BCS were not different ($P \geq 0.13$) between treatments. At conclusion of the supplementation trial in April, RR cows had greater BCS ($P < 0.02$). However, BCS change did not differ between RR and WCS treatments over the course of the supplementation period from December to April. A possible explanation for the decreased BCS of RR cows just prior to calving could be the decreased rumen capacity at this time (Vanzant et al., 1991; Stanley et al., 1993). Decreased rumen capacity could cause a decreased DMI resulting in the loss of BCS observed in this study. Gunter et al. (2002) also reported a 0.6 unit increase in BCS for cows grazing winter pasture compared to those receiving the corn-corn gluten feed supplement at the conclusion of the supplementation period in the first year of their experiment, these results were not different the second year however. Our data is in agreement with Villalobos et al. (1997) and Gunter et al. (2002) demonstrating that the use high-quality forage has the ability to increase BCS during lactation. Dziuk and Bellows (1983) reported that BCS is more closely related to reproduction in beef cattle than BW. Cows in low BCS (< 4) may breed later or not at all compared to cows in adequate BCS ($\geq$ 5). Therefore, while both treatments lost BW during the supplementation period, the gain in BCS prior to breeding is physiologically more important for cow productivity.

Estimated hay dry matter intake (DMI) (Table 3-3) was decreased ($P < 0.001$) for RR supplemented cows compared to WCS supplemented cows during Period 1 (December to January) but no differences in hay DMI were observed for periods 2, 3, or 4. As mentioned previously, a decrease in rumen capacity could have caused a decrease in DMI during this period. The rye-ryegrass forage in this study had much improved chemical composition compared to the hay offered (Table 3-2). Additionally, cows in the RR system had the opportunity to consume RR forage at the expense of hay forage. Cows in the RR system could replace hay with an alternative forage, in contrast WCS system cows had only hay to consume. This in turn could have caused the decrease in hay DMI during this period. Previous research indicates that grazing of winter pasture can cause decreases in hay DMI by as much as 14% (Gunter et al., 2002).

In conclusion, limit grazing cows on rye-ryegrass as a supplement proved beneficial to minimize BW loss during parturition and lactation and increasing BCS over the entire supplementation period compared to supplementing bahiagrass pasture and hay with WCS. Maintenance or improving cow BCS should improve the probability of successful rebreeding. Though intake of hay was not significantly different between supplementation strategies in this study, other research implies that it is decreased with forage supplementation.

Calf Performance

Calf birth weights (Table 3-3) tended to be greater for calves from RR cows ($P = 0.09$) compared to calves from WCS cows. Whereas April 19th BW and weaning weight (WWT) were similar ($P \geq 0.11$) between treatments. While tending to be significant, the birth weights in the current study were only 2 kg different between treatments. Gunter et al. (2002), Hill et al. (1985), and Utley and McCormick (1978) all reported no differences in birth weights between cows grazing winter pasture or those being supplemented with a concentrate, though the range in birth weights (~2 kg) were similar to this study. Gunter et al. (2002) also reported similar WWT for calves nursing cows limit-grazing winter annual pasture (206 kg) compared to calves nursing cows being supplemented with a corn-corn gluten meal concentrate (211 kg). Though not statistically significant in the current study ($P = 0.13$) the differences in WWT between RR calves and WCS calves (12 kg) are more comparable to studies in which WWT was greater for calves nursing cows grazing winter pasture. Hill et al. (1985) reported an increase in WWT of 9 kg for calves nursing cows grazed on ryegrass sod-seeded into Coastal bermudagrass and 15 kg for calves nursing cows grazed on ryegrass-sod-seeded into Pensacola bahiagrass. Likewise, Utley and McCormick (1978) reported an average increase in WWT of 30 kg for calves nursing cows grazing ryegrass sod-seeded into Coastal bermudagrass compared those nursing cows receiving a supplement of cottonseed meal over a two-year experiment. The discrepancy between the WWT of calves in the current study and Gunter et al. (2002) compared to those in Hill et al. (1985) and Utley and McCormick (1978) most likely arises from the fact that cows in Gunter et al. (2002) were limit-grazed for a total of 14 hr/wk on winter pasture while those in the latter two studies had continuous access. Therefore, calves in Gunter et al. (2002) only had access for the same amount of time as the cows which could have decreased the calves' forage intake of winter pasture due to differences in forage allowance in comparison to the other two. This restriction in grazing time also likely hindered the calves in the current study as they too only had access to winter pasture for 14 hr/wk. In addition, as reported by Ansotegui et al. (1991), it is likely that calves older than 70 to 100 days have the ability to be self-sufficient in acquiring nutrients when forage quality and quantity is available. The calves in the present study and those in Gunter et al. (2002) had average birthdays of February 11 and 28, respectively. Calves in Utley and McCormick (1978) were already nursing when moved onto winter pasture in early February and cows in Hill et al. (1985) began calving January. Also, treatment groups in the present study and in Gunter et al. (2002) were removed from the winter pasture in mid-April while those in previously mentioned studies had access until May. The increased average age and time spent on pasture could also have contributed to the increased WWT seen in those studies. Additionally, because calves were born onto supplementation treatments, adjusted 205-day weaning weights were calculated in order to account for differences in calf age, calf sex, and dam age. Rye-ryegrass calves had greater 205-day weights (P = 0.05) compared to WCS calves. Though unadjusted weaning weights only tended to be greater for RR calves and 205-day weights were greater, the weight difference between supplementation treatments for both measurements was similar. Rye-ryegrass calves had adjusted 205-day weights of 259 kg compared to WCS calves which had an adjusted 205-day weight of 245 kg. These weights further illustrate the increased calf weights due to RR supplementation.

