EFFECT OF GROWING BEEF REPLACEMENT HEIFERS ON WHEAT PASTURE BEFORE AND DURING BREEDING ON REPRODUCTIVE PEFORMANCE

By

MARSHA H. BRYANT

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Thesis Approved:

Dr. Gerald W. Horn

Thesis Adviser

Dr. Glenn Selk

Dr. Robert Wettemann

Dr. David Lalman

Dr. A. Gordon Emslie

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Successful reproduction is of great importance to most livestock operations, particularly the cow-calf segment of the beef industry. Sustainable cow-calf production systems are dependent on introduction of replacement heifers into the herd. Replacement heifers provide new and improved genetics which in turn optimize the returns of the operation. The growth and development as well as subsequent fertility of replacement heifers are critical to the success of a cow-calf herd.

Many producers choose to grow replacement heifers on high-quality forages such as wheat pasture. These high quality forages often raise questions of compromised fertility as a result of high levels of crude protein present in the forages. Excess dietary crude protein has been shown to have deleterious effects on reproduction in dairy and beef cattle. However, not all researchers have reported high levels of dietary protein negatively effect reproduction.

It is with these conflicting results in mind that the current work was undertaken. The broad objective for this review and research is to find and provide comparisons and possible answers to the question: Does the consumption of forages high in crude protein cause deleterious effects on reproductive performance?

CHAPTER II

REVIEW OF LITERATURE

Factors Affecting Reproductive Performance of Beef Heifers

Attainment of Puberty

The attainment of puberty in beef heifers is characterized by a number of physiological and endocrinological changes. Short (1984) defined puberty as the state or stage of development in which a female expresses a fertile ovulation that is followed by a normal length estrous cycle thus allowing for pregnancy success. A number of factors influence the rate of maturation in beef heifers and the attainment of puberty. These factors are important to consider as well as the interaction between the factors. Age, growth, nutrition and the production of adequate levels of reproductive hormones all influence the ability of a heifer to become pubertal.

Age

The age of a heifer is a common factor used to quantify the attainment of puberty. Puberty in beef heifers occurs from 6 to 24 months of age (Moran et al, 1989). The chronological age at which heifers become pubertal can vary greatly although the physiological age at which heifers reach puberty is more common (Moran et al, 1989). Heifers should become pubertal 1 to 3 months before the average age that they are to bebred. A common goal among beef replacement heifer programs is to develop females that will calve at two years of age. These heifers have to be pubertal at 12 to 14 months of

age to reach this production goal. Lesmeister et al. (1973) explained the importance of this rational by concluding that heifers at 2 years of age, calving early in the calving season will have higher average lifetime calf production due to the weaning of heavier calves. However this goal to have heifers bred early in the first breeding season may result in unsatisfactory pregnancy results because of heifers being bred at pubertal estrus. Byerley et al. (1987) conducted a study comparing the pregnancy rates of crossbred heifers bred by a fertile bull on the first pubertal estrus to heifers bred by a fertile bull on third estrus. They found that a greater percentage (78%) of heifers bred on third estrus became pregnant as compared with heifers bred on the first pubertal estrus (57%). Byerley also reported an increased pregnancy rate in heifers with increased age at first estrus. However, this was not observed at the third estrus. This study shows the sub-optimal fertility of pubertal estrus resulting in lowered pregnancy rates, but heifers that are older at pubertal estrus will have greater chances of pregnancy success.

The specific age at which puberty occurs in beef heifers is a function of genetics and the level of growth from weaning to pre-breeding (Short, 1994). Following achievement of a certain age, body weight will impact the attainment of puberty in heifers (Greer et al., 1983; Yelich et al., 1995).

Growth

Growth is needed to ensure not only the attainment of puberty but the continuation of regular estrous cycles (Bond et al., 1958). However, it has been suggested that growth rate has a lesser effect on puberty after a certain critical weight has been reached (Schillo et al., 1992). Until heifers reach a particular target weight estrus is

unlikely to occur. This demonstrates the major role that body weight and growth play in the attainment of puberty. A general rule of thumb for developing replacement heifers is the concept of target weight. This principle is used to ensure that heifers are cycling prior to the breeding season by feeding them to a pre-breeding target weight of 53-65% of the herd average mature weight (Patterson et al., 1999; Funston, 2004). Furthermore, Simpson and coworkers (1998) reported that body weight and body condition score accounted for 55% of observed variation in age at first conception in heifers. Yelich et al. (1995) looked at the effect of three rates of gain (full-fed to gain 1.36 kg/d, limit-fed to gain 0.68 kg/d, and maintenance-full-fed to gain 0.23 kg/d for 16 wks, then full-fed to gain 1.36 kg/d) on carcass composition, lipid partitioning, and age and body weight at puberty. Heifers that were full-fed had increased rate of gain, greater body weight and body condition score, and younger age at the time of puberty (Yelich et al., 1995). Yelich concluded that age has a permissive role in regulating the attainment of puberty. Body fat, associated with many hormones and metabolites is a major contributor to the age at which puberty will occur.

Management factors concerning growth have a large impact on the physiological processes that support the attainment of puberty (Patterson et al., 1992). Post-weaning gain has a large effect on the attainment of puberty. Numerous studies have shown that if post-weaning gain is increased puberty will be advanced (Ferrell, 1982; Fleck et al., 1980; Hall et al., 1995; Hopper et al., 1993). Similarly, decreased body weight gain has been shown to delay puberty in heifers (Granger et al., 1990). Several studies have shown that even when the rate and timing of post weaning body weight gain was varied in heifers, the subsequent reproductive performance was unaffected (Clanton et al., 1983;

Lynch et al., 1997; Freetly et al., 2001). Wiltbank et al. (1966) showed that pre-weaning growth rate is inversely correlated with age at puberty in beef heifers; whereas, the effect of post-weaning growth rate on puberty is more influenced by the plane of nutrition.

Nutrition

Nutrition is a key component of heifer development. It is involved in proper growth and reproductive maturation (Patterson et al., 1992). Nutritional management will influence the age and weight at which a heifer will become pubertal. This is supported by the studies of Joubert et al. (1954), Short and Bellows (1971) and Pinney et al. (1972), who reported that a higher plane of nutrition increased weight at puberty. On the other hand, Day et al. (1986) reported heifers on a low plane of nutrition during the pre-pubertal period had decreased gonadotropin secretion resulting in the delay of puberty. Dunn et al. (1969) and Hill et al. (1970) also showed that lower levels of nutrition delayed the first estrus and impaired subsequent breeding in beef heifers. Moreover, Ferrell (1982) reported that improper nutrition during the post-weaning period in the form of moderate under-feeding or over-feeding have prolonged effects on age and weight at puberty in beef heifers. However, Varner and coworkers (1977) suggested that age at puberty can be reduced when heifers are sorted into heavy and lightweight groups at weaning and fed accordingly.

Along with plane of nutrition, alterations in dietary nutrients have been shown to impact the onset of puberty as well. Diets high in protein have been shown to result in an earlier onset of puberty in Zebu heifers because of faster growth rates (Oyedipe et al., 1982). However, supplementing heifers with ruminally undegradable intake protein in the form of blood and corn gluten meal did not advance puberty in beef heifers (Lalman et

al., 1993). Lammoglia et al. (2000) supplemented fat to heifers and found that age at puberty was unaffected but supplementation tended to increase the proportion of heifers pubertal by breeding. Whitney et al. (2000) reported that supplemental fat in the form of soybean oil resulted in decreased time to first conception in beef heifers. Increasing the amount of propionate available to the animal by increasing energy intake has been shown to result in earlier pregnancy (Lemenager et al., 1980). In contrast, Lalman and coworkers (1993) showed that supplementing heifers with propionic acid did not affect the onset of puberty as compared with control heifers when body weight gain was held constant between the two groups of heifers. These conflicting results may be in part due to the effect on body weight gain by increasing energy intake.

The use of ionophores may also have positive effects on puberty and reproduction. Moseley et al. (1977) conducted a study to determine the effect of feeding monensin on age at puberty and conception rates. In this study 184 yearling heifers were randomly assigned by weight and bred to three treatments: 1) full-time grazing on wheat pasture, oats, ryegrass and 0.91 kg per head per day of 20% protein cubes 2) part-time grazing on wheat pasture and 0.91 kg per head daily of range cubes 3) heifers fed in drylot 1.36 to 3.18 kg per head daily of a high energy grain concentrate, bermudagrass hay and 0.91 kg per head per day range cubes. Heifers within each treatment were assigned to either receive 200 mg or 0 mg monensin per head per day. Moseley et al. (1977) reported that feeding monensin will accelerate the onset of puberty in heifers. However, this decrease in age at puberty was not attributed to an increase in body weight. Furthermore, feeding monensin had no deleterious effect on conception rates. Similarly,

Bushmich (1980) reported that feeding monensin enhanced the ovarian response to gonadotropins.

The evidence from these studies show some potential benefits of supplementation of dietary nutrients on reproductive maturation, however the results are not consistent. Therefore, the primary goal of heifer development should be to provide cattle with adequate nutrition as cost effectively as possible as long as cattle reach a target weight and attain puberty prior to the breeding season.

Conception

Nutrition

Reproductive performance in heifers is closely related to the nutritional status of the heifers. The effects of high and low levels of nutrition on subsequent fertility have been extensively studied. Hill et al (1969) reported that heifers fed 85% of maintenance requirements for energy and protein had decreased pregnancy rates as compared with control heifers fed a maintenance level of the same diet. Short and Bellows (1971) compared the reproductive potential of heifers fed to gain 0.23, 0.45, or 0.68 kg/day. Fewer heifers that gained 0.23 kg/day became pregnant as compared with the other groups. Furthermore, heifers in the low gain group tended to conceive later and had greater embryonic losses.

IGF-I

*I*GF-I stimulates ovarian function in cattle (Spicer et al., 1993). It has been shown to have direct local effects on granulosa cell mitosis and production of estradiol; this stimulates follicular growth (Spicer et al., 1993). Circulating IGF-I is produced in the liver under the direction of growth hormone and is responsive to energy balance.

Nutrition and more specifically energy intake, has been shown to be a major factor in controlling concentrations of IGF-I in the blood. One study conducted by Houseknecht and coworkers (1988) reported that low energy levels severely decreased concentrations of IGF-I in beef heifers. In contrast, Breier et al. (1986) reported that IGF-I concentrations were increased in steers on high and moderated planes of nutrition compared with those on lower planes of nutrition. Cooke et al. (2008) showed that the frequency of supplementation can play a role in the amount of IGF-I present in plasma. When cows were offered an energy supplement based on fibrous byproducts daily, IGF-I concentrations in plasma were increased as compared with cows supplemented 3 times weekly (Cooke et al., 2008). This increase in IGF-I concentrations could improve the reproductive efficiency of cows consuming low quality forages by influencing steroid production by the gonads (Armstrong et al., 2002). The results of most studies would agree that, plane of nutrition, composition of the diet as well as nutrient intake may influence concentrations of IGF-I.

Estrous synchronization and artificial insemination

The use of hormonal treatment to synchronize estrous of heifers has been commercially available for many years. Estrous synchronization will concentrate breeding and calving seasons and allow for the use of artificial insemination. Methods to synchronize estrous have been reviewed by Patterson et al. (2003). Control of estrus in beef heifers requires the manipulation of both the follicular waves as well as the luteal phase of the cycle (Patterson et al., 1999). New methods of estrous synchronization in replacement beef heifers the utilize progesterone treatment before treatment with GnRH and prostaglandin offers significant potential to synchronize estrous and increase

conception rates (Patterson et al., 2003). The uses of GnRH and progesterone sources such as CIDRs to synchronize estrous have been suggested to induce cyclicity. Lamb et al. (2006) showed that conception rates in heifers synchronized with GnRH and CIDRs were not affected by the pubertal status of the heifers prior to synchronization. This could be a result of these hormones causing the heifers to show luteal activity.

Rather than detecting estrus many producers choose to artificially inseminate all animals at a predetermined time. However, timing of artificial insemination can also have an effect on conception. Most timed AI protocols call for insemination 54 and 56 hours after prostaglandin is given. The average interval from prostaglandin injection to estrus in heifers can range from 42 to 60 hours (Lamb et al., 2006). Busch et al. (2008) conducted an experiment to compare pregnancy rates of beef cows fixed time artificially inseminated at either 54 or 66 h after the administration of a CO-Synch plus CIDR protocol. Pregnancy rates were greater in cows that were fixed time artificially inseminated at 66 h as compared with cows inseminated at 54 h. However, mixed results have been reported and more research is needed to identify the appropriate timing of artificial insemination which allows for successful conception.

Uterine pH at the time of insemination has also been shown to have an effect on conception. The initiation of standing estrus within 24 h of fixed time AI has been shown to be associated with increased pregnancy rates (Perry et al., 2007). The start of estrus occurs after a rise in concentrations of estradiol. These increased levels in turn affect the pH of the uterine environment (Allrich, 1994). Perry and Perry (2008) reported that administration of estradiol cypionate to cows synchronized by the Co-Synch protocol resulted in elevated pre-ovulatory concentrations of estradiol, increased the percentage of

cows in standing estrus, and decreased uterine pH. Perry concluded that decreased pregnancy rates in cows not in standing estrus at the time of insemination could be a result of an adverse uterine environment due to inadequate concentrations of estradiol.

Bull fertility

The majority of beef females in the United States are bred by natural service. Therefore, optimum sperm production and libido in the bull are of critical importance when looking at factors affecting conception. Studies showing the effect of plane of nutrition on sperm production in the bull are limited except for extreme conditions. In a review article, Dziuk and Bellows (1983) stated that bulls must be provided with an adequate diet for optimum sperm production. Farin et al. (1982) used 93 beef bulls and 2316 females to determine the relationship between breeding assessments of bulls and successful mating. Farin concluded that libido scores can identify groups of bulls that can service more females and breeding soundness exams should be used to identify bulls that can successfully impregnate females. More recently, a study was conducted to evaluate the influence of seminal quality and bull on pregnancy rates in fixed time AI programs (DellAqua et al., 2009). Semen samples from eight bulls were extended with Andromed and Buto-Bov. Frozen extended semen samples were used to inseminate 1429 cows. Semen quality was improved with both extenders. However, conception rates varied from 28% to 61% according to the bull this resulted in a significant ($P<0.01$) bull effect on fixed time AI pregnancy rates (DellAqua et al., 2009).

Characterization of High Quality Forages

Forage quality is affected by many factors such as genetics, physiological, environmental and plant development. Furthermore, the nutritive value of any forage is primarily determined by its chemical composition (Van Soest, 1982). Plant maturity is a major factor affecting the quality of forage. As plant maturity increases, forage quality for ruminant animals decreases through an increase in cell wall concentration and decrease in crude protein concentrations.

Composition and quality of cool-season forages

Annual cool-season grasses have the ability to provide both grain for human and animal consumption as well as grazing for livestock production systems. These grasses often do well under limited precipitation but do not in hot (above 35° C) humid areas (Phillips et al., 1996). Annual cool-season grasses grow best where precipitation is less than 760 mm (Phillips et al., 1996). Cool-season grasses such as ryegrass, rye, wheat, oats, triticale, brome, and fescue provide valuable winter and spring grazing. These cool season grasses are high in quality and are capable of producing gains in excess of 1 kg per day and are often used as a protein and energy supplement (Bagley, 1993). Cool-season grasses are often characterized by low dry matter contents, high crude protein, and high dry matter digestibility (Vogel, 1983). Blasi et al. (1991) reported crude protein values of smooth brome to be as high as 25% of DM. Beck and coworkers (2008) summarized the chemical composition of fescue, ryegrass, and winter wheat pastures. In the month of March, the crude protein in these cool season grasses ranged from 24.1 to 27.3%. Dry matter digestibility during March was high and ranged from 79.0 to 92.8 %

DM. Reid et al. (1988) reported average values of 38.3 and 65.3% for ADF and NDF, respectively, in fescue, orchardgrass, ryegrass and brome forages fed to cattle.

In the southern Great Plains winter wheat is a major cool-season forage used for growing beef cattle. Wheat forage provides high levels of crude protein and is rapidly fermented in the rumen. Wheat forage generally contains high concentrations of crude protein. In the late fall and early spring it commonly ranges from 25 to 30% of crude protein on a DM basis (Johnson et al., 1974). A large amount of the nitrogen present is in the form of non-protein nitrogen (Horn, 1983). Horn and co-workers (1977) reported as much as 37.18% of total nitrogen as non-protein nitrogen in forage samples collected from wheat pastures. Similarly, Johnson et al (1974) reported a range of 16 to 33% of total nitrogen in the form of non protein nitrogen. The soluble nitrogen fraction in wheat forage is also high with reported values ranging from 44 to 62% of total nitrogen. One study by Branine and Galyean (1990) showed that the total nitrogen of winter wheat ranged from 4.9 to 3.4% of dry matter from early April to mid May. Furthermore, soluble nitrogen ranged from 40.8 to 38.2% of total nitrogen and 30.6 to 26.4% of total nitrogen was in the form of soluble non-protein nitrogen (Branine and Galyean, 1990). Up to 75% of wheat forage nitrogen is rapidly fermented in the rumen and has a high disappearance rate of approximately 19% per hour (Vogel, 1989). The presence of these nitrogen fractions in such high amounts in conjunction with the rapid ruminal degradation rate can result in very high levels of ammonia being released into the blood (Johnson, 1974).

The fiber content of wheat forage is considered to be rather low. Horn (1983) reported that most values for ADF were below 30% of DM and most NDF values were below 50% of DM. Branine and Galyean (1990) reported ADF values in wheat forage to

range from 21 to 22% during early April to late May while NDF concentrations ranged from 43 to 50%. It has been suggested that the rate of ruminal nitrogen digestion is highly dependent on the fiber content in the forage (Nocek and Grant, 1987).

Composition and quality of warm-season grasses

The new growth of warm season grasses such as switchgrass, and big bluestem also has high levels of crude protein. However, warm season grasses tend to be more slowly degraded in the rumen than cool season grasses (Van Soest, 1982). Hackmann et al. (2008) characterized the chemical composition of warm season grasses with average values of 18.0, 26.6 and 62.3% of DM for crude protein, ADF and NDF, respectively. The fiber content of warm season grasses is higher than that of cool-season grasses. Reid et al. (1988) reported average values of 42.7 and 74.5% for ADF and NDF, respectively for warm season grasses. Similar values for ADF and NDF were reported in big bluestem by Blasi and coworkers (1991).

Dietary Protein and Urea Nitrogen

Dietary protein is a required nutrient for growth, maintenance, and reproduction of ruminants. Ruminant animals, unlike other mammals are unique in their ability to utilize both non-protein nitrogen (NPN) and true protein to satisfy their requirements for amino acids (National Research Council, 2000). Crude protein consumed by the ruminant animal is partitioned into two parts; a soluble component and an insoluble component. The soluble component is made up primarily of NPN in the form of urea, ammonia, nitrates, amines and free amino acids. This fraction is degraded rapidly and completely. Prichard and Van Soest (1977) described the insoluble component of forages as true protein partitioned into three components. These three components include a rapidly available fraction, a slowly available fraction and a final fraction of unavailable proteins. Most of the total dietary protein fed is degraded in the rumen into ammonia (Church, 1988). Dinning and coworkers (1948) showed that if the amount of ammonia in the rumen is greater than the amount that can be metabolized it will be absorbed through the ruminal wall into the portal blood.

Urea, formed from the detoxification of ammonia, appears in the blood and milk of an animal and can be quantified as milk, plasma, or serum urea nitrogen, often referred to as blood urea nitrogen (MUN, PUN, SUN, and BUN respectively). The level of urea that is present in milk or blood constituents is reflective of the amount of protein consumed. Therefore, the measurement of MUN, PUN, SUN, or BUN provides an index of the metabolism of dietary protein (Roseler et al., 1993).

Dietary Protein and Reproduction

Several studies have been conducted to examine the effects of excessive dietary protein on successful breeding. The results of these studies have been mixed, however a large number have reported a negative relationship.

High Protein Diets and Dairy Cattle Reproduction

In the dairy industry an increase in the nutrient density of diets is needed in order to maintain high levels of milk production. This increase is often in the form of energy and supplemental protein such as soybean meal or urea. When feeding a diet supplemented with soybean meal above NRC requirements, Roseler et al., (1993) reported higher PUN concentrations as compared with balanced diet. Similar results have been reported when the percentage of crude protein is increased in the diet. Jordan and Swanson (1979) fed increasing levels of crude protein to lactating dairy cows (12.7, 16.3, 19.3% DM) and reported significantly higher PUN concentrations in the group fed the highest level of crude protein (9.08 vs. 18.25 mg/dL). High dietary protein resulting in high concentrations of urea nitrogen in plasma has been associated with decreased fertility in dairy cattle. Butler (1996) reported that PUN concentrations greater than 19 mg/dL were associated with decreased pregnancy rates. Similar results have been reported by Ferguson et al. (1993) and Canfield et al. (1990). Contrary to the previous findings, not all researchers have noted a negative relationship between dietary protein and reproduction. Howard et al. (1987) reported successful breeding in cows fed increasing amounts of crude protein from 14.5 to 19.4% of the DM. Likewise, a study in which dairy cows were fed either 13 or 20% CP showed that reproductive performance was not significantly decreased when cows were fed 20% CP (Carroll et al., 1988).

Garcia-Bojalil et al. (1994) fed 12 or 27% crude protein diets to non-lactating cows before and during superovulation and found that there was no effect of diet on follicular recruitment or growth, total number of embryos collected, or fertilized embryos.

There is an increasing body of evidence to suggest that level of dietary protein does play a role in dairy cattle fertility. Increased crude protein levels, increased degradability, and high concentrations of urea systemically have been shown to play a role in decreased fertility. Not all have observed these results and it is important to note that the metabolism of dietary protein depends to a large extent on the energy available in the rumen. When there is insufficient energy, ammonium ions that are in excess are converted to urea by the liver. Therefore the negative effects of high dietary protein are likely influenced by level of energy intake. In a review article Westwood and coworkers (1998) used meta-analyses to investigate the contrasting results of many studies with dairy cattle in various stages of production. When looking at the effect of increasing dietary protein on conception rates they found a strong indication of increased risk of conception failure with increased dietary protein. Likewise, Ferguson and Chalupa (1989) applied logistic regression analysis to the existing data on protein effects on reproductive performance in lactating cows to better understand the impact of ruminally degradable protein and undegradable protein on conception rate. They suggested that intake of ruminally degradable protein in excess of requirements is associated with a decrease in conception rate in dairy cows.

High Protein Diets and Beef Cattle Reproduction

In the beef industry proper development of replacement heifers is of major importance to the productivity of a cow herd. Heifers should be managed in such a way

that they reach puberty quickly, and conceive early in the first breeding season. In the fall and early winter forage availability is often limited. Weight gains of non-supplemented heifers may be inadequate for them to reach puberty and conceive early in the first breeding season. High quality grasses are often used to support the growth of these heifers through the winter. However, the effect of high quality grasses on subsequent fertility has been questioned. Beck and coworkers (2005) conducted an experiment using beef replacement heifers that were program-fed to gain 0.68 kg/d with a 13.7% CP diet or placed on wheat and ryegrass pastures. Heifers that grazed wheat and ryegrass pastures had significantly greater SUN levels and lower pregnancy rates as compared to heifers that were program-fed. Contrary to the results reported by Beck, embryo survivability has been shown to be unaffected by increased protein levels in the diet (Kenny et al., 2001, Kenny et al., 2002). The embryo survival rate in nulliparous beef heifers either consuming increased levels of forage crude protein or high levels of rumen degradable protein, was unaffected by dietary urea regardless of increased systemic concentrations of ammonia and urea (Kenny et al., 2001, Kenny et al., 2002).

The results from numerous studies in both dairy cattle and beef cattle show that there is no consensus on the effects of dietary protein on reproduction. Studies are summarized in the following table.

Conception Rates (CR) and Urea Nitrogen Concentrations of Cattle Fed Moderate or Elevated Crude Protein

Reference	% Dietary Crude Protein			
	14-16		19-27	
	CR (%)	Urea N (mg/dL)	CR (%)	Urea N (mg/dL)
Jordan and Swanson, 1979	53	Not reported	40	Not reported
Howard et al., 1987	87	15	85	26
Carroll et al., 1988	64	11	56	24
Canfield et al., 1990	47	12	31	17
Elrod and Butler, 1991	83	< 16	62	>16
Garcia-Bojalil et al., 1994	31	<16	48	>23
Beck et al., 2005	88	9 - 18	69	14 - 21

The explanation for the confounding results reported from these studies is likely due to the possibility that the concentrations and rumen degradability of the dietary crude protein interact with different stages of production, such as lactation, and changes in energy status. These interactions are important to consider when examining the effects of protein on reproductive performance.

Proposed mechanism of action

Many studies have been conducted with the objective of determining the underlying causes for decreased reproductive performance that is associated with feeding increased levels of dietary protein. Several proposed mechanisms have been studied relative to the detrimental effect of high dietary protein on subsequent fertility. One potential mechanism of fertility depression is the effect on the uterine environment. This change in the uterine environment may in turn affect the viability of sperm and embryos.

Uterine environment

Elevations in blood urea and ammonia can lead to an increase in the amount of urea and ammonia present in the reproductive tract (Duby et al., 1984, Johnson et al., 1986, Holtz et al., 1986). Carroll et al.(1987) reported urea nitrogen levels in the vaginal fluid of cows fed a TMR containing 20% CP to be significantly greater than that of cows fed 13% CP (8.2 vs 20.9 mg/dL). As plasma ammonia and urea concentrations increase, the decrease in fertility may be related to the changes in the uterine environment by decreasing the pH, lowering the mineral content, and causing impairment of the inflammatory response.

At estrus, uterine pH in cows is approximately 6.8 (Elrod and Butler, 1993). This pH is similar to the pH of ejaculated sperm, which has been reported to be 6.8 (Acott and Carr, 1984). Elrod and Butler (1993) characterized the changes in uterine pH of cows fed two levels of protein (15 vs 21% CP). Uterine pH at estrus and on day 7 of the estrus cycle was determined. In cows fed lower levels of protein, uterine pH was higher during the luteal phase than estrus. The cows receiving high levels of protein had significantly lower uterine pH during the luteal phase and a similar pH during estrus. These pH changes were parallel to the changes in concentrations of Mg, K, and P reported by Jordan et al. (1983) during various stages of the estrous cycle. The concentrations of these ions increase during the luteal phase but decreased in cows fed high levels of protein. In addition, Elrod and Butler (1993) proposed the question of whether the effect of high protein in the diet on uterine pH was specific to the uterus or could it also be present in the pH of other bodily fluids. To answer this question, 36 Holstein cows in early lactation were fed a balanced diet, a diet high in UIP, or a diet high in DIP. It was reported that the alterations of pH were unique to the uterus and no significant differences

in pH were observed in blood, saliva, or urine. Furthermore, excess crude protein in the diet, regardless of protein source or degradability was found to alter the uterine environment in this study.

Ions (Ca, Mg, K, Zn, and P) play a vital role in establishing a fertile environment in the reproductive tract. The concentrations of these ions in the secretions of the uterus may be altered by the amount of protein in the diet. Wiebold (1988) found differing ionic concentrations of uterine fluid in which viable embryos were obtained when compared with the uterine fluid containing unviable embryos. This study provided evidence that the ionic composition of uterine fluid may play a vital role in embryonic survivability. A study using high producing dairy cows fed either 12 or 23% CP found that cows fed high levels of protein had lower concentrations of Ca, Mg, P, K, and increased Zn concentrations during the luteal phase (Jordan et al., 1983). Similarly, Elrod and Butler (1992) reported that higher concentrations of ammonia were negatively associated with net ion flux across the endometrium. Lower concentrations of these minerals can be detrimental to proper cell function (McMormack et al., 1990).

Barton et al. (1996) suggested that the elevation of ammonia in tissues subsequent to high CP intakes may delay clearance of uterine contaminants by reducing the immunogenic functions of macrophages and white blood cells. Normal systemic concentrations of ammonia in cattle are approximately 0.08 mg/dL (Bartik, 1981). The viability of bovine lymphocytes has been found to be affected by ammonia concentrations less than 1 mg/dL. Kluciski and Targowski (1984) reported ammonia levels of 0.5 to 1.0 mg/dL in cattle to be clinically sub-toxic. Jordan et al. (1983) reported ammonia concentrations in cows fed 23% CP to be 0.8 ± 0.05 mg/dL. These values are

within the reported sub toxic range. Intake of diets high in CP may increase ammonia levels which in turn lower the immunoresponsiveness of the animals to infectious disease (Targowski et al., 1984) resulting in a decrease in fertility.

Effect on sperm.

In order for successful breeding to occur, a large amount of competent spermatozoa must arrive at the site of fertilization. Motility and the survivability of sperm both seem to be affected by the level of protein in the diet of the female. In order to investigate the potentially toxic effects to sperm, Williams et al. (1989) obtained uterine flushings from Holstein cows fed either 12 or 28% CP on days 1, 5, and 10 of the estrous cycle. When bovine semen was incubated in the flushings no significant differences in percent motility, or percent intact acrosomes was observed between the two treatments. However, as length of incubation increased, a significant reduction in percent motility and intact acrosomes was noted. Furthermore, the effect of pre-incubating mouse spermatozoa in the uterine flushings for 1 hour on in vitro fertilization of mouse oocytes was examined and no significant differences were found. Turner and Howards (1978) showed that epididymal spermatozoa diluted with urea were immotile. Deitz and Flipse (1969) added ammonia to washed bovine spermatozoa at the levels of 4, 8, 12, 16 mM, and reported increased inhibition of oxygen uptake by 11, 16, 30, 33%, respectively. Furthermore, in a neutral pH spermatozoa are most active and survive the longest, when pH decreases in the uterus because of increased concentrations of urea or ammonia the sperm are adversely affected (Jordan and Swanson 1979).

Effect on Embryos

The effect on systemic concentrations of ammonia and urea on embryo viability and various measurements of embryo development have been examined with mixed results.

In one study, 175 crossbred beef heifers were randomly assigned to graze pastures with low (127.74 g/kg CP) or high (231.77 g/kg CP) protein concentrations. The intake of forages high in CP resulted in significantly higher ammonia and urea levels in the blood. However, they reported a high overall embryo survival rate (71%) and no treatment differences. Significant differences were not found for embryo weight, crown-rump measurement, or amniotic and allontoic fluid volumes across diets (Kenny et al., 2001). Garcia-Bojalil et al. (1994) reported similar results. They found elevated plasma urea nitrogen concentrations in non-lactating cows receiving increased dietary CP levels of 27.3% compared to cows receiving lower levels of CP at 12.4%. However, it was found that diet did not affect the quantity or quality of embryos recovered after superovulation. Embryo development was also found to be unaffected by diet in this experiment. Likewise, Gath and coworkers (1999) reported no effect of high dietary crude protein in the form of urea on embryo development 3 days post AI or between day 7 and 35 of pregnancy when good quality embryos were transferred in beef heifers. Also in agreement with the prior studies, a study performed on mature ewes fed excess DIP showed no effect of diet on embryo recovery or embryo damage (Berardinelli et al., 2001). Contrary to these reports Elrod and Butler (1993), reported decreased pregnancy rate to first service in cows fed high CP levels. The authors suggested a greater incidence of early embryonic death in cows fed high CP because of observed prolonged luteal phases followed by return to estrus post-insemination. Rhoads (2006) also showed that

embryos collected from lactating cows with high levels of PUN were less likely to establish pregnancy.

The energy status of the animals in these different studies was different. Therefore, the effects of high dietary protein in lactating cows may mediate processes that would result in impaired embryo development. However, these results may not be found in non-lactating cattle or beef cattle with positive energy balances.

Summary of Review of Literature

In most production systems replacement heifers are bred to produce their first calf at approximately 24 months of age to increase profitability during their lifetime. In order to reach this production goal, heifers must conceive at 14 to 16 months of age. Therefore, the attainment of puberty is very important in replacement heifers, and the many factors that affect this are important to consider.

Factors that affect conception in cattle are immense in the literature. Nutrition is a key component of heifer development but is also highly involved in adequate reproductive performance of replacement heifers. Alterations of dietary nutrients have been shown to affect reproductive performance in heifers. The majority of the evidence presented showed deleterious effects increased crude protein on subsequent reproduction. One consistent finding is that the consumption of excessive amounts of protein increased urea nitrogen concentrations. However, high systemic concentrations of urea in both males and females, and its effects on fertility are still under question.

Selected Bibliography

Acott, T. S. and D. W. Carr. 1984. Inhibition of bovine spermatozoa by caudal epididymal fluid: II. Interaction of pH and a quiescence factor. Biol. Reprod. 30:926-935.

Allrich R.D. 1994. Endocrine and neural control of estrus in dairy cows. J. Dairy Sci. 77:2738-2744.

Armstrong, D. G., T. G. McEvoy, G. Baxter, J. J. Robinson, C. O. Hogg, K. J. Woad, R. Webb, and K. D. Sinclair. 2001. Effect of dietary energy and protein on bovine follicular dynamics and embryo production in vitro: associations with the ovarian insulin-like growth factor system. Biol. Reprod. 64:1624-1632.

Bagley, C.P. 1993. Nutritional management of replacement beef heifers: a review. J. Anim. Sci. 71:3155-3163.

Bartik, M. 1981. Veterinary Toxicology. Developments in Animal and Veterinary Sciences. 7:40-47.

Barton, B. A., H. A. Rosario, G. W. Anderson, B. P. Grindle, and D. J. Carroll. 1996. Effects of dietary crude protein, breed, parity and health status on the fertility of dairy cows. J. Dairy Sci. 79:2225-2236.

Beck, P.A., S.A. Gunter, K.S. Lusby, C.P. West, K.B. Watkins and D.S. Hubbell, III. 2008. Animal performance and economic comparison of novel and toxic endophyte tall fescues to cool-season annuals. J. Anim. Sci. 86: 2043-2055.

Beck, P. A., S. A. Gunter, J. M. Phillips, and D. L. Kreider. 2005. Development of

replacement heifers using programmed feeding. Prof. Anim. Sci. 21:365-370.

Berardinelli, J. G., J. Weng, P. J. Burfening, and R. Adair. 2001. Effect of excess degradable intake protein on early embryonic development, ovarian steroids, and blood urea nitrogen of days 2, 3, 4, and 5 of the estrous cycle in mature ewes. J. Anim. Sci. 79:193-199.

Blasi, D. A., J.K. Ward, T.J. Klopfenstein, and R. A. Britton. 1991. Escape proteins for beef cows: III Performance of lactating beef cows grazing smooth brome or big bluestem. J. Anim. Sci. 69:2294-2302.

Bond, J., J.N. Wiltbank, and A. C. Cook, 1958. Cessation of estrus and ovarian activity in a group of beef heifers on extremely low levels of energy and protein. J. Anim. Sci. 17:1211.

Branine, M.E., and M.L. Galyean. 1990. Influence of grain and monensin supplementation on ruminal fermentation, intake, digesta kinetics and incidence and severity of frothy bloat in steers grazing winter wheat pastures. J. Anim. Sci. 68:1139-1150.

Breier, B. H., J. J. Bass, J. H. Butler, and P. D. Gluckman. 1986. The somatotrophic axis in young steers: influence of nutritional status on pulsatile release of growth hormone and circulating concentrations of insulin-like growth factor 1. J. Endocr. 111:209-215.

Bush, D.C., D.J. Schafer, D.J. Wilson, D. A. Mallory, N.R. Leitman, J.K. Haden, M.R. Ellersieck, M.F. Smith, and D. J. Patterson. 2008. Timing of artificial

insemination in postpartum beef cows following administration of the CO-Synch + CIDR protocol. J. Anim. Sci. published online 14 Mar 2008.

Bushmich, S.L., R.D. Randel, M.M. McCartor and L.H. Carroll. 1980. Effect of dietary monensin on ovarian response following gonadotropin treatment in prepubertal heifers. J. Anim. Sci. 51:692.

Butler, W. R., J. J. Calaman, and S. W. Beam. 1996. Plasma and milk urea nitrogen in relation to pregnancy rate in lactating dairy cattle. J. Anim. Sci. 74:858-865.

Byerley, D.J., R. B. Staigmiller, J.G. Berardinelli, and R. E. Short. 1987. Pregnancy rates of beef heifers bred either on puberal or third estrus. J. Anim. Sci. 65:645-650.

Canfield, R. W., C. J. Sniffen, and R. W. Butler. 1990. Effects of excess degradable protein on postpartum reproduction and energy balance in dairy cattle. J. Dairy Sci. 73:2342-2349.

Carroll, D. J., B. A. Barton, G. W. Anderson and B. P. Grindle. 1987. Influence of dietary crude protein intake on urea nitrogen and ammonia concentration of plasma, ruminal, and vaginal fluids of dairy cows. J. Dairy Sci. 70(Suppl. 1):117 (Abstr.).