Calf ADG from birth until April was greater (P = 0.05) for RR calves (Table 3-3) than for WCS calves. Hill et al. (1985) also reported differences in ADG from birth until conclusion of the winter supplementation period as did Utley and McCormick (1978). Calf ADG during this period was greater in the current study for both treatments than the ADG of calves in the aforementioned studies when compared to similar supplementation program. While in the current study ADG was 1.05 and 0.91 kg/day for RR and WCS, respectively, Hill et al. (1985) reported gains of 0.83 and 0.68 kg/day for winter pasture and concentrate and Utley and McCormick (1978) reported gains of 0.94 and 0.67 kg/day for winter pasture and concentrate, respectively. The increased ADG in the current study compared to the previous literature could be a factor of improved genetics utilized in the AI program in this trial and in the modern cow herd. Additionally, the tendency for greater calf ADG in the RR compared to WCS calves could be potentially be a result of increased milk production from the cows on the RR system. Alternatively, calves in the RR system could have been grazing the RR forage, in contrast the calves in the WCS system could not consume any WCS and hay consumption would have resulted in a decreased dietary energy supply compared to RR calves. However, neither milk production or calf forage-feed intake were measured in this experiment. Average daily gain from birth until weaning was not different (P = 0.13) between treatments however. Weight per day of age (WDOA) also tended to be greater (P = 0.10) for RR calves compared to WCS calves.

In contrast to total ADG observed in Hill et al. (1985), Gunter et al. (2002) and Utley and McCormick (1978) are in agreement with the current study in reporting no differences between treatments. Though not statistically significant in the current study, both RR and WCS treatments had greater total ADG than the others reported. Though not reported in other studies, WDOA tended to be greater in the current study for RR calves compared to WCS calves. Weight per day of age is a truer representation of the effect of the supplementation treatment on calf performance because it provides a comparison of growth without influence of sire and dam effects on birth weight. The results in the current study and other reported agree that the use of winter pasture as a supplementation tool is comparable and can be superior to the use of a traditional concentrate feeds in measures of calf performance. Overall, calves nursing cows limit-grazed on rye-ryegrass pasture in this study demonstrate equal or superior performance when compared to calves nursing cows supplemented with whole cottonseed.