Carroll, D. J., B. A. Barton, G. W. Anderson, and R. D. Smith. 1988. Influence of protein intake and feeding strategy on reproductive performance of dairy cows. J. Dairy Sci. 71:3470-3481.

Church, D. C. The Ruminant Animal: Digestive Physiology and Nutrition. Prentice Hall, New Jersey, USA, 1988.

Clanton, D.C., L.E. Jones, and M.E. England. 1983. Effect of rate and time of gain after

weaning on the development of replacement heifers. J. Anim. Sci. 56:280-285.

Cooke, R. F., J. D. Arthington, D. B. Araujo, G. C. Lamb and A. D. Ealy. 2008. Effects of supplementation frequency on performance, reproductive, and metabolic responses of Brahman-crossbred females. J. Anim. Sci. 86:2296-2309

Day, M.L., K. Imakawa, D.D. Zalesky, R.J. Kittok, and J.E. Kinder. 1986. Effects of restriction of dietary energy intake during the prepubertal period on secretion of luteinizing hormone and responsiveness of the pituitary to luteinizing hormone-releasing hormone in heifers. J. Anim. Sci. 62: 1641-1648.

DellAqua, J. A., A. M. Crespilho, C. P. Freitas, P. Guasti, F. S. Zahn, and F. O. Papa. 2009. Influence of seminal quality and bull on fertility rates in fixed time artificial insemination programs. Bio. Reprod. 81:628.

Dietz, R. W., and R. J. Flipse. 1969. Metabolism of bovine semen. Biol. Reprod. 1:200-206.

Dinning, J. S., H. M. Briggs, W. D. Gallup, H. W. Orr, and R. Butler. 1948. Effect of orally administered urea on the ammonia and urea concentration in the blood of cattle and sheep, with observations on blood ammonia levels associated with symptoms of alkalosis. Am. J. Physiol. 153:41.

Duby, R. T., J. P. Tritschler, R. W. Prange, and F. T. Abdul-Wahid. 1984. Effect of dietary crude protein on urea in fluids of the reproductive tract of ewes and dairy cows. J. Anim Sci. 59 (Suppl. 1):339(Abstr.)

Dunn, T.G., J.E. Ingalls, D.R. Zimmerman, and J.N. Wiltbank. 1969. Reproductive

performance of 2-year-old Hereford and angus heifers as influenced by pre- and post-calving energy intake. J. Anim. Sci. 29:719-726.

Dziuk, P.J., and R.A. Bellows. 1983. Management of reproduction in beef cattle, sheep and pigs. J. Anim Sci. 57:355-379.

Elrod, C. C., M. Van Amburgh, and W. R. Butler. 1993. Alterations of pH in response to increased dietary protein in cattle are unique to the uterus. J. Anim. Sci. 71:702-706.

Elrod, C. C., and W. R. Butler. 1993. Reduction of fertility and alteration of uterine pH in heifers fed excess ruminally degradable protein. J. Anim. Sci. 71:694-701.

Farin, P.W., P.J. Chenoweth, E.R. Mateos and J.E. Pexton. 1982. Beef bulls mated to estrus synchronized heifers: single-vs-multi-sire breeding groups. Theriogenology. 17:365.

Ferrell, C.L. 1982. Effects of postweaning rate of gain on onset of puberty and productive performance of heifers of different breeds. J. Anim. Sci. 55:1272-1283.

Ferguson, J. D., and W. Chalupa. 1989. Impact of protein nutrition on reproduction in dairy cows. J. Dairy Sci. 72:746-766

Ferguson, J. D., D. T. Galligan, T. Blanchard, and M. Reeves. 1993. Serum urea nitrogen and conception rate: The usefulness of test information. J. Dairy Sci. 76:3742-3746.

Fleck, A.T., R.R. Schalles, and G.H. Kiracofe. 1980. Effect of growth rate through 30 months on reproductive performance of beef heifers. J. Anim. Sci. 51:816-821.

Freetly, H.C., C.L. Ferrell, and T.G. Jenkins. 2001. Production performance of beef cows raised on three different nutritionally controlled heifer development programs. J. Anim. Sci. 79:819-826.

Funston, R.N., and G.H. Duetscher. 2004. Comparison of target breeding weight and breeding date for replacement beef heifers and effects on subsequent reproduction and calf performance. J. Anim. Sci. 82:3094-3099.

Garcia-Bojalil, C. M., C. R. Staples, W. W. Thatcher, and M. Drost. 1994. Protein intake and development of ovarian follicles and embryos of superovulated nonlactating dairy cows. J. Dairy Sci. 77:2537-2548.

Gath, V. P., P. Lonergan, M. P. Boland, and D. O'Callaghan. 1999. Effect of diet type on establishment of pregnancy and embryo development in beef heifers. Theriogenology. 51:224 (Abstr.).

Granger, A.L., W.E. Wyatt, F.G. Hembry, W.M. Craig, and D.L. Thompson, Jr. 1990. Effects of breed and wintering diet on heifer postweaning growth and development. J. Anim. Sci. 68:304-316.

Greer, R.C., R.W. Whitman, R.B. Staigmiller, and D.C. Anderson. 1983. Estimating the impact of management decisions on the occurrence of puberty in beef heifers. J. Anim. Sci. 56:30-39.

Hackmann, T.J., J.D. Sampson, and J. N. Spain. 2008. Comparing relative feed value with degradation parameters of grass and legume forages. J. Anim. Sci. 86:2344-2356.

Hall, J.B., R.B. Staigmiller, R.A. Bellows, R.E. Short, W.M. Moseley, and S.E. Bellows. 1995. Body compostition and metabolic profiles associated with puberty in beef heifers. J. Anim. Sci. 73:3409-3420

Hill, J.R. Jr., D. R. Lamond, D.M. Henricks, J.F. Dickey, and G.D. Niswender. 1970. The effects of undernutrition on ovarian function and fertility in beef heifers. Biol. Reprod. 2: 78-84.

Holtz, C. R., R. D. Smith, and C. J. Sniffen. 1986. Reproductive and metabolic responses of dairy cattle to the level and degradability of dietary protein. J. Dairy Sci. 69(Suppl. 1):243 (Abstr.)

Hopper, H.W., S.E. Williams, D.J. Byerley, M.M. Rolloson, P.O. Ahmed, and T. E. Kiser, 1993b. Effect of prepubertal body weight gain and breed on carcass compostition at puberty in beef heifers. J. Anim. Sci. 71:1104-1111.

Horn, F.P. 1983. Chemical compostition of wheat pasture. Pages 47-54 in Proc. Natl. Wheat Pasture Symp. Oklahoma Agric. Exp. Stn. MP115. Stillwater, Ok.

Horn, F.P., G. W. Horn, and H.R. Crookshank. 1977. Effect of short-term fasting and refeeding on weight and blood components of steers grazing wheat pasture. J. Anim. Sci. 44:288-294.

Houseknecht, K. L., D. L. Boggs, D. R. Campion, J. L. Sartin, T. E. Kiser, G. B. Rampacek, and H. E. Amos. 1988. Effect of dietary energy source and level on serum growth hormone, insulin-like growth factor 1, growth and body composition in beef heifers. J. Anim. Sci. 66:2916-2923.

Howard, H. J., E. P. Aalseth, G. D. Adams, and L. J. Bush. 1987. Influence of dietary protein on reproductive performance of dairy cows. J. Dairy Sci. 70:1563-1571.

Johnson, R.R., F.P. Horn, and A.D. Tillman. 1974. Influence of harvest date and N and K fertility levels on soluble carbohydrate and nitrogen fractions in winter wheat pasture. Anim. Sci. Res. 34-42.

Johnson, D. W., M. I. Poos-Floyd, R. T. Duby and J. P. Tritschler. 1986. Effect of dietary crude protein intake on plasma and cervical mucus levels of ammonia and urea in the bovine. J. Dairy Sci. 69(Suppl. 1):242-243 (Abstr.)

Jordan, E. R., T. E. Chapman, D. W. Holtan, and L. W. Swanson. 1983. Relationship of dietary crude protein to composition of uterine secretions and blood in high-producing postpartum dairy cows. J. Dairy Sci. 66:1854-1862.

Jordan, E. R., and L. V. Swanson. 1979. Effect of crude protein on reproductive efficiency, serum total protein, and albumin in the high-producing dairy cow. J. Dairy Sci. 62:58-63.

Joubert, D.M. 1954. The influence of high and low nutritional planes on the oestrus cycle and conception rate of heifers. J. Agricultural Sci. 45:164-172.

Kenny, D. A., M. P. Boland, M. G. Diskin, and J. M. Sreenan. 2002. Effect of rumen degradable protein with or without fermentable carbohydrate supplementation on blood metabolites and embryo survival in cattle. British Society of Animal Science. 74:529-537

Kenny, D. A., M. P. Boland, M. G. Diskin, and J. M. Sreenan. 2001. Effect of pasture

crude protein and fermentable energy supplementation on blood metabolite and progesterone concentrations and on embryo survival in heifers. British Society of Animal Science. 73:501-511

Klucinski, W., and S. P. Targowski. 1984. Ammonia toxicity for mammalian and avian lymphocytes from blood. Immunopharmacology. 8:47-52.

Lalman, D.L., M.K. Peterson, R.P. Ansotegui, M.W. Tess, C.K. Clark, and J.S. Wiley. 1993. The effects of ruminally undegradable protein, proprionic acid, and monensin on puberty and pregnancy in beef heifers. J. Anim. Sci. 71: 2843-2852.

Lamb, G. C., J. E. Larson, T. W. Geary, J. S. Stevenson, S. K. Johnson, M. L. Day, R. P. Ansotegui, D. J. Kesler, J. M. DeJarnette and D. G. Landblom. 2006. Synchronization of estrus and artificial insemination in replacement beef heifers using gonadotropin-releasing hormone, prostaglandin F2 alpha, and progesterone. J. Anim. Sci. 84:3000-3009.

Lammoglia, M.A., R.A. Bellows, E. E. Grings, J.W. Bergman, S.E. Bellows, R.E. Short, D.M. Hallford, and R. D. Randel. 2000. Effects of dietary fat and sire breed on puberty, weight, and reproductive traits on F_1 beef heifers. J. Anim. Sci. 78: 2244-2252.

Lemenager, R.P., W.H. Smith, T.G. Martin, W.L. Singleton, and J.R. Hodges. 1980. Effects of winter and summer energy levels on heifer growth and reproductive performance. J. Anim. Sci. 51:837-842.

Lesmeister, J.L., P.J. Burfening, and R.L. Blackwell. 1973. Date of first calving in beef

cows and subsequent calf production. J. Anim. Sci. 36:1-6.

Lynch, J.M., G.C. Lamb, B.L. Miller, R.T. Brandt, Jr., R.C. Cochran, and J.E. Minton. 1997. Influence of timing of gain on growth and reproductive performance of beef replacement heifers. J. Anim. Sci. 75:1715-1722.

McCormack, J. G., A. P. Halestrap, and R. M. Denton. 1990. Role of calcium ions in regulation of mammalian intramitochondrial metabolism. Physiol. Rev. 70(2):391-416

Moran, C., J.F. Quirke, and J.F. Roche. 1989. Puberty in beef heifers: a review. Anim. Reprod. Sci. 18:167-182.

Moseley, W.M., M.M. McCartor, and R.D. Randel. 1977. Effects of monensin on growth and reproductive performance of beef heifers. J. Anim. Sci. 45:961-968.

National Research Council. 2000. Nutrient requirements of beef cattle. Natl. Acd. Sci., Washington, D.C.

Nocek, J.E., and A.L. Grant. 1987. Characterization of In Situ nitrogen and fiber digestion and bacterial nitrogen contamination of hay crop forages preserved at different dry matter percentages. J. Anim. Sci. 64:552-564.

Oyedipe, E.O., J.K. Osori, O. Akerejola, and D. Saror. 1982. Effect of level of nutrition on onset of puberty and conception rates of zebu heifers. Theriogenology 18:525-539.

Patterson, D.J., F.N. Kojima, and M.F. Smith. 2003 A review of methods to synchronize estrus in replacement beef heifers and postpartum cows. J. Anim. Sci. 81: E166-

167.

Patterson, D.J., R.C. Perry, G.H. Kiracofe, R. A. Bellows, R. B. Staigmiller, and L. B. Corah. 1992b. Management considerations in heifer development and puberty. J. Anim. Sci. 70:4018-4035.

Patterson, D. J., S.L. Wood, and R.F. Randle. 1999. Procedures that support reproductive management of replacement beef heifers. Proc. Am. Soc Anim. Sci. 1999.

Perry, G.A., B.L. Perry. 2008. Effect of preovulatory concentrations of estradiol and initiation of standing estrus on uterine pH in beef cows. Domestic Animal Endocrinology. 34:333-338.

Perry, G.A., M. F. Smith, A.J. Roberts, M.D. MacNeil, and T.W. Geary. 2007. Relationship between size of ovulatory follicle and pregnancy success in beef heifers. J. Anim. Sci. 85:684-689.

Phillips, W. A., S. C. Rao, R. L. Dalrymple, and E. L. Klepper. 1996. Annual Cool-Season Grasses. Cool-Season Forage Grasses. Pg 781-802

Pichard, G., and P. J. Van Soest. 1977. Protein solubility of ruminant feeds. Proc. Cornell Nutr. Conf., p.91-98.

Pinney, Don O., D. F. Stephens, and L.S. Pope. 1972. Lifetime effects of winter supplemental feed level and age at first parturition on range beef cows. J. Anim. Sci. 34:1067-1074.

Reid, R.L., G.A. Jung, and W.V. Thayne. 1988. Relationships between nutritive quality and fiber components of cool season and warm season forages: a retrospective

study. J. Anim. Sci. 66:1275-1291.

Rhoads, M. L., R. P. Rhoads, R. O. Gilbert, R. Toole, and W. R. Butler. 2006. Detrimental effects of high plasma urea nitrogen levels on viability of embryos from lactating dairy cows. J. Anim. Sci. 79:193-199.

Roseler, D. K., J. D. Ferguson, C. J. Sniffen, and J. Herrema. 1993. Dietary protein degradability effects on plasma and milk urea nitrogen and milk nonprotein nitrogen in Holstein cows. J. Dairy Sci. 76:525-534.

Schillo, K.K., J.B. Hall, and S. M. Hileman. 1992. Effects of nutrition and season on the onset of puberty in beef heifer. J. Anim. Sci. 70:3994-4005.

Short, R.E., and R.A. Bellows. 1971. Relationships among weight gains, age at puberty and reproductive performance in heifers. J. Anim. Sci. 32:127-131.

Short, R. E., and R. B. Staigmiller, R.A. Bellows and R. C. Greer. Breeding heifers at one year of age: Biological and economic considerations. pp 55-60 of Factors Affecting Calf Crop Edited by Michael J. Fields and Robert S. Sand. CRC Press 1994.

Short, R.V. 1984. Estrous and menstrual cycles. Hormonal control of reproduction. Reproduction in Mammals. Cambridge University Press. Pg. 115-152.

Simpson, R.B., C.C. Chase, Jr., A.C. Hammond, M.J. Williams and T. A. Olsen. 1998. Average daily gain, blood metabolites, and body composition at first conception in Hereford, Senepol, and reciprocral crossbred heifers on two levels of winter nutrition and two summer grazing treatments. J. Anim. Sci. 76:396-403.

Spicer, L. J., E. Alpizar, and S. E. Echternkamp. 1993. Effects of insulin, insulin-like growth factor I, and gonadotropins on bovine granulose cell proliferation, progesterone production, estradiol production, and (or) insulin-like growth factor I production in vitro. J. Anim. Sci. 71:1232-1241.

Targowski, S. P., W. Klucinski, S. Babiker, and B. J. Nonnecke. 1984. Effect of ammonia on in vivo and in vitro immune responses. Infect. Immun. 43:289-293.

Turner, T. T., and S. S. Howards. 1978. Factors involved in the initiation of sperm motility. Biol. Reprod. 18:571-578.

Van Soest, P.J., 1982. Nutritional ecology of the ruminant. O&B books. Corvallis, Or.

Varner, L.W., R.A. Bellos, and D.S. Christensen. 1997. A management system for wintering replacement heifers. J. Anim. Sci. 44:165-171.

Vogel, G.L.1988. Kinetics of ruminal nitrogen digestion of wheat forage and high protein feedstuffs and the effects of supplemental protein on the performance of growing cattle on wheat pasture. Ph.D. dissertation. Oklahoma State University, Stillwater, Oklahoma.

Vogel, G.L., W. A. Phillips, G. W. Horn, M.J. ford and R. W. McNew. 1989. Effects of supplemental silage on forage intake and utilization by steers grazing wheat pasture or bermudagrass. J. Anim. Sci. 67:232-240.

Westwood, C. T., I. J. Lean, and R. C. Kellaway. 1998. Indications and implications for testing of milk urea in dairy cattle: A quantitative review. Part 2 Effect of dietary protein on reproductive performance. New Zealand Veterinary Journal. 46:123-

130.

Whitney, M.B., B.W. Hess, L.A. Burgwald-Balstad, J.L. Sayer, C.M. Tsposito, C.T. Talbott, and D. M. Hallford. 2000. Effects of supplemental soybean level on in vitro digestion and performance of prepubertal beef heifers. J. Anim. Sci. 78:504-514.

Wiebold, J. L. 1988. Embryonic mortality and the uterine environment in first service lactating dairy cows. J. Reprod. Fert. 84:393-399.

Williams, J. S., C. S. Gardiner, L. S. Schuller, L. V. Swanson, and A. R. Menino. 1987. Evaluation of uterine flushings collected from two levels of crude protein. 79th ASAS annual meeting proc. 65:415.

Wiltbank, J.N., K.E. Gregory, L.A. Swiger, J.E. Ingalls, J.A. Rothlisberger, and R.M. Koch. 1966. Effects of heterosis on age and weight at puberty in beef heifers. J. Anim. Sci. 25: 744-751.

Yelich, J. V., R. P. Wettemann, H. G. Dolezal, K. S. Lusby, D. K. Bishop and L. J. Spicer. 1995. Effects of growth rate on carcass composition and lipid partitioning at puberty and growth hormone, insulin-like growth factor I, insulin, and metabolites before puberty in beef heifers. J. Anim. Sci 73:2390-2405.

CHAPTER III

EFFECT OF GROWING BEEF REPLACEMENT HEIFERS ON WHEAT PASTURE BEFORE AND DURING BREEDING ON REPRODUCTIVE PERFORMANCE

M. H. Bryant, G. E. Selk, D. R. Stein, R. P. Wettemann, D. L. Lalman, G. W. Horn

ABSTRACT: Unsatisfactory breeding performance has been reported when replacement heifers have been exposed to bulls or AI while grazing small grains. The objective of this study was to compare reproductive performance of heifers grazing wheat pasture before and during breeding with heifers grazing wheat pasture until approximately 3 weeks before breeding. In each of two years, 40 spring-born Angus and Angus crossbred heifers were placed on wheat pasture in December and randomly assigned to one of two treatment groups in mid March. Group one (WP; n=20) remained on wheat pasture (mean CP 26.6 %) through estrus synchronization and fixed-time AI (FAI). Group two (DL; n=20) was placed in drylot and had free choice access to a corn-based growing ration (11.1% CP) through estrous synchronization and FAI. Heifers were exposed to fertile bulls 10 d after FAI for 45 d. Conception after FAI was determined at 32 d post-AI by ultrasonography. Five weekly blood samples starting 5 wks before FAI were obtained to describe luteal activity prior to estrous synchronization and for analysis of urea-N concentrations before and during estrous synchronization and FAI.

Reproductive data were analyzed using the PROC GLIMMIX procedure of SAS. Concentrations of urea in plasma or serum, and insulin like growth factor-I were analyzed with the mixed model procedure of SAS with year and sampling block as random variables. The percentage of heifers with luteal activity was 75% and 55% for WP and DL, respectively ($P = 0.08$). Drylot heifers were heavier than WP heifers (408 vs. 394 kg ± 4.49) at the time of AI ($P < 0.01$) but were similar ($P = 0.43$) when final body weight was measured on native range (417 vs. 414 kg ± 5.26). Conception rate to FAI was similar ($P = 0.38$) for WP (53%) and DL (43%) and final pregnancy rate was similar ($P = 0.34$) for WP (98%) and DL (95%). Concentrations of urea were less (5.77 mg/dL vs. 29.15 mg/dL, $P < 0.01$) for DL heifers during all weeks after treatments were imposed. Reproductive performance of heifers grazing wheat pasture during estrous synchronization and FAI was similar to heifers consuming a corn-based growing diet in drylot.

Key words: beef replacement heifers, wheat pasture, reproduction

INTRODUCTION

Growing beef cattle on wheat pasture is a major beef production program in the southern Great Plains. The majority of these cattle are stocker cattle that are placed on wheat pasture and grown to heavier weights before being placed in feedlots. However, wheat pasture also provides an excellent alternative to develop replacement heifers. Some producers have adopted the method of growing beef replacement heifers on their wheat pastures as a way to diversify their operations.

Wheat pasture contains a high amount of crude protein. Soluble nitrogen makes up a significant amount of the total nitrogen that is found in wheat forage. This soluble nitrogen fraction is highly degraded in the rumen into ammonia. Vogel et al. (1989) reported that 50 to 75% of total wheat forage nitrogen had a very rapid ruminal degradation rate of 16 to 19% per hour.

It is common for producers to expose yearling replacement heifers to bulls or to artificial insemination (AI) two to three weeks prior to the start of the breeding season for mature cows. These producers that AI yearling heifers while they are still grazing wheat pasture have reported that although they have a high percentage of heifers displaying estrus, subsequent pregnancy rates are below their expectations.

Reduced pregnancy rates have been reported for heifers grazing wheat and ryegrass pastures when compared with heifers that were program-fed to gain 0.68kg/d with a 3.7% CP diet (Beck et al., 2005). Similarly, extensive research has been done in the dairy industry suggesting that greater percentages of protein in the diet through

supplementation of urea or soybean meal, is associated with a reduction in fertility (Canfield et al., 1990; Elrod and Butler, 1993; Ferguson et al., 1993).

The reduction in reproductive performance in previous studies has been attributed to high concentrations of urea nitrogen in the blood. Elrod and Butler (1993) reported that concentrations of plasma urea nitrogen greater than 16 mg/dL decreased pregnancy rates by 30% when compared with heifers with concentrations that were less than 16 mg/dL. Horn and coworkers (1977) reported that plasma urea nitrogen concentrations of steers grazing wheat pasture, ranged from 18.1 mg/dL to 28.3 mg/dL. These concentrations are within the range of plasma urea nitrogen concentrations reported by Elrod and Butler that resulted in decreased pregnancy rates (1993).

Several mechanisms have been studied relative to the negative effects of excess dietary protein. One of the mechanisms is the adverse effects that increased dietary protein has on the uterine environment. This change in the uterine environment may be attributed to increased levels of urea causing a decrease in the pH, decrease in the mineral content and impairing the inflammatory response. Elrod and Butler (1993) concluded that excessive dietary protein causes a decrease in uterine pH during the luteal phase which resulted in the reduction of fertility. The change in uterine environment may in turn affect the viability of sperm and embryos.

The current study was undertaken with the objective to compare reproductive performance of heifers that grazed wheat pasture before and during breeding with heifers that grazed wheat pasture but were removed approximately three weeks before breeding.

MATERIALS AND METHODS

Research Site

A two-year trial was conducted during the late-fall to early-spring of 2006 to 2007 and 2007 to 2008 at the Oklahoma State University Wheat Pasture Unit near Stillwater, OK. The Oklahoma State University Animal Care and Use Committee approved all experimental procedures used in this study.

Year 1

Pasture and animal management. On September 14, 2006, 36.58 ha of clean tilled wheat pasture were planted to hard red winter wheat (Triticum aestivum, variety Endurance) at a seeding rate of 135 kg/ha (2 bu/acre). A preplant application of 115 kg/ha (102 lb/acre) urea (46-0-0) was applied prior to planting. The wheat pasture was divided into four paddocks (average 9.15 ha/pasture). Forty fall-weaned Angus and Angus crossbred heifers were moved to the Wheat Pasture Research Unit on December 13, 2006. Heifers originally came from the OSU Range Cow Research Center, North Range Unit (n = 20) and South Range Unit (n = 20). Cattle grazing wheat pasture were rotated between pastures at approximately 3 week intervals to allow for adequate forage availability. Heifers had free-choice access to a monensin-containing mineral mixture (R1620) while grazing wheat pasture. Mean±std dev.daily intake of the mineral mixture and monensin was 0.045±0.015 kg/heifer and 82±28 mg/heifer, respectively. On March 13, 2007 heifers were blocked by location of origin and allotted by weight to 2 treatment groups. Twenty heifers remained at the research unit and continued to graze wheat pasture. The additional 20 heifers were transported to the OSU Range Cow Research

Center, South Unit, where they were placed in a drylot and fed a total mixed ration in self feeders. The ration included 39.9% rolled corn, 34.9% ground alfalfa hay, 22.2% cottonseed hulls, 2.5% cane molasses and 0.2% salt. The corn- based growing ration was formulated to result in a similar rate of gain as heifers grazing wheat pasture. The composition of the diet is summarized in Table 1. Estrous cycles of the heifers were synchronized starting on March 27, using the Co-synch plus CIDR protocol described by Lamb and coworkers (2001). Heifers received an intramuscular injection of 100 μg of GnRH (Cystorelin, Merial; Athens, GA) and a CIDR (Pfizer Animal Health, New York, NY) was placed intravaginally. Seven days later all heifers received 25 mg of prostaglandin F2 alpha (Lutalyse, Pfizer Animal Health) and the CIDRs were removed. A second injection of 100 μg of GnRH was given 2 days later followed by fixed time artificial insemination using two sires equally between treatment groups. One fertile bull was placed with each group of heifers on April 15. Bulls were rotated between groups on April 23. On May 1 heifers and bulls remaining on wheat pasture and those in drylot were moved to a native range pasture located at the North Range Unit. Heifers were comingled on this native range pasture until the end of the trial. Using transrectal ultrasonography all heifers were diagnosed for pregnancy on May 7. On June 7, bulls were removed and heifers were moved back to their respective herd of origin. Final pregnancy status of the heifers was determined on September 25. Calendar of events during year one is in Table 2.

Forage sampling procedures and laboratory analyses. Forage mass and diet quality samples were collected from 3 random locations within the wheat pasture on March 13, March 20, March 27, April 3, and April 10. Wheat forage mass was determined by hand

clipping forage to ground level inside 0.19 m^2 quadrants. In an effort to simulate forage the heifers were consuming, diet quality samples were obtained by hand clipping the upper portion of the plants. Forage samples were dried in a forced air oven at 55º C and weighed for dry matter determination. Diet quality samples were ground to pass through a 2-mm screen in a Wiley Mill (Arthur A. Thomas, Philadelphia, PA) and stored in plastic containers until analyzed. Neutral detergent fiber and acid detergent fiber were determined (Van Soest et al., 1991) using an Ankom200 Fiber Analyzer (Ankom Technology, Macedon, NY). Nitrogen content of forage samples was analyzed as Kjeldahl nitrogen (AOAC 1996). Soluble nitrogen fractions were determined using a procedure similar to that described by Prigge and coworkers (1976). Briefly, 0.5 g of sample was placed in an Erlenmeyer flask containing 125 ml of "Ohio" mineral buffer (Johnson, 1966) with the pH adjusted to 6.5. The mixture was agitated in a 39º C water bath for 1 hour. The solution was then filtered and 25 ml filtrate was analyzed by Kjeldahl yielding the amount of soluble nitrogen. For determination of soluble non-protein nitrogen, 5 ml of 1.07 N sulfuric acid and 5 ml of a 10% Na tungstate solution were mixed with 25 ml of filtrate in a centrifuge tube. The mixture was incubated overnight at 5º C and then centrifuged for 10 minutes at 11950 x g. Twenty five milliliters of supernatant were placed in a Kjeldahl flask and nitrogen was determined by the Kjeldahl procedure. Soluble protein nitrogen was determined by the difference in nitrogen between the soluble nitrogen and soluble non-protein nitrogen fractions.

Body weight. Body weights were recorded at initial placement on wheat pasture on December 13 after heifers were transported 11-15 miles to the research unit. Body weight measures were taken following an approximate 6 h withholding of feed and water on

March 13, the day treatments were imposed. Full weights of the heifers were recorded at time of artificial insemination on April 5. After both groups of heifers had grazed native range for 4 days a final weight was taken following an approximate 6 hour withholding of feed and water on May 4.

Blood sampling procedures and laboratory analyses. Blood was sampled by tail venipuncture into vacutainer tubes (Becton Dickinson Vacutainer Systems, Franklin Lakes, NJ) containing ethylenediaminetetraacetic acid, stored on ice, centrifuged at 2500 x g for 20 minutes at 4º C, and plasma was recovered and stored at -20º C until analyzed. Samples were obtained once a week for 5 weeks staring on March 13 and ending on April 10. Samples were blocked for laboratory analysis by treatment, heifer, and day. Concentrations of plasma urea-nitrogen were quantified in all blood samples using a commercially available kit (Urea Nitrogen Reagent, Teco Diagnostic, Anaheim, CA). Microplates (Beckman Coulter, Fullerton CA) were used in the analyses of blood urea-nitrogen, and absorbance was measured at 630 nm, using a plate reader (Multiskan Spectrum; Thermo Scientific, Waltham, MA). Intra- and inter-assay coefficients of variation were 5 and 7.5%, respectively.

Concentrations of insulin-like growth factor-I (IGF-I) in plasma were determined after acid ethanol extraction (16h at 4º C) by radioimmunoassay (Echternkamp et al., 1990) in all samples. Intra- and inter-assay coefficients of variation were 10.8 and 18.3%, respectively.

Concentrations of progesterone in plasma were quantified as described by Vizcarra et al., (1997) using a solid phase radioimmunoassay (Coat-A-Count Progesterone kit. Diagnostic Products Corp). Concentrations of progesterone in plasma

samples taken the first three weeks were used to determine the onset of ovarian luteal activity. Duplicates with a coefficient of variation greater than 10 % were reanalyzed. Intra- and inter-assay coefficients of variation were 3.1 and 9.3%, respectively. The criterion for luteal activity was one or more blood samples with concentrations of progesterone greater than 1 ng/mL (Wettemann et al., 1972).

Year 2

Pasture and animal Management. Wheat pasture was planted as described for year 1 except planting date was September 19, 2007. The wheat pasture was divided into four pastures (average 9.15 ha/pasture). Forty fall weaned Angus and Angus crossbred heifers were moved to the wheat pasture research unit on December 7, 2007. Heifers originally came from the OSU Range Cow Research Center, North Range Unit (n = 20) and South Range Unit (n = 20). Cattle grazing wheat pasture were rotated between pastures at approximately 3 week intervals to allow for adequate forage availability. Heifers had free-choice access to a monensin-containing mineral mixture (R1600) while grazing wheat pasture. Mean±std dev.daily intake of the mineral mixture and monensin was 0.031±0.004 kg/heifer and 54±6 mg/heifer, respectively. On March 11, 2008 heifers were blocked by location of origin and allotted by weight to 2 treatment groups. The treatment groups and drylot diet were the same as described for year one. Bulls from the Purebred Beef Center were found in the wheat pasture with the heifers in February. One heifer was inadvertently exposed to a bull and was removed from the study. Estrous cycles of the heifers were synchronized starting on March 25, using the same method as year 1. Fixed time artificial insemination was performed on April 3. One fertile bull was placed with each group of heifers on April 15. Bulls were rotated between the groups on April 22. On

May 2 heifers and bulls remaining on wheat pasture and those in drylot were moved to a native range pasture located at the North Range Unit. Heifers were comingled on this native range pasture until the end of the trial. Using transrectal ultrasonography all heifers were diagnosed for pregnancy on May 5. On June 5, bulls were removed and heifers were moved back to their respective herd of origin. Final pregnancy status of heifers was determined on September 22 and September 24. Calendar of events during year two is shown in Table 2.

Forage sampling procedures and laboratory analyses. Forage mass and diet quality samples were collected from four random locations within the wheat pasture on December 20, January 4, January 11, February 4, February 25, March 11, March 19, March 25, April 1, April 8, April 22, and April 29. Sampling procedures and laboratory analyses were the same as described for year 1.

Body weight. Body weight of heifers were measured at initial placement on wheat pasture on December 7, at the time treatments were imposed on March 11, at time of artificial insemination on April 3. A final body weight was recorded on May 5. Weighing conditions are similar to those described in year one.

Blood sampling procedures and laboratory analyses. Blood was sampled by tail venipuncture into 10 mL vacutainer tubes without anticoagulant for serum harvest. Samples were refrigerated overnight at 4º C, centrifuged at 2500 x g for 20 minutes at 4º C, and serum was recovered and stored at -20º C until analyzed. Samples were obtained once a week for 5 weeks starting on March 11 and ending on April 8. Serum concentrations of progesterone, urea-nitrogen and IGF-I were determined using laboratory procedures described in year 1.

Statistical Analyses

All heifers were equally allocated by source. Body weight and ADG of the heifers were analyzed as a completely random design using the PROC MIXED procedure of SAS (SAS Inst., Inc., Cary, NC). The model included treatment as a fixed effect and year as a random variable.

Concentrations of urea nitrogen and IGF-I were analyzed as a completely randomized design using the PROC MIXED procedure of SAS. Six covariance structures (variance component, compound symmetry, Huynh-Feldt, first-order autoregressive, Toepliz and unstructured) were examined to select the best according to the goodness of fit statistic. The covariance structure with the best goodness of fit statistic was the first-order autoregressive. The statistical model included treatment, day, block and all interactions. Block was considered to be random and all other effects in the model were considered fixed. Means were separated using Least Square Means.

The percentage of heifers with luteal activity, percentage of heifers detected as pregnant by ultrasound, and the final percentage of heifers determined pregnant by rectal palpation were analyzed using the PROC GLIMMIX procedure of SAS with treatment as a fixed effect and year as a random variable.

RESULTS

Monthly mean temperatures and total precipitation during years one and two were obtained through Oklahoma Mesonet (http://www.mesonet.org). The environmental monitoring station used is located 2.0 miles west of Stillwater, Oklahoma. Temperature and precipitation data for both years are presented in Table 3. The mean monthly ambient temperatures from August to April in both years of the study ranged from 1 to 29ºC. The mean total precipitation during August through April was 526 mm and 614 mm for years one and two, respectively. Mean monthly normal temperatures and total precipitation was determined by averaging monthly data from 1971 to 2000. In Stillwater, normal monthly temperature ranged from 1 to 27ºC and precipitation averaged 617 mm during August through the end of April.

Forage composition and quality

Year one. Wheat forage composition and quality during year one are shown in Table 4. Crude protein values ranged from 29.1% to 18.2%. Soluble nitrogen in forage samples increased from 33.2% to 46.1% of total nitrogen. Similarly, soluble non-protein nitrogen increased from 20.0% to 28.1% of total nitrogen. Soluble protein nitrogen remained rather constant at around 13.0% of total nitrogen during the first four weeks of sampling and then increased to 18.0% of total nitrogen. The cell wall constituents (ADF and NDF) averaged 26.9% and 49.8% respectively, across the five sampling dates.

Year two. Wheat forage composition and quality during year two are shown in Table 5. Crude protein values ranged from 26.2% to 34.3% during the time in which treatments were imposed. Soluble nitrogen in forage samples ranged from 26.5% to 39.9% of total nitrogen. Soluble non-protein nitrogen remained rather constant at around 18.0% of total

nitrogen. Soluble protein nitrogen ranged from 8.9% to 21.7% of total nitrogen. The cell wall constituents (ADF and NDF) averaged 26.4% and 44.9% respectively, across the five sampling dates.

Heifer data

Heifer weight and reproductive data are summarized in Table 6. Heifers assigned in drylot or wheat pasture had similar ($P = 0.92$) body weights at the initial placement on wheat pasture. Body weights did not differ ($P = 0.84$) at the time heifers were allotted to two treatment groups. Likewise, final body weight measurements were similar ($P = 0.44$) for heifers in drylot or grazed on wheat pasture. However, body weight at the time of AI differed ($P = 0.01$) between treatment groups. Average daily gain from the initial placement on wheat pasture until heifers were allocated to treatment groups was similar ($P = 0.72$) between treatment groups. Average daily gain of heifers in drylot differed ($P = 0.01$) from heifers grazed on wheat pasture over the time of allotment to treatments to fixed time AI. From the time of AI to the final body weight measurement, average daily gains were different ($P = 0.01$) between treatments.

Reproductive measures of heifers are summarized in Table 6. There was a tendency ($P = 0.08$) for a greater percentage of heifers in the wheat pasture group to have luteal activity (Figure 1) as compared with the drylot group. The percentage of heifers pregnant to fixed time AI did not differ ($P = 0.38$). Forty three percent of drylot heifers were pregnant to fixed time AI, and 53% of the wheat pasture heifers were pregnant to fixed time AI (Figure 2). There was no effect (P = 0.34) of treatment on final pregnancy rate (Figure 3).