Reproduction

There were no synchronization protocol or treatment x synchronization protocol effects ($P \geq 0.10$) for any measured responses. Rye-ryegrass cows tended (P = 0.12) to have a slightly greater estrous cycling rate compared to WCS cows (92 vs. 82%). This could likely be due to the increased BCS score of RR cows at breeding. Rye-ryegrass cows had greater (P = 0.02) estrous response (Table 3-4) than WCS cows. Over 78% of

RR cows compared to 50% of WCS cows exhibited estrous following estrous synchronization during a 23-d post-partum period. This is likely attributable to the tendency for RR cows to have a greater percent cycling compared to WCS cows. While it would be expected that RR cows would have greater conception rates due to a greater estrous response this was not observed. Contrary to the greater estrous response exhibited by the RR cows, they had a lower conception rate compared to WCS cows (P = 0.05). Of the 29 RR cows that showed a response, only 51.7% conceived to initial insemination while 82.4% of WCS cows conceived. Gunter et al. (2002) reported possible deleterious effects on reproduction due to increased grazing time of winter annual forage, however in the current study it is most likely due to semen quality used. Of the 29 RR cows bred to artificial insemination, 7 were bred to 2 different AI sires that had conception rates below 33% while all other sires used had conception rates over 60%. Of the 7 RR cows bred to these 2 sires only 1 cow conceived. With the low number of animals used in this experiment, low fertility sires can cause large differences in conception rates, which we believe caused this difference not the RR supplementation treatment.

Timed-AI (TAI) pregnancy rates were not different between treatments (Table 3-4; mean = 38.8%, P = 0.21). Of the 8 RR cows that did not show an estrous response 25% became pregnant to TAI and 52.9% of WCS cows became pregnant to TAI. Though not significantly different, we believe the disparity between the TAI pregnancy rate in the RR and WCS cows to be partially due to the same sires that we believe caused the low conception rates in RR cows. Of the 8 RR cows bred to TAI, 6 were bred to the same two sires of which only 2 became pregnant. Synchronized pregnancy rates tended (P =

0.07) to be greater for WCS cows (67.7%) than RR cows (46.0%) however, as discussed previously this is likely due to the use of two sires that had lower conception rates (< 33%) than all other sires (> 60%). Thirty-day pregnancy rates were similar (P = 0.56, mean = 68.8%) between treatments and included cows bred to AI, TAI, and bull during the first 30 d of the breeding season. Total breeding season pregnancy rates were the same (P = 0.91, mean = 90.0%) for both treatments.

In agreement with the current experiment, Gunter et al. (2002) reported no differences for cows grazing winter annual pasture for 14 hr/wk or receiving a corn-corn gluten feed concentrate. In addition to observing no treatment differences, pregnancy rates for each treatment were similar to those observed in this study (92 and 93% for concentrate and winter annual, respectively). Utley and McCormick (1978) also reported no differences in pregnancy rates over a 2-yr period for cows grazing either ryegrass sod-seeded into coastal bermudagrass or receiving cottonseed meal as a supplement during the winter supplementation period. Year one pregnancy rates were 100% for cows grazing ryegrass and 92% for cows receiving cottonseed meal, while year two pregnancy rates were 95 and 96%, respectively. Hill et al. (1985) reported similar pregnancy rates for cows grazing annual ryegrass sod-seeded into coastal bermudagrass (94.2%) and those receiving cottonseed meal (93.2%). Hill et al. (1985) also evaluated the use of sod-seeded ryegrass in Pensacola bahiagrass pastures and observed no differences in pregnancy rates between treatments. The results from the current study in addition to the others discussed demonstrate that pregnancy rates are similar for cows grazing winter annual pastures compared to a traditional concentrate being fed during the winter supplementation period and provide adequate levels of supplementary nutrition to ensure acceptable pregnancy rates.

Economic Evaluation

A summary of the costs associated with supplementing cows in this experiment are presented in Table 3-5. The total cost per cow for the RR treatment was $244.90 while the total cost per cow for the WCS treatment was $259.00. In addition to the RR treatment being $14.10/cow cheaper in supplementation cost, revenue from calves would be greater due to the tendency for increased WWT. Though calf WWT was not significantly different between RR and WCS treatments, RR calves averaged 229 kg and WCS calves averaged 217 kg. Even with decreased value/unit of BW for heavier weights, an increase in saleable calf kg/cow will result in an increase in total dollar revenue per cow. An analysis was performed utilizing market prices at the time of weaning in the current study with a base price of $2.64/kg and a price slide of $0.22/100 kg. Calves from the RR treatment generated $20.39 more revenue than WCS calves. When added to the difference in supplementation cost between RR and WCS and assuming similar costs throughout the rest of the year, the RR supplementation program could yield a $34.49/cow advantage over a traditional supplementation program such as the one used in this study. The favorable economics of a winter supplementation program utilizing winter annual pastures are also reported by Hill et al. (1985) and Utley and McCormick (1978).