Urea-nitrogen

Urea nitrogen concentrations of heifers in drylot decreased rapidly ($P < 0.01$) after the heifers were taken off wheat pasture and placed in a drylot for one week (Figure 4). After treatments were imposed, heifers in drylot had lesser ($P < 0.01$) urea nitrogen concentrations as compared with heifers grazed on wheat pasture (Figure 4). Concentrations of urea nitrogen of heifers in drylot ranged from a high of 24.76 mg/dL to a low of 5.77 mg/dL. Concentrations of urea nitrogen in heifers grazed on wheat pasture ranged from 29.15 to 16.97 mg/dL. Two days prior to artificial insemination urea nitrogen concentrations were 7.91 mg/dL and 22.45 mg/dL for wheat pasture and drylot, respectively.

Insulin-like growth factor-I

There was not a treatment by day interaction ($P = 0.56$) for IGF-I concentrations. Mean IGF-I concentrations (Figure 5) were similar ($P = 0.36$) between the drylot group (198.4 ± 25.10 ng/mL) and wheat pasture group (179.0 ± 25.10 ng/mL). Concentrations of IGF-I of heifers in drylot or grazed on wheat pasture (Figure 5) decreased ($P = 0.06$) from 213.85 ng/mL (first week) to 174.01 ng/mL (fifth week).

DISCUSSION

The objective of this study was to compare reproductive performance of heifers grazing wheat pasture before and during breeding with heifers grazing wheat pasture until approximately three weeks prior to breeding.

Forage availability and quality

In each of the two years the mean monthly temperatures were within 2°C of the normal monthly means for all months in the trial (August through April) except for March in year one, which was 6°C above the normal mean for the Stillwater, Oklahoma area. The total precipitation during the experiment, at the study site for each of the two years was 526 mm and 614 mm, respectively. Normal total precipitation for this area is 617 mm. However, the wheat pastures of both years were representation of what can be expected in the average production setting.

The crude protein content of wheat forage is often high and at times can exceed 30% (Horn, 1983). In the current study, the crude protein values of wheat forage samples collected during year one ranged from 29% to 18% and during year two 34% to 28%. These values are typical of crude protein content of wheat forage; a range from 26% to 32% is commonly reported (Mader and Horn, 1986; Horn et al., 1997; Horn, 2006; Beck et al., 2008). The crude protein of wheat forage during each of the two years of the current study, were in excess of what is required for growing replacement heifers. A significant portion of total nitrogen in wheat forage is present in the form of soluble nitrogen. Horn and coworkers (1977) observed soluble nitrogen amounts in wheat forage to be around 45% of total nitrogen. Likewise, in this study, values of soluble nitrogen ranged from 27% to 46% in each of the two years. Furthermore, of the nitrogen present in

forage samples obtained during year one, as much as 28% was present in the form of non-protein nitrogen. Samples obtained during year two had 17 to 19% of the total nitrogen in the form of non-protein nitrogen. These values are similar to what was found by Johnson et al. (1973) in which wheat forage non-protein nitrogen ranged from 11 to 27% of total nitrogen. Johnson et al. (1973) concluded that the presence of these nitrogen fractions in such high amounts, in conjunction with high levels of protein in the diet could result in very high levels of ammonia absorbed into the blood. The fiber content of wheat forage is considered to be rather low. Horn (1983) reported that most values for ADF are below 30% of DM and most NDF are below 50% of DM. The fiber content of samples collected in this study were similar to these values.

Heifer Data

The diets in this study were designed so that heifers in each group would have similar growth rates. The crude protein content of the wheat forage, as well as the content of the drylot ration was adequate to support the gains of 0.29 to 2.13 kg/day of both groups of heifers for each of the two years (NRC 1996). When data were pooled across the two years, body weights of the drylot heifers were similar ($P > 0.05$) to the wheat pasture group at all times in which weight was measured except for at the time of AI. At the time of AI, heifers maintained in drylot had heavier ($P = 0.01$) body weights when compared with the heifers grazing wheat pasture (408.0 and 393.9 ± 4.48 kg, respectively). This difference in weight may be attributed to increased rumeno-reticular fill in the drylot heifers. The heifers in either treatment group were not shrunk for this weight in order to minimize the stress prior to breeding.

The management of heifers during the winter period after weaning plays an important role in the age at which puberty and conception will occur. Short and Bellows (1971) studied the effects of three different weight gains (0.23, 0.45 or .68 kg/d) on puberty and subsequent reproduction. The percentage of heifers displaying signs of estrus, and conception rates increased with increasing weight gain. The gains achieved during the wintering period in this study were above a rate of gain that might cause delayed estrus or decreased conception rate. Heifers in both treatment groups grew at similar ($P = 0.72$) rates during the wintering period. When pooled across the two years, average daily gains were greater ($P = 0.01$) for heifers maintained in drylot (2.13 kg/d) compared with heifers grazed on wheat pasture (1.56 kg/d) during the time of allotment to treatment groups to the time of AI. This difference could in part be due to the fact that the AI weight was not a shrunk weight. Regardless of treatment differences in average daily gain, each group grew at an acceptable rate for replacement beef heifers.

Urea-nitrogen

Extensive research has been conducted relative to the effects of high dietary protein levels on metabolites of ruminants. Urea is a metabolite of dietary protein which is formed from the detoxification of ammonia by the liver and thus found in the blood. The general conclusion among researchers is that the level of urea that is present in milk or blood is reflective of the amount of protein consumed by ruminants (Jordan and Swanson, 1979; Roseler et al., 1993; Butler 1996). Similar results were observed in this study. Plasma samples were used for analysis during the first year and serum samples used the second year. To compare the difference of plasma vs. serum in this laboratory analysis, 6 random steers from the OSU NP Barn were sampled for both plasma and

serum. The mean difference of 0.65 mg/dL, with serum being higher in urea nitrogen concentrations was not significant (P=0.65). The concentrations of urea nitrogen found in heifers grazing wheat forage for both years one and two mimics the change in crude protein in the wheat forage. Mean concentrations of urea nitrogen for heifers grazing wheat pasture ranged from 17 to 29 mg/dL. These values are similar to urea nitrogen concentrations of steers grazing wheat pasture reported by Horn and coworkers (1977). When pooled across two years, the heifers consuming wheat forage had increased ($P < 0.01$) levels of urea nitrogen compared to heifers maintained in drylot, for all dates after treatments were imposed. At the first sampling date both the drylot group and wheat pasture group had been consuming wheat forage therefore, urea nitrogen levels were not different ($P = 0.45$) at this time. However, after treatments were imposed, a decrease ($P < 0.01$) in urea nitrogen concentrations was noted in the drylot group. This decrease was present after heifers were consuming the drylot diet for as little as one week. The urea nitrogen concentrations of this treatment group remained lower for all subsequent sampling dates. The elevated concentration of urea nitrogen found in the wheat pasture heifers is an effect of the wheat forage. The forage that the heifers were consuming had a large amount of nitrogen in the form of soluble nitrogen. This soluble nitrogen fraction is highly degraded in the rumen. Vogel et al. (1989) reported that 50 to 75% of total wheat forage nitrogen had a very rapid ruminal degradation rate of 16 to 19% per hour. Dinning and coworkers (1948) showed that if the amount of ammonia in the rumen is greater than the amount that can be metabolized it will be absorbed through the ruminal wall into the portal blood. Furthermore, urea is formed from the detoxification of ammonia and thus a probable cause for the increased concentrations of urea nitrogen found in this study.

IGF-1

IGF-I stimulates ovarian function in cattle (Spicer et al., 1993). It has been shown to have direct local effects on granulosa cell mitosis and production of estradiol; this stimulates follicular growth (Spicer et al., 1993). Nutrition and more specifically energy intake, has been shown to be a major factor in controlling concentrations of IGF-I in the blood. One study conducted by Houseknecht and coworkers (1988) reported that low energy levels severely decreased concentrations of IGF-I in beef heifers. In contrast, Breier et al. (1986) reported that IGF-I concentrations were increased in steers on high and moderated planes of nutrition compared with those on lower planes of nutrition. Mean concentrations of IGF-I in the blood across the five sampling dates, were similar ($P = 0.36$) between heifers in drylot (196.4 ± 25.10) and heifers grazed on wheat pasture (179.0 ± 25.10) in the current study. Therefore, heifers grazed on wheat pasture or in drylot were in similar planes of nutrition. Jones et al. (1991) reported increased levels of IGF-I prior to puberty in Angus beef heifers. Jones and coworkers concluded that the increase in IGF-I may be reflective of increased activity of the hypothalamic-hypophyseal-ovarian axis. Concentrations of IGF-I in the blood had a tendency ($P = 0.06$) to change during the five weeks of sampling. This change could be attributed to the luteal activity of heifers at the time of sampling. The change in IGF-I concentrations over time could also be reflective of the amount of protein intake of the heifers. Elsasser and coworkers (1989) noted positive associations between plasma IGF-I concentrations and protein intake. Intake was not measured in the current study, however as the wheat forage matured less protein was available to the grazing heifers and may have affected the level of protein intake and thus the concentrations of IGF-I present in the blood. The results of

most studies would agree that, plane of nutrition, composition of the diet as well as nutrient intake may influence concentrations of IGF-I.

Reproductive Measures

There was a tendency for more heifers grazing wheat pasture (P = 0.08) to display luteal activity as compared with heifers in drylot. Increased gluconeogenic activity as a result of feeding high energy diets that promote increased propionate activity have been shown to accelerate the onset of puberty in heifers (Randal, 1990). Similarly, Ciccioli and coworkers (2005) reported a greater incidence of puberty in beef heifers fed high-starch diets as compared with heifers fed low-starch diets. The tendency for a greater percentage of heifers consuming wheat forage to display luteal activity in this study may be a result of increased propionate which could increase plasma levels of insulin and glucose and enhance reproductive function. The stresses of changing diets as well as environment, and management changes could have played a role in the tendency for a lower percentage of heifers in drylot ration to display luteal activity.

Pregnancy rates to fixed time AI in the current study were 43 and 53% for drylot and wheat pasture, respectively. Similar pregnancy rates have been reported in studies using CO-Synch plus CIDR fixed-time AI protocol (Lamb and Larson, 2004). Heifers maintained in drylot had a similar (P = 0.38) pregnancy rate to fixed time AI as compared with heifers that were grazed on wheat pasture. In contrast to our findings, Beck et al. (2005) reported earlier conception in heifers that were fed in drylot to gain 0.68 kg/d when compared with heifers that where grazed on wheat and ryegrass pastures. Beck concluded that the decreased conception rates in the grazed heifers may be attributed to higher serum urea nitrogen levels. However, in the current study an increase in urea

nitrogen concentrations in heifers grazing wheat pasture had no adverse affect on conception rates to AI.

An increase in crude protein in the diet results in an increase in systemic urea nitrogen, this has been associated with decreased pregnancy rates in dairy cattle (Canfield et al., 1990; Ferguson et al., 1993; Butler, 1996) and beef cattle (Beck et al., 2005). In contrast, it has been shown that embryo survival rate in nulliparous beef heifers either consuming increased levels of forage crude protein or high levels of rumen degradable protein, was not affected by dietary urea regardless of increased systemic concentrations of ammonia and urea (Kenny et al., 2001; Kenny et al., 2002). Data found in the literature is inconclusive on the affects of high dietary crude protein on reproduction. An explanation for the mixed results between studies may be attributed to the possibility that the concentrations and rumen degradability of dietary crude protein interact with different production levels such as lactation and changes in energy status. These interactions are important to consider when examining the effects of protein on luteal activity and pregnancy rates.

In the current study, the final pregnancy rate of heifers was not affected by increased level of protein despite the increase in urea nitrogen. Our data does not support producer opinion that growing replacement beef heifers on wheat pasture decreases reproductive performance. Thus, growing heifers on wheat pasture and selling bred heifers may be an acceptable way for producers to diversify their operations in the southern Great Plains.

SUMMARY AND CONCLUSIONS

In conclusion, changes in urea nitrogen concentrations in heifers grazed on wheat pasture are parallel to the changes in wheat pasture composition and quality, specifically CP values. Concentrations of urea-nitrogen were decreased ($P < 0.01$) for heifers maintained in drylot during all weeks after treatments were imposed. However, reproductive performance of heifers grazed on wheat pasture during estrous synchronization and fixed time AI was similar to heifers consuming the drylot ration. The high crude protein content of wheat forage resulted in increased systemic urea nitrogen concentrations in heifers, but had no adverse effects on subsequent reproductive performance.

LITERATURE CITED

AOAC. 1996. Official Methods of Analysis. (16th Ed.) Association of Official Analytical Chemists, Arlington, VA.

Beck, P. A., S. A. Gunter, K. S. Lusby, C. P. West, K. B. Watkins, and D. S. Hubbell. 2008. Animal performance and economic comparison of novel and toxic endophyte tall fescues to cool-season annuals. J. Anim. Sci. 86:2043-2055.

Beck, P. A., S. A. Gunter, J. M. Phillips, and D. L. Kreider. 2005. Development of replacement heifers using programmed feeding. Prof. Anim. Sci. 21:365-370.

Breier, B. H., J. J. Bass, J. H. Butler, and P. D. Gluckman. 1986. The somatotrophic axis in young steers: influence of nutritional status on pulsatile release of growth hormone and circulating concentrations of insulin-like growth factor 1. J. Endocr. 111:209-215.

Butler, W. R., J. J. Calaman, and S. W. Beam. 1996. Plasma and milk urea nitrogen in relation to pregnancy rate in lactating dairy cattle. J. Anim. Sci. 74:858-865.

Canfield, R. W., C. J. Sniffen, and R. W. Butler. 1990. Effects of excess degradable protein on postpartum reproduction and energy balance in dairy cattle. J. Dairy Sci. 73:2342-2349.

Ciccioli, N. H., S. L. Charles-Edwards, C. Floyd, R. P. Wettemann, H. T. Purvis, K. S. Lusby, G. W. Horn, and D. L. Lalman. 2005. Incidence of puberty in beef heifers fed high-or low-starch diets for different periods before breeding. J. Anim. Sci. 83:2653-2662.

Dinning, J. S., H. M. Briggs, W. D. Gallup, H. W. Orr, and R. Butler. 1948. Effect of orally administered urea on the ammonia and urea concentration in the blood of cattle and sheep, with observations on blood ammonia levels associated with symptoms of alkalosis. Am. J. Physiol. 153:41.

Echternkamp, S. E., L. J. Spicer, K. E. Gregory, S. F. Canning, and J. M. Hammond. 1990. Concentrations of insulin-like growth factor-I in blood and ovarian follicular fluid of cattle selected for twins. Biol. Reprod. 43:8-14.

Elrod, C. C., and W. R. Butler. 1993. Reduction of fertility and alteration of uterine pH in heifers fed excess ruminally degradable protein. J. Anim. Sci. 71:694-701.

Elsasser, T. H., T. S. Rumsey, and A. C. Hammond. 1989. Influence of diet on basal and growth hormone-stimulated plasma concentrations of IFG-I in beef cattle. J. Anim. Sci. 67:128-141.

Ferguson, J. D., D. T. Galligan, T. Blanchard, and M. Reeves. 1993. Serum urea nitrogen and conception rate: The usefulness of test information. J. Dairy Sci. 76:3742-3746.

Horn, F. P., G. W. Horn, and H. R. Crookshank. 1977. Effect of short–term fasting and refeeding on weight and blood components of steers grazing wheat pasture. J. Anim. Sci. 44:288-294.

Horn, F. P. 1983. Chemical composition of wheat pasture. Proc. Natl. Wheat Pasture Symp. Oklahoma Agric. Exp. Stn. MP115:47-54.

Horn, G. W. 2006. Growing cattle on winter wheat pasture: Management and herd health considerations. Vet. Clin. Food Anim. 22:335-356.

Horn, G. W., B. R. Clay, and L. I. Croy. 1997. Wheat pasture bloat of stockers.

Oklahoma Agric. Exp. Sta. Res. Rep. MP-101:26.

Houseknecht, K. L., D. L. Boggs, D. R. Campion, J. L. Sartin, T. E. Kiser, G. B. Rampacek, and H. E. Amos. 1988. Effect of dietary energy source and level on serum growth hormone, insulin-like growth factor 1, growth and body composition in beef heifers. J. Anim. Sci. 66:2916-2923.

Johnson, R. R. 1966. Techniques and procedures for in vitro and in vivo rumen studies. J. Anim. Sci. 25:855-875.

Johnson, R. R., M. McGeehon, E. Williams, and H. C. Young. 1973. Studies on nutritive value of wheat pasture. Oklahoma Agric. Exp. Sta. Res. Rep. MP-90:13-15.

Jones, E. J., J. D. Armstrong, and R. W. Harvey. 1991. Changes in metabolites, metabolic hormones, and luteinizing hormone before puberty in Angus, Braford, Charolais, and Simmental heifers. J. Anim. Sci. 69:1607-1615.

Jordan, E. R., and L. V. Swanson. 1979. Effect of crude protein on reproductive efficiency, serum total protein, and albumin in the high-producing dairy cow. J. Dairy Sci. 62:58-63.

Kenny, D. A., M. P. Boland, M. G. Diskin, and J. M. Sreenan. 2002. Effect of rumen degradable protein with or without fermentable carbohydrate supplementation on blood metabolites and embryo survival in cattle. British Society of Animal Science. 74:529-537.

Kenny, D. A., M. P. Boland, M. G. Diskin, and J. M. Sreenan. 2001. Effect of pasture crude protein and fermentable energy supplementation on blood metabolite and progesterone concentrations and on embryo survival in heifers. British Society of Animal Science. 73:501-511.

Lamb, G. C., J. S. Stevenson, D. J. Kesler, H. A. Garverick, D. R. Brown, and B. E. Salfen. 2001. Inclusion of an intravaginal progesterone insert plus GnRH and prostaglandin F2alpha for ovulation control in postpartum suckled beef cows. J. Anim. Sci. 79:2253-2259.

Lamb, G. C. and J. E. Larson. 2004. Review of estrus synchronization systems: CIDR. Proc. App. Repro. Strat. pp 75-84.

Mader, T. L., and G. W. Horn. 1986. Low-quality roughages for steers grazing wheat pasture. II. Effect of wheat forage intake and utilization. J. Anim. Sci. 62:1113-1119.

National Research Council. 1996. Nutrient requirements of beef cattle. Natl. Acd. Sci., Washington, D.C.

Prigge, E. C., R. R. Johnson, F. N. Owens, and D. Williams. 1976. Soluble nitrogen and acid production of high moisture corn. J. Anim. Sci. 42: 490-496.

Randel, R. D. 1990. Nutrition and postpartum rebreeding in cattle. J. Anim. Sci. 68:853

Roseler, D. K., J. D. Ferguson, C. J. Sniffen, and J. Herrema. 1993. Dietary protein degradability effects on plasma and milk urea nitrogen and milk nonprotein nitrogen in Holstein cows. J. Dairy Sci. 76:525-534.

Short, R. E. and R. A. Bellows. 1971. Relationships among weight gains, age at puberty and reproductive performance in heifers. J. Anim. Sci. 32:127.

Spicer, L. J., E. Alpizar, and S. E. Echternkamp. 1993. Effects of insulin, insulin-like growth factor I, and gonadotropins on bovine granulose cell proliferation, progesterone production, estradiol production, and (or) insulin-like growth factor I production in vitro. J. Anim. Sci. 71:1232-1241.

Wettemann, R.P., H. D. Hafs, L. A. Edgerton, and L. V. Swanson. 1972. Estradiol and progesterone in blood serum during the bovine estrous cycle. J. Anim. Sci. 34:1020-1024.

Van Soest, P. J., J. B. Robertson, and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3583-3587.

Vizcarra, J. A., R. P. Wettemann, T. D. Braden, A. M. Turzillo, and T. M. Nett. 1997. Effect of gonadotropin-releasing hormone (GnRH) pulse frequency on serum and pituitary concentrations of luteinizing hormone and follicle stimulating hormone, GnRH receptors, and messenger ribonucleic acid for gonadotropin subunits in cows.

Vogel, G. J., W. A. Phillips, G. W. Horn, M. J. Ford, and R. W. McNew. 1989. Effects of supplemental silage on forage intake and utilization by steers grazing wheat pasture of bermudagrass. J. Anim. Sci. 67:232-240.

Table 1. Ingredient and calculated nutrient composition (DM basis) of ration fed to heifers in drylot

Item	
Ingredient composition	
Rolled Corn, %	39.97
Ground Alfalfa Hay, %	34.97
Cottonseed Hulls, %	22.23
Cane Molasses, %	2.55
Salt, %	0.28
Calculated nutrient composition	
NE_m, Mcal/kg	1.61
NE_g, Mcal/kg	0.91
TDN, %	70.24
Fat, %	2.69
Crude Protein, %	11.11
Potassium, %	1.18
Calcium, %	0.59
Phosphorus, %	0.23
Magnesium, %	0.21
Sulfur, %	0.19
Cobalt, ppm	0.12
Copper, ppm	10.40
Iron, ppm	90.30
Manganese, ppm	45.00
Selenium, ppm	0.23
Zinc, ppm	20.80

Table 2. Calendar of events for heifers during 2006 to 2007 and 2007 to 2008

	Year	
Event	Year 1 (2006-2007)	Year 2 (2007-2008)
Initial placement on wheat pasture (Wt 1)	December 13, 2006	December 7, 2007
Allotted to 2 treatment groups (Wt 2)	March 13, 2007	March 11, 2008
Start of synchronization	March 27, 2007	March 25, 2008
Time of AI (Wt 3)	April 5, 2007	April 3, 2008
Bulls placed with heifers	April 15, 2007	April 15, 2008
All animals moved to native range	May 1, 2007	May 2, 2008
Final shrunk Wt (Wt 4)	May 4, 2007	May 5, 2008
Transrectal ultrasonography	May 7, 2007	May 5, 2008
Bulls removed	June 7, 2007	June 5, 2008
Rectal palpation	September 25, 2007	September 22 and 24, 2008

Table 3. Monthly mean temperatures and total precipitation during years one and two in Stillwater, OK

	Mean temperature, °C			Total precipitation, mm		
Item	YR1	YR2	Normal[1]	YR1	YR2	Normal
August	29	28	27	61	33	77
September	21	23	22	34	117	105
October	16	17	16	40	84	83
November	10	10	9	31	22	65
December	5	3	3	71	27	45
January	1	3	1	34	14	33
February	4	4	4	11	66	41
March	15	10	9	139	105	81
April	13	14	15	105	146	87
May	21	21	20	265	162	137
June	24	26	25	425	125	110
July	26	28	28	178	127	68
Totals:	-	-	-	1394	1028	932

[1]Normal temperature and precipitation are averages from 1971 to 2000 for Stillwater, OK (Oklahoma Climate Data, http://climate.ocs.ou.edu/).

Table 4. Chemical composition (DM basis) of wheat forage during year one (2006-2007).

Item	Clipping Date					
	March 13, 2007	March 20, 2007	March 27, 2007	April 3, 2007	April 10, 2007	Mean ± Std. Dev.
Sample number	1	2	3	4	5	
No. of samples	3	3	3	3	3	
CP, %	28.4	29.1	26.2	19.4	18.2	24.3 ± 5.12
Total N, %	4.5	4.7	4.2	3.1	2.9	3.9 ± 0.83
Sol. N, % of total N	33.2	28.3	29.5	30.6	46.1	33.5 ± 7.25
Sol. NPN, % of total N	20.0	16.4	16.2	20.8	28.1	20.3 ± 4.83
Sol. Protein, % of total N	13.2	11.9	13.4	12.0	18.0	13.7 ± 2.50
ADF, %	24.9	26.8	27.5	27.5	27.9	26.9 ± 1.20
NDF, %	43.6	52.7	51.2	52.1	49.5	49.8 ± 3.68

Table 5. Chemical composition (DM basis) of wheat forage during year two (2007-2008).

Item	Clipping Date													
	Dec. 20	Jan. 4	Jan. 11	Feb. 4	Feb. 25	March 11	March 19	March 25	April 1	April 8	April 22	April 29	Mean ± Std. Dev.[1]	Mean ± Std. Dev.[2]
Sample number	1	2	3	4	5	6	7	8	9	10	11	12		
No. of samples	3	3	3	3	3	4	4	4	4	4	4	4		
DM, %	40.1	35.3	34.6	30.4	32.9	28.0	21.0	25.6	24.8	25.4	26.1	26.2	29.2 ± 5.51	25.0 ± 2.53
CP, %	24.9	23.1	22.7	27.6	25.1	28.3	34.3	27.3	28.7	26.2	21.6	15.6	25.5 ± 4.58	29.0 ± 3.14
Total N, %	4.0	3.7	3.6	4.4	4.0	4.5	5.5	4.4	4.6	4.2	3.5	2.5	4.1 ± 0.73	4.6 ± 0.50
Sol. N, % of total N	37.4	35.7	37.7	40.0	36.5	39.9	26.5	35.9	34.3	35.4	27.5	33.5	35.0 ± 4.23	34.4 ± 4.90
Sol. NPN, % of total N	25.8	25.9	19.5	19.3	19.0	18.2	17.5	16.5	19.2	18.7	16.8	22.4	20.0 ± 3.16	18.0 ± 1.06
Sol. Protein, % of total N	11.6	9.7	18.2	19.7	17.5	21.7	8.9	19.4	15.1	16.7	10.7	11.1	15.0 ± 4.43	16.4 ± 4.88
ADF, %	21.7	21.7	19.4	17.9	21.8	21.2	37.7	25.2	24.3	23.7	29.8	32.8	24.8 ± 5.84	26.4 ± 6.48
NDF, %	43.5	40.0	43.2	44.5	43.0	40.0	50.7	43.5	45.7	44.7	51.6	57.1	45.6 ± 5.05	44.9 ± 3.88

[1]Mean and standard deviation of samples 1 - 12
[2]Mean and standard deviation of samples 6 – 10 (i.e., the time that treatments were imposed).

Table 6. Least square means for body weight and reproductive measures of heifers in drylot or grazing wheat pasture (data pooled across years).

Item	Treatment		SE	*P* - value
	Drylot	Wheat Pasture		
Body wt, kg				
Initial placement on wheat	259.2	259.6	2.96	0.92
Allotment to treatments	358.9	358.0	9.67	0.84
Time of AI	408.0	393.9	4.48	0.01
Final BW on native range	417.0	413.3	5.26	0.44
ADG, kg				
Initial placement-Allotment, 90 days	1.08	1.06	0.082	0.72
Allotment-AI, 23 days	2.13	1.56	0.579	0.01
AI-Final BW, 29 days	0.29	0.63	0.048	0.01
Reproductive measures				
Luteal activity, %	55	75	11	0.08
Pregnant at ultrasound, %	43	53	8	0.38
Final pregnancy status, %	88	95	5	0.34

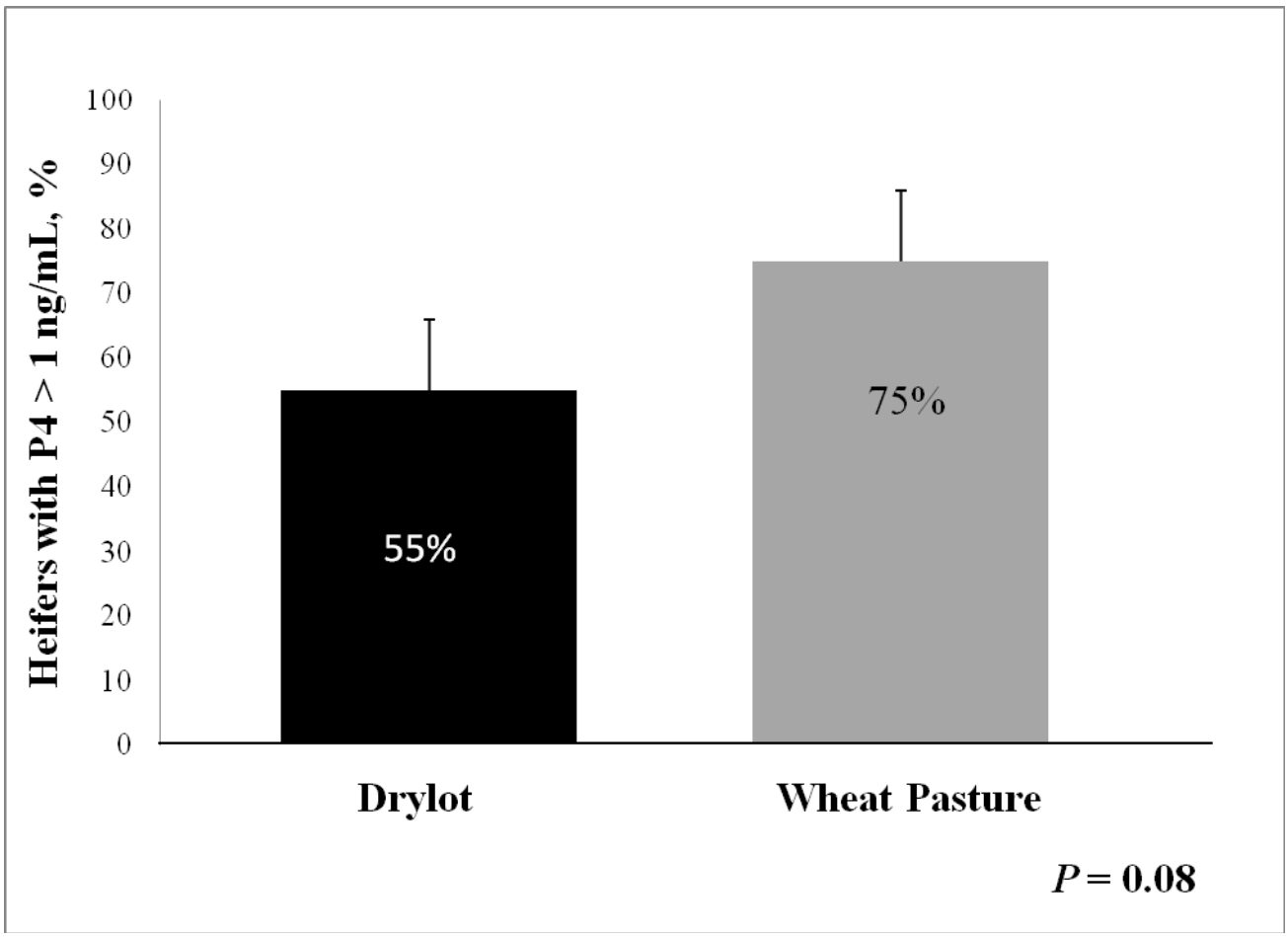


Figure 1. Luteal activity of heifers in drylot (indicated by black bar) or grazing wheat pasture (indicated by grey bar). Data were pooled across years one and two (2006-2007 and 2007-2008). Standard error = 11%.

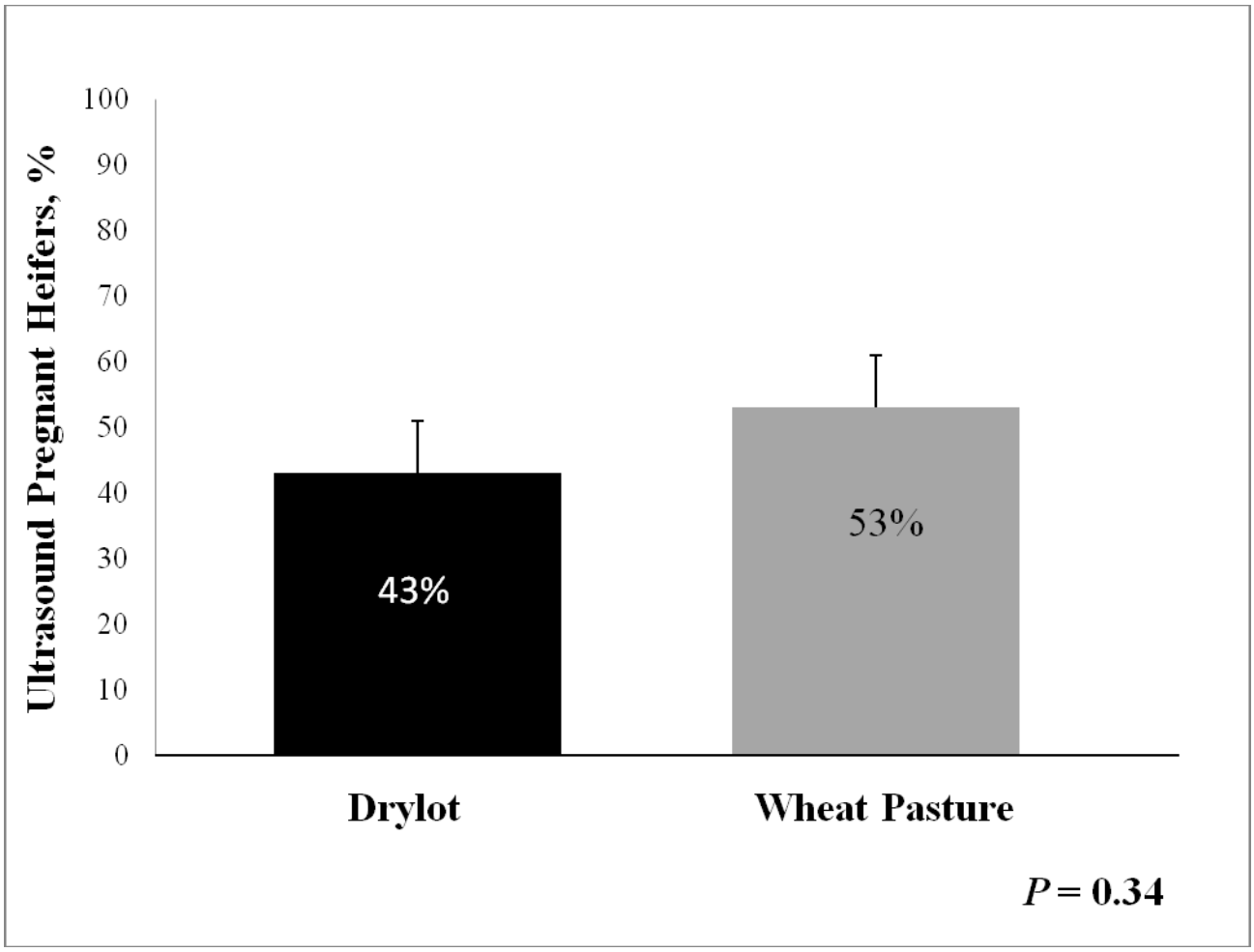


Figure 2. Percentage of heifers pregnant to fixed time AI that were either in drylot (indicated by black bar) or grazing wheat pasture (indicated by grey bar). Data were pooled across years one and two (2006-2007 and 2007-2008). Standard error = 8%.

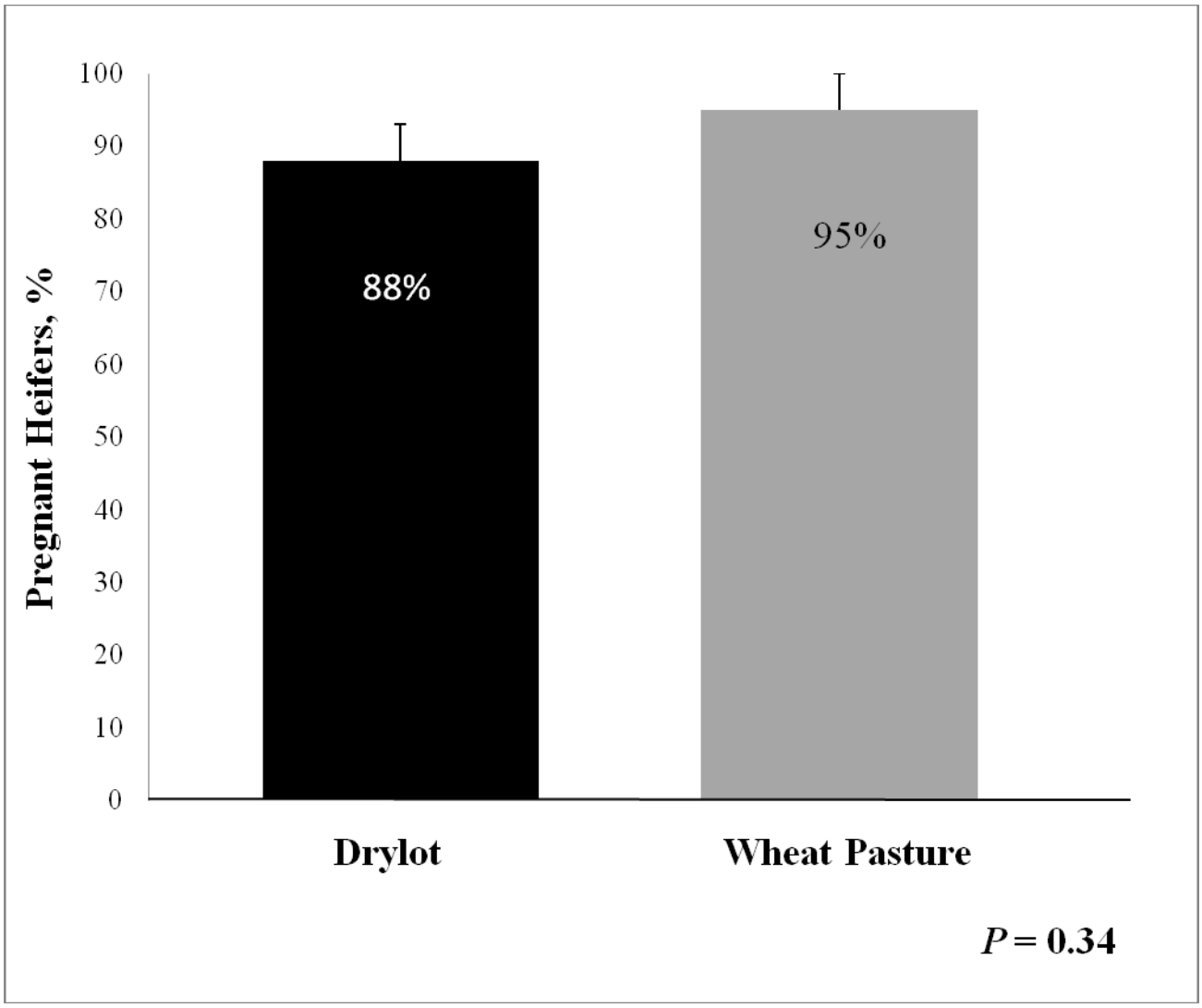


Figure 3. Final pregnancy rate of heifers in drylot (indicated by black bar) or grazing wheat pasture (indicated by grey bar). Data were pooled across years one and two (2006-2007 and 2007-2008). Standard error = 5%.