Table 3-1. Pasture yield and chemical composition of bahiagrass pastures utilized for grazing cows supplemented with rye-ryegrass or whole cottonseed.

Item	Month	Supplement System: Rye-Ryegrass	Supplement System: WCS[1]	SEM[2]	P-value
DM Yield, kg/ha	December	895.0	910.0	79.76	0.91
	January	906.7	966.7	50.99	0.49
	February	820.0	746.7	25.21	0.17
	March	906.7	960.0	21.35	0.22
	April	813.3	853.3	21.03	0.31
CP, %	December	5.53	5.75	0.33	0.64
	January	5.25	6.02	0.43	0.32
	February	6.42	7.31	1.00	0.59
	March	11.97	8.19	0.93	0.23
	April	16.43	13.075	1.47	0.18
IVDMD, %[3]	December	49	53	-	-
	January	54	47	-	-
	February	55	48	-	-
	March	73	65	-	-
	April	69	64	-	-
DM, %	December	91.6	91.6	0.22	0.88
	January	91.0	91.3	0.07	0.15
	February	91.7	91.5	0.03	0.04
	March	91.6	91.5	0.10	0.55
	April	91.5	91.4	0.47	0.95
OM, %	December	95.6	97.0	0.05	0.003
	January	95.7	97.3	0.07	0.004
	February	92.6	97.1	0.04	<0.001
	March	92.8	96.5	0.32	0.02
	April	92.7	94.8	0.33	0.05

[1] Whole cottonseed.
[2] Standard error of mean, n=2.
[3] In vitro dry matter digestibility, monthly composite samples analyzed using a commercial laboratory (Dairy One, Ithaca, NY).

Table 3-2. Chemical composition of hay and supplement offered to cows grazing rye-ryegrass or receiving whole cottonseed.

		Supplement System		
Item	Month	Rye-Ryegrass	WCS[1]	Hay
DM Yield, kg/ha	December	3,147	-	-
	January	2,027	-	-
	February	1,427	-	-
	March	1,433	-	-
	April	1,480	-	-
CP, %	December	20.00	-	7.0
	January	17.1	23.2	9.2
	February	21.5	27.4	10.0
	March	18.6	26.0	9.4
	April	14.5	26.8	9.3
IVDMD,%[2]	December	70	-	58
	January	69	57	57
	February	67	76	63
	March	60	64	59
	April	50	70	63
DM, %	December	16.3	-	92.1
	January	17.9	92.9	92.8
	February	15.4	93.1	92.3
	March	16.2	93.1	91.8
	April	19.9	93.4	91.7
OM, %	December	91.2	-	95.2
	January	90.6	96.3	95.6
	February	90.2	95.7	95.5
	March	92.1	95.9	96.1
	April	91.1	94.5	95.6

[1] Whole cottonseed.

[2] In vitro dry matter digestibility, monthly composite samples analyzed using a commercial laboratory (Dairy One, Ithaca, NY).

Table 3-3. Cow body weight, body condition score, hay offered, and calf weights for rye-ryegrass and whole cottonseed supplementation treatments.

	Supplement System			
Item	Rye-Ryegrass	WCS	SEM[1]	P-value
Cow BW, kg				
12/8/10	596	585	8.8	0.36
1/13/11	617	590	8.1	0.02
4/19/11	589	561	9.1	0.04
BW change, kg[2]	-8	-24	11.4	0.43
Cow BCS				
December	5.0	5.0	0.11	0.93
January	4.8	5.1	0.08	0.03
February	5.1	5.1	0.08	0.91
March	5.3	5.0	0.10	0.13
April	5.5	5.1	0.13	0.02
BCS change[3]	0.5	0.1	0.27	0.35
Hay offered, kg/d[4]				
Period 1	9.8	11.2	0.02	<0.001
Period 2	12.2	14.0	0.73	0.22
Period 3	9.0	10.1	0.47	0.24
Period 4	6.1	6.9	0.99	0.64
Average	9.3	10.6	-	-
Calf BW, kg				
Birth weight	39	37	1.04	0.09
4/19/11[5]	111	100	4.45	0.11
WWT, kg[6]	229	217	5.99	0.13
205-day[7]	259	245	7.09	0.05
Calf ADG, kg				
Birth-4/19/11	1.05	0.91	0.05	0.05
Birth-8/8/11	1.06	1.01	0.02	0.13
WDOA, kg[8]	1.29	1.23	0.02	0.10