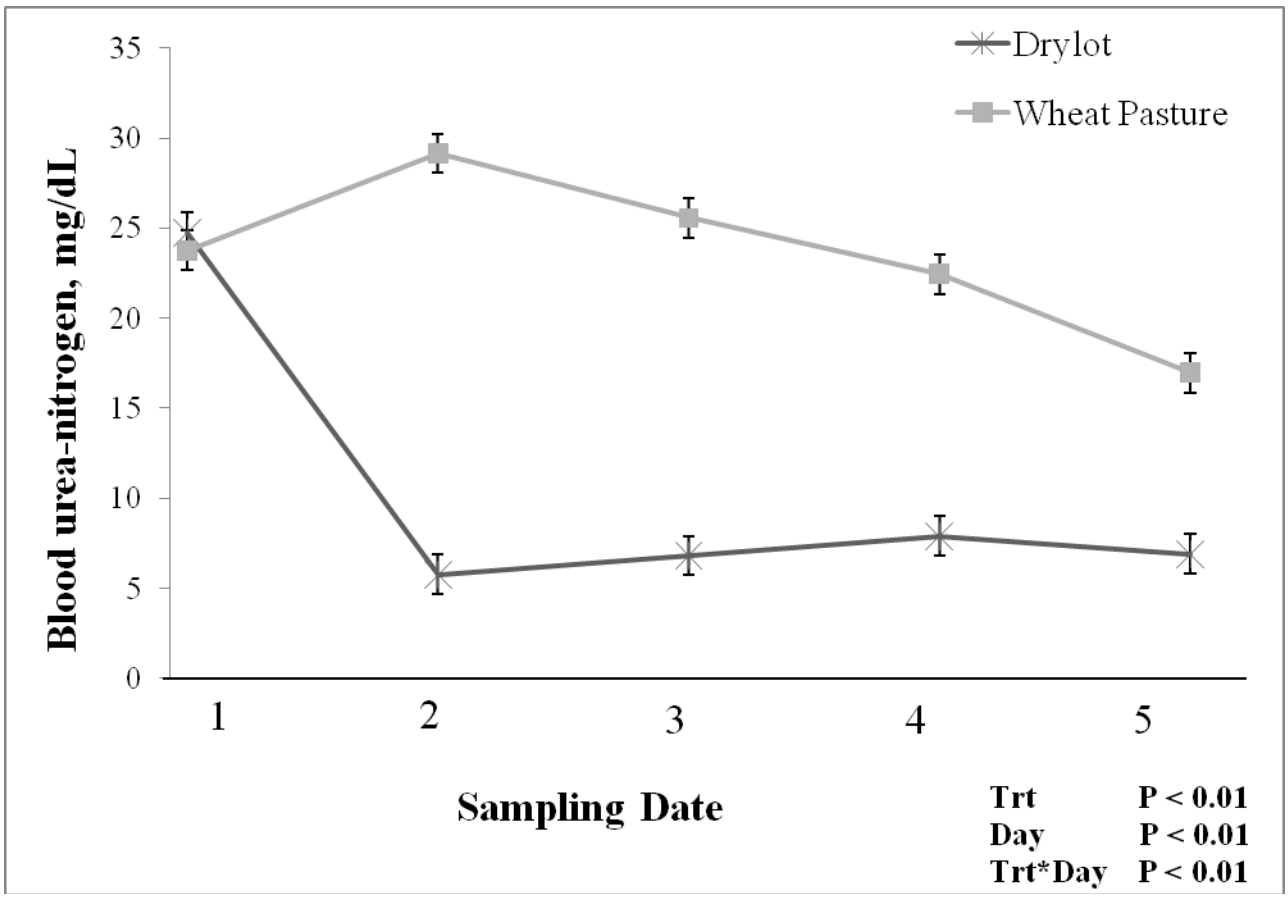


Figure 4. Blood urea-nitrogen concentrations of heifers in drylot (indicated by black line) or grazing wheat pasture (indicated by grey line). Data were pooled across years one and two (2006-2007 and 2007-2008).

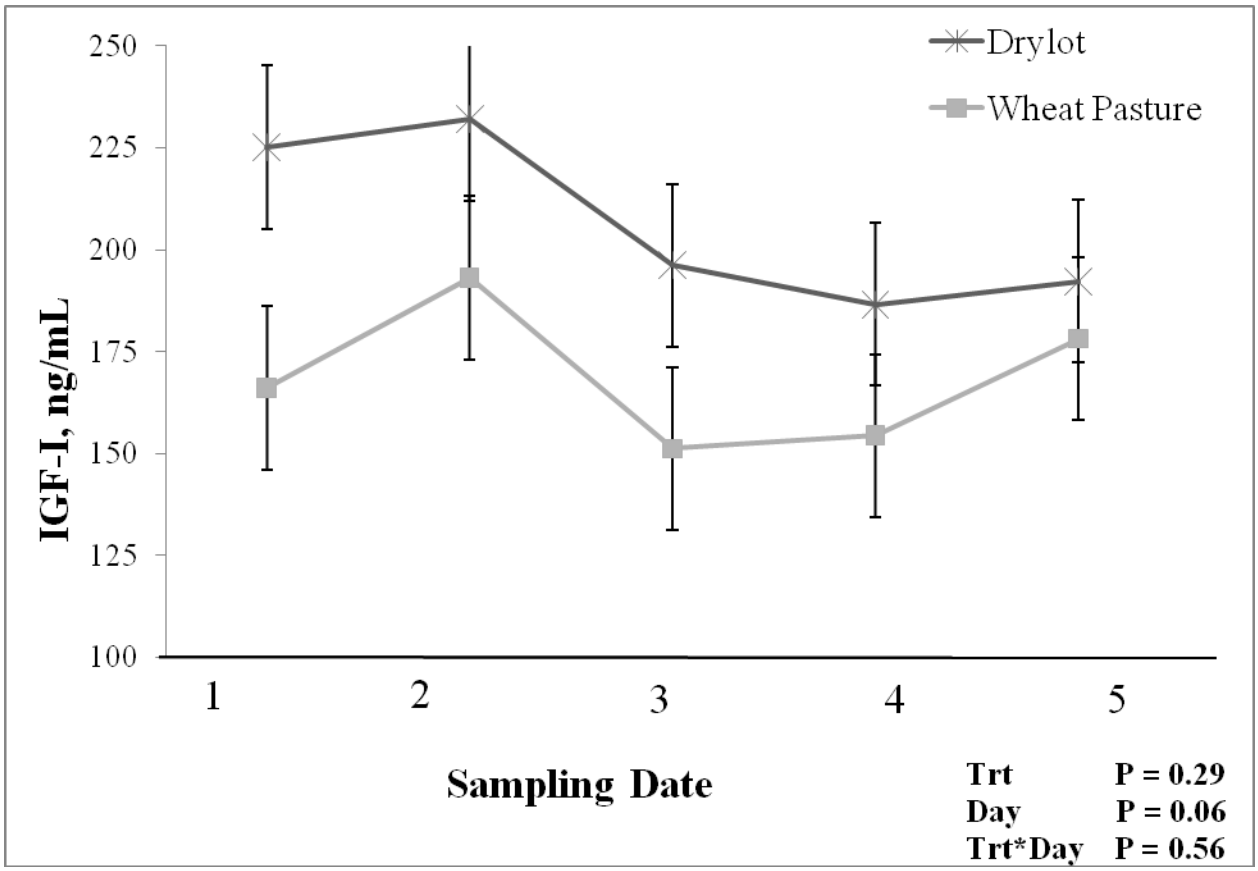


Figure 5. IGF-I concentrations of heifers in drylot (indicated by black line) or grazing wheat pasture (indicated by grey line). Data were pooled across years one and two (2006-2007 and 2007-2008).

APPENDIX

Appendix Table 1. Least square means for body weight and reproductive measures of heifers in drylot or grazing wheat pasture during years one and two.

Item	Treatment		SE	*P* - value
	Drylot	Wheat Pasture		
	Year 1 (2006 -2007)			
Number of heifers	20	20		
Body wt, kg				
Initial placement on wheat (12/13/06)	259.4	263.5	3.00	0.34
Allotment to treatments (3/13/07)	368.9	367.0	4.37	0.76
Time of AI (4/5/07)	404.7	389.5	4.38	0.02
Final BW on native range (5/4/07)	416.0	404.8	3.90	0.05
ADG, kg				
12/13/06-3/13/07, 90 days	1.18	1.12	0.038	0.24
3/13/07-4/5/07, 23 days	1.55	0.98	0.099	0.01
4/5/07-5/4/07, 29 days	0.37	0.50	0.067	0.19
Reproductive measures				
Luteal activity, %	45	65	11	0.23
Pregnant at ultrasound, %	45	45	11	1.00
Final pregnancy status, %	90	100	4	0.99
	Year 2 (2007-2008)			
Number of heifers	20	20		
Body wt, kg				
Initial placement on wheat (12/7/07)	259.0	255.8	3.82	0.56
Allotment to treatments (3/11/08)	349.0	349.1	4.43	0.98
Time of AI (4/3/08)	411.3	398.3	4.94	0.07
Final BW on native range (5/5/08)	417.9	421.7	5.40	0.62
ADG, kg				
12/7/07-3/11/08, 95 days	0.97	1.01	0.029	0.38
3/11/08-4/3/08, 23 days	2.71	2.14	0.076	0.01
4/3/08-5/5/08, 32 days	0.22	0.77	0.060	0.01
Reproductive measures				
Luteal activity, %	65	85	10	0.21
Pregnant at ultrasound, %	40	60	11	0.23
Final pregnancy status, %	85	90	8	0.66

Appendix Table 2. Least square means for urea-nitrogen concentrations (mg/dL) of heifers in drylot or grazing wheat pasture.

	Sampling date					
	Year 1 (2006-2007)[1]					
Treatment	March 13, 2007	March 20, 2007	March 27, 2007	April 3, 2007	April 10, 2007	SE
Drylot[4]	30.19[a]	5.67[b]	7.00[b]	7.70[b]	6.11[b]	1.248
Wheat Pasture	29.19[a]	28.34[a]	24.84[c]	18.08[d]	13.21[e]	1.248
	Year 2 (2007-2008)[2]					
Treatment	March 11, 2008	March 19, 2008	March 25, 2008	April 1, 2008	April 8, 2008	SE
Drylot[4]	19.15[a]	5.76[b]	6.56[b]	8.10[b]	7.72[b]	1.428
Wheat Pasture	18.33[a]	29.95[c]	26.29[c]	26.83[c]	20.71[a]	1.425
	Pooled across years (2006-2008)[3]					
Treatment	1	2	3	4	5	SE
Drylot[4]	24.76[a]	5.77[b]	6.82[b]	7.91[b]	6.91[b]	1.052
Wheat Pasture	23.76[a]	29.15[c]	25.57[a]	22.45[a]	16.97[c]	1.051

[1] Within year 1, means within rows or columns without a common superscript differ ($P < 0.001$)
[2] Within year 2, means within rows or columns, without a common superscript differ ($P < 0.001$)
[3] Within pooled years, means within rows or columns, without a common superscript differ ($P < 0.05$)
[4] For all years, both treatment groups were grazing wheat pasture when the first blood samples were obtained. Treatments were imposed in all sampling dates thereafter

Appendix Table 3. Least square means of IGF-I concentrations in heifers in drylot or grazing wheat pasture.

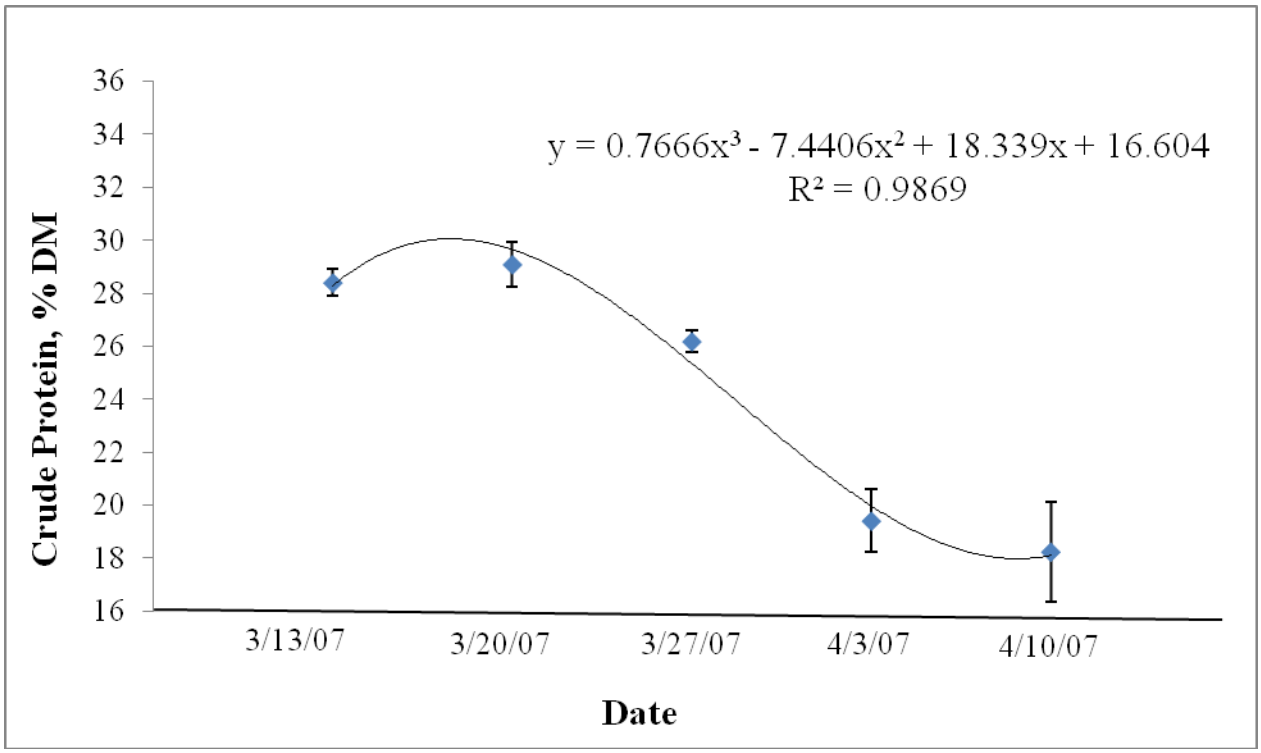
	Treatment			
	Drylot	Wheat Pasture	SE	*P* - value
		Year 1 (2006-2007)		
IGF-I, ng/mL	192.2	187.3	48.85	0.87
		Year 2 (2007-2008)		
IGF-I, ng/mL	206.4	168.6	28.55	0.09
		Pooled across years (2006-2008)[1]		
IGF-I, ng/mL	196.4	179.0	25.10	0.29

[1]Data were pooled across years one and two (2006-2007 and 2007-2008).