[1] Standard error of the mean, n=2.
[2] BW change from initiation of experiment to initiation of breeding season on 4/19/11.
[3] BCS change from initiation of experiment to initiation of breeding season on 4/19/11.
[4] Period 1: December to January; Period 2: January to February; Period 3: February to March; Period 4: March to April
[5] Date cow-calf pairs ended supplement treatments.
[6] Weaning weight
[7] Adjusted 205-day weight
[8] Weight per day of age

Table 3-4. Synchronization and total pregnancy rates in cows managed on either rye-ryegrass or with whole cottonseed.[1]

Item	Supplement System: Rye-Ryegrass	Supplement System: WCS[2]	P-Value
Estrous cycling, %	91.1, (31/34)	81.8, (24/33)	0.12
Estrous response, %[3]	78.4, (29/37)	50.0, (17/34)	0.02
Conception rate, %[4]	51.7, (15/29)	82.4, (14/17)	0.05
Timed-AI response, %[5]	25.0, (2/8)	52.9, (9/17)	0.21
Synchronized pregnancy rate, %[6]	46.0, (17/37)	67.7, (23/34)	0.07
Thirty-day pregnancy rate, %[7]	67.5, (27/40)	70.0, (28/40)	0.56
Breeding season pregnancy rate, %[7]	90.0, (36/40)	90.0, (36/40)	0.91

[1] Table lists percentages with raw animal numbers in parentheses.
[2] Whole cottonseed
[3] Percentage of cows over 30 days postpartum with plasma urea nitrogen levels $\geq$ 1.0 ng/mL
[4] Percentage of cows displaying estrus 3 d after $PGF_{2\alpha}$ of total treated.
[5] Percentage of cows pregnant to AI of the total that exhibited estrus and were AI.
[6] Percentage of cows pregnant to timed-AI of the total that were timed-AI.
[7] Percentage of cows pregnant during the synchronized breeding of the total treated.
[8] Percentage of cows pregnant during synchronization protocol or to bull.

Table 3-5. Cost comparison for rye-ryegrass and whole cottonseed winter supplement system.

	Supplement System	
Expenses per cow, $[1]	Rye-Ryegrass	WCS[2]
Field Preparation	28.36	-
Fertilizer	49.02	-
Seed	19.33	-
Water	13.13	-
Labor	7.43	12.75
Feed Cost		
Hay	127.63	145.25
WCS	-	101.00
Total Cost	244.90	259.00

[1]Based on market prices at time of experiment: Fertilizer $555.15/mt; v-ripping, $37.50/ha; disking, $25.83/ha; planting, $31.25/ha; fertilization, $20.00/ha; water, $10.00/acre inch; labor, $10.00/hour; hay, $110.00/mt; and whole cottonseed, $231.00/mt

[2] Whole cottonseed

CHAPTER 4
CONCLUSIONS

Limit-grazing gestating and lactating cows and calves on rye-ryegrass winter pasture resulted in increased BCS in cows when compared to a traditional winter supplementation utilizing whole cottonseed. Body weight losses associated with parturition and lactation were also minimized compared to the feeding of whole cottonseed. Thirty-day pregnancy rates and breeding season pregnancy rates were not different between treatments. In addition, calves nursing cows limit-grazed on rye-ryegrass tended to have greater BW per day of age from birth to weaning. Equally important, the supplementation cost on a per cow basis was less for the rye-ryegrass system implying that with the equal or better performance measurements reported in this study, utilizing winter annual pasture in supplementation systems during periods of low nutrient availability from dormant perennial pastures can be beneficial.

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BIOGRAPHICAL SKETCH

Cody Alan Welchons was born and raised in Valrico, Fl. Upon graduation from high school, Cody was accepted into the University of Florida where he quickly found a home at Alpha Gamma Rho fraternity and in the Animal Sciences department. After completion of his undergraduate degree in beef science he began his graduate program in ruminant nutrition under the guidance of Dr. Matt Hersom. After graduation Cody plans to continue working in the beef industry in Texas.