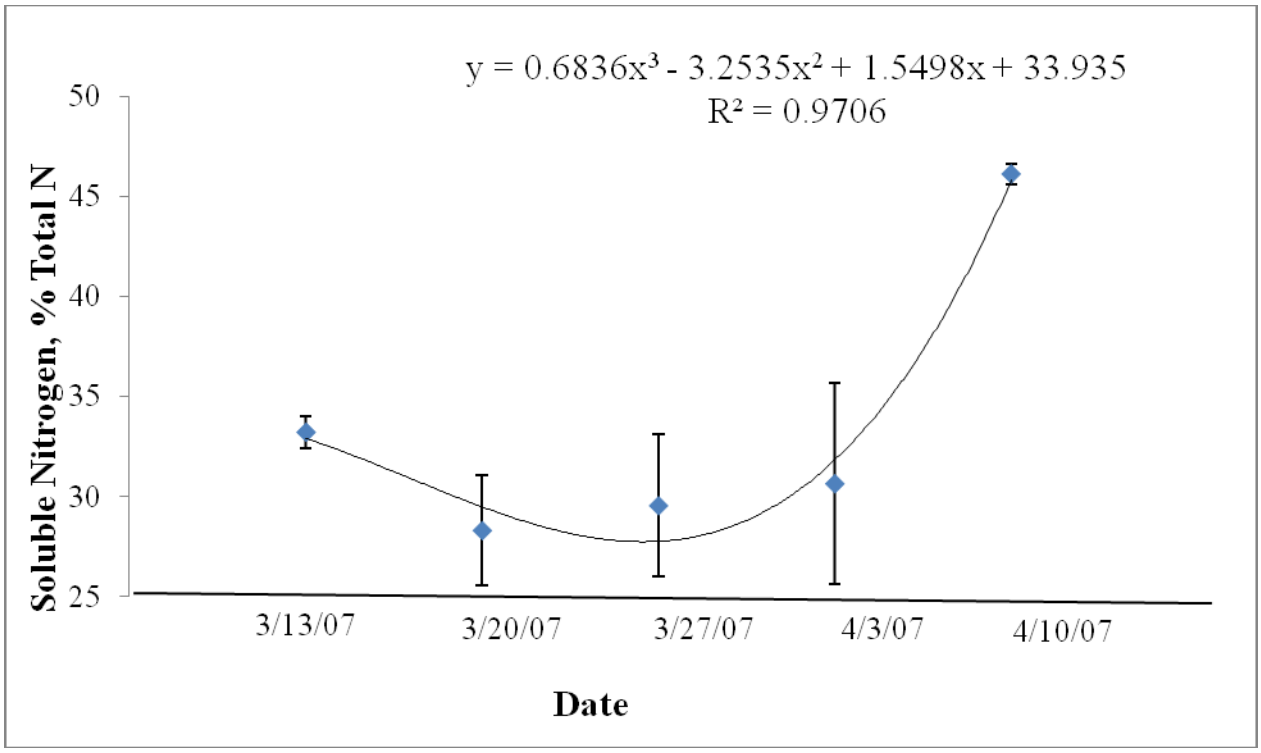
Appendix Table 4. Least square means of IGF-I concentrations in heifers in drylot or grazing wheat pasture. Data were pooled across years one and two (2006-2007 and 2007-2008).[1]

	Sampling date						
	1	2	3	4	5	SE	P -value
IGF-I, ng/mL	213.85[a]	211.29[a]	179.74[b]	164.50[b]	174.01[b]	26.0	0.07

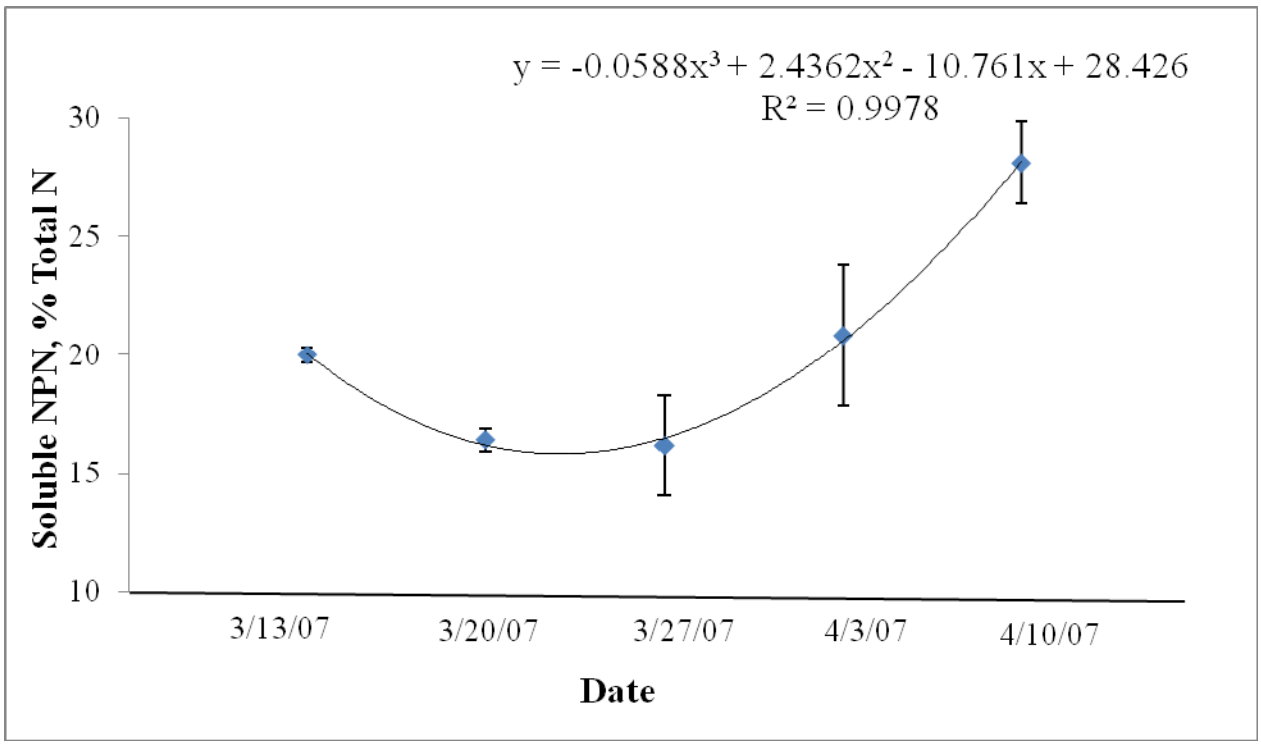
[1] Means without a common superscript differ ($P < 0.05$)



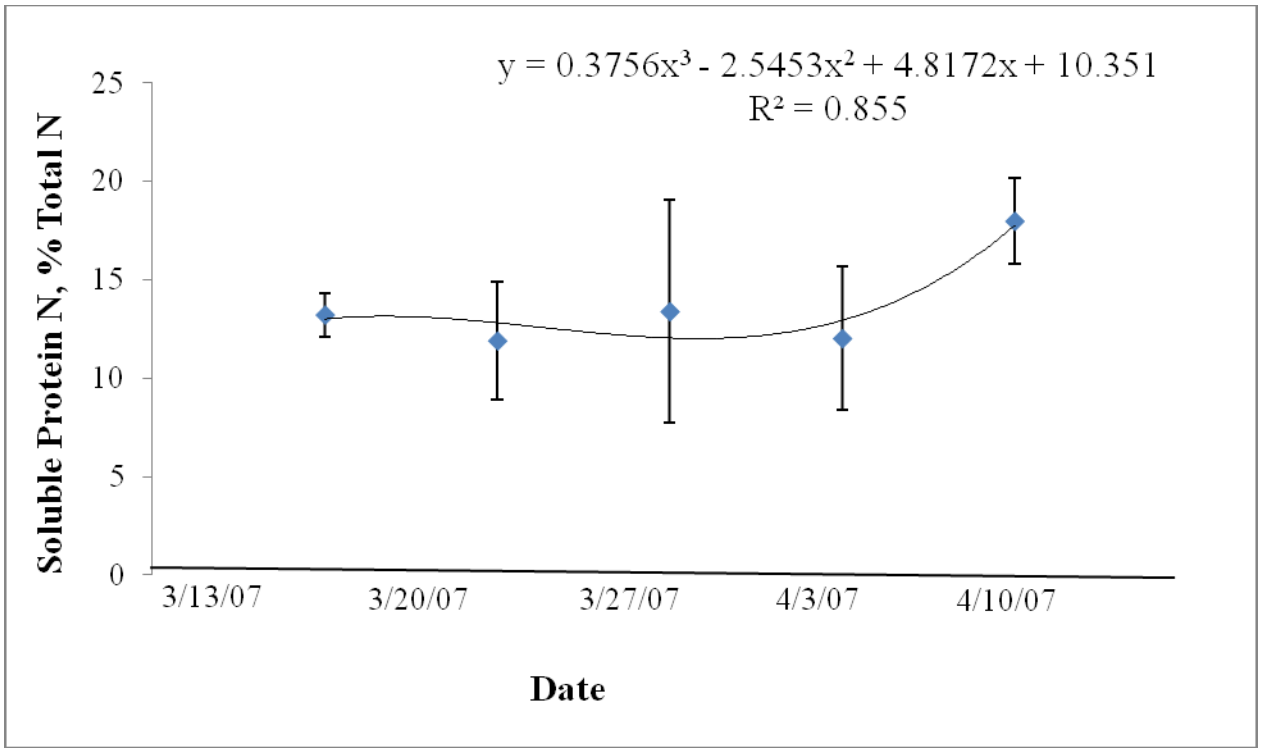
Appendix Figure 5. Crude protein of forage samples collected from wheat pasture during year one (2006-2007).



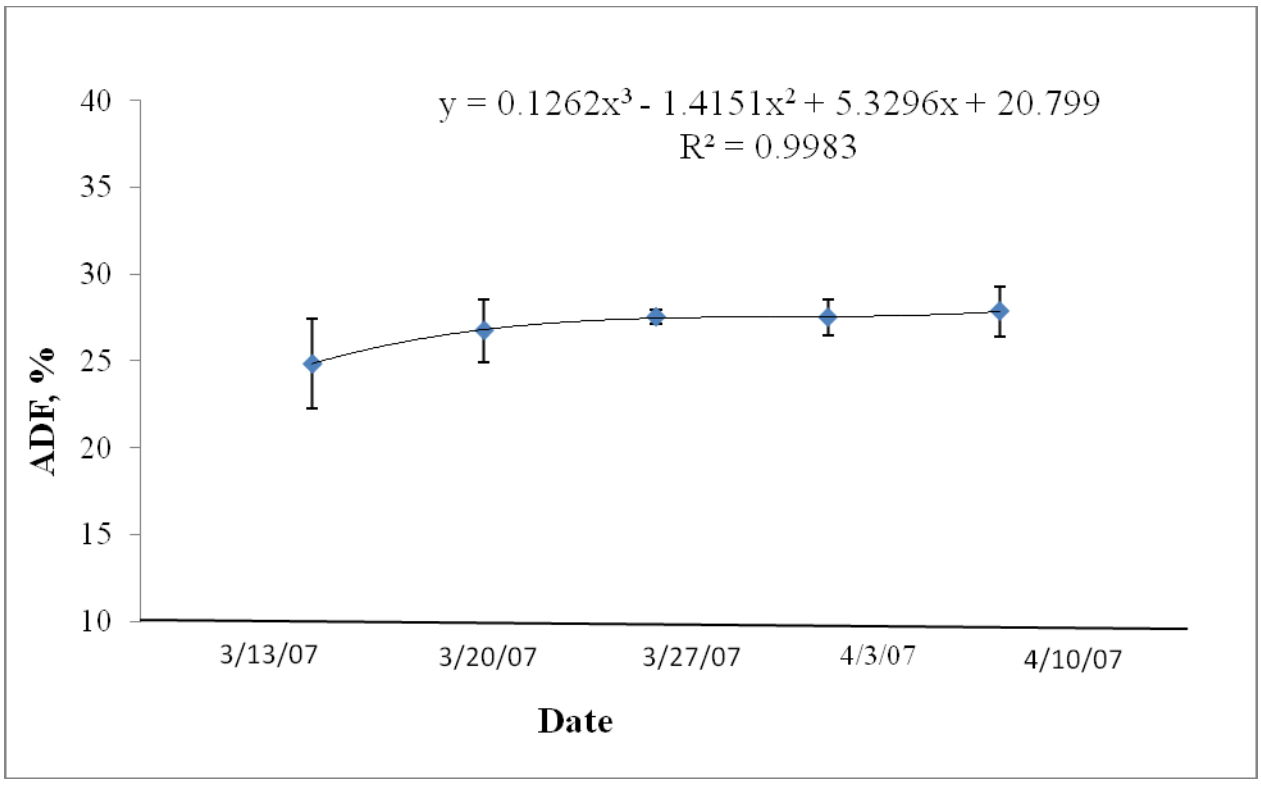
Appendix Figure 6. Soluble nitrogen fraction of forage samples collected from wheat pasture during year one. (2006-2007).



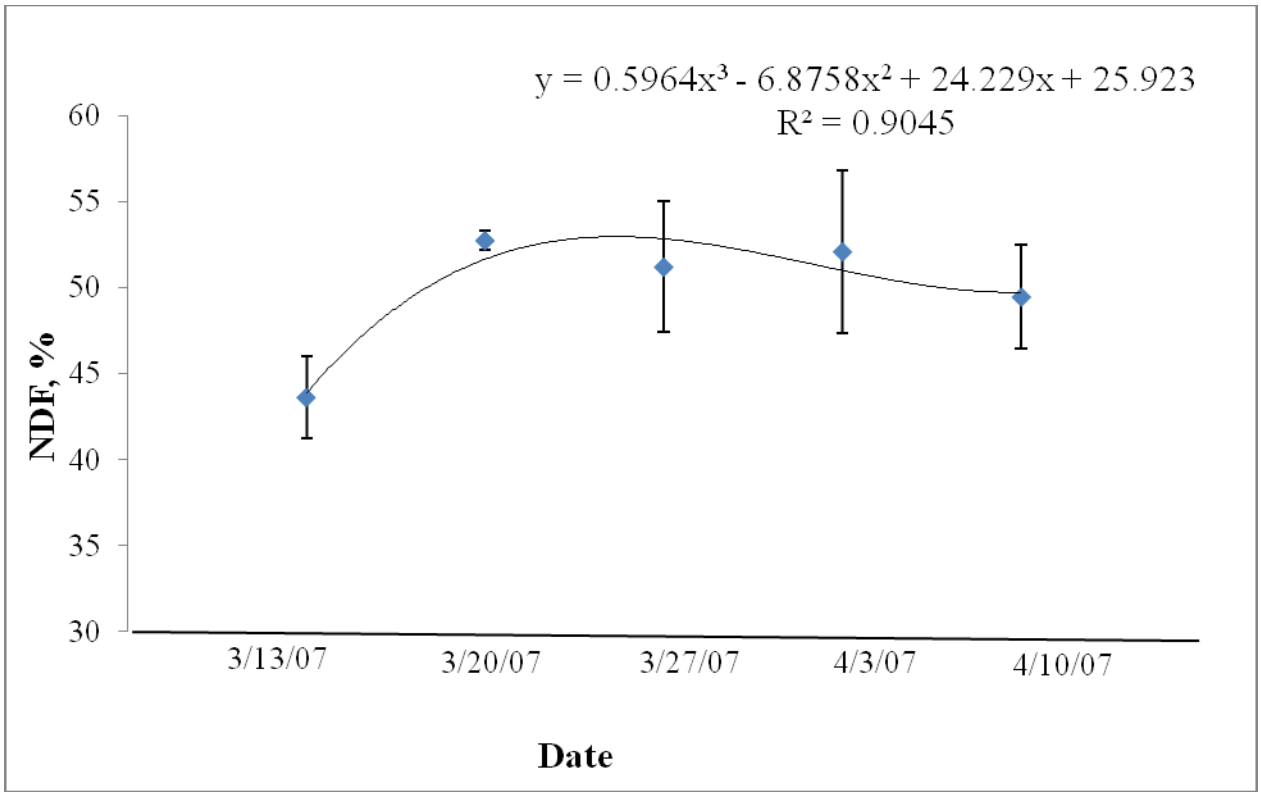
Appendix Figure 7. Soluble non-protein nitrogen fraction of forage samples collected from wheat pasture during year one (2006-2007).



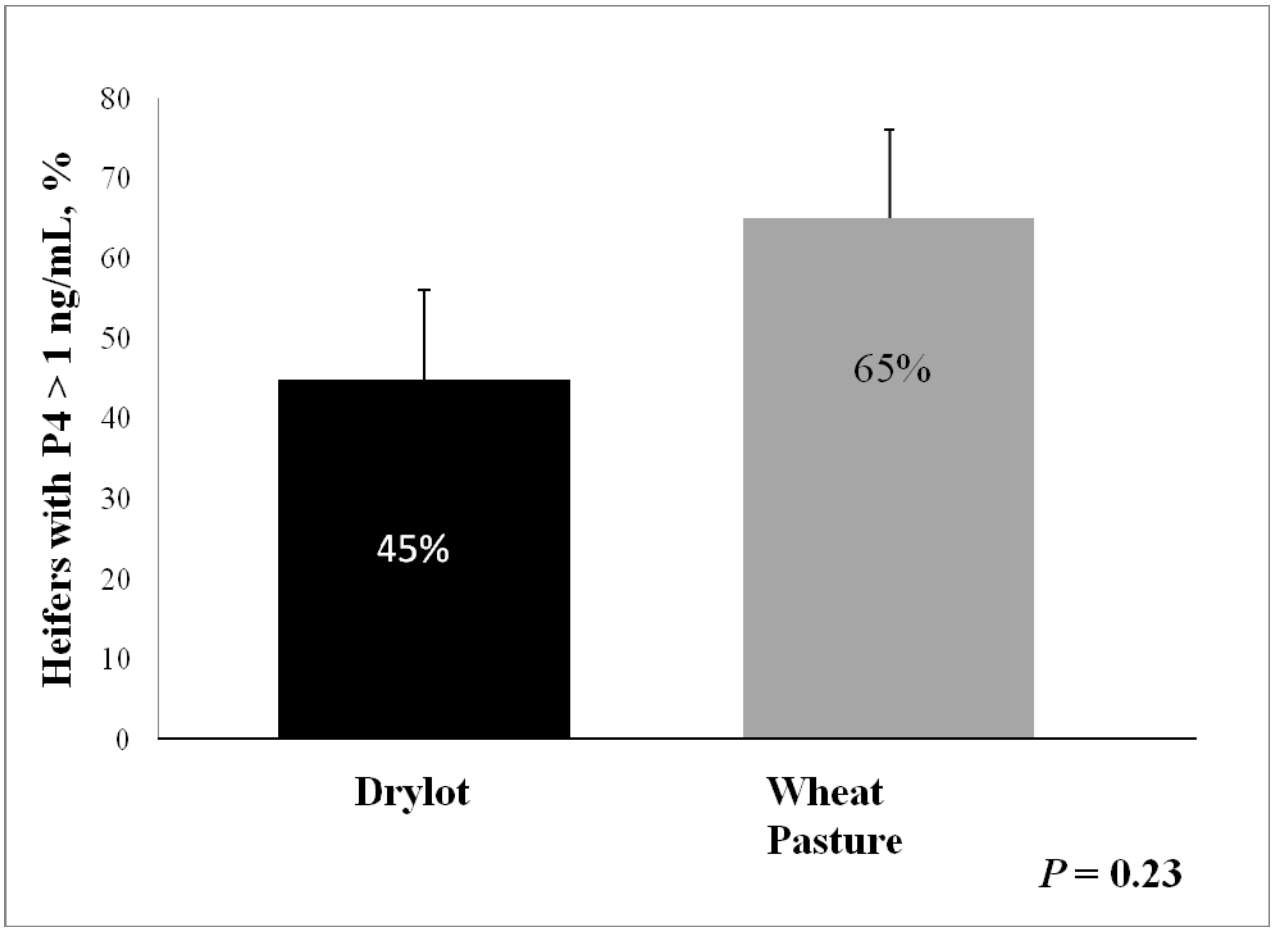
Appendix Figure 8. Soluble protein nitrogen fraction of forage samples collected from wheat pasture during year one (2006-2007).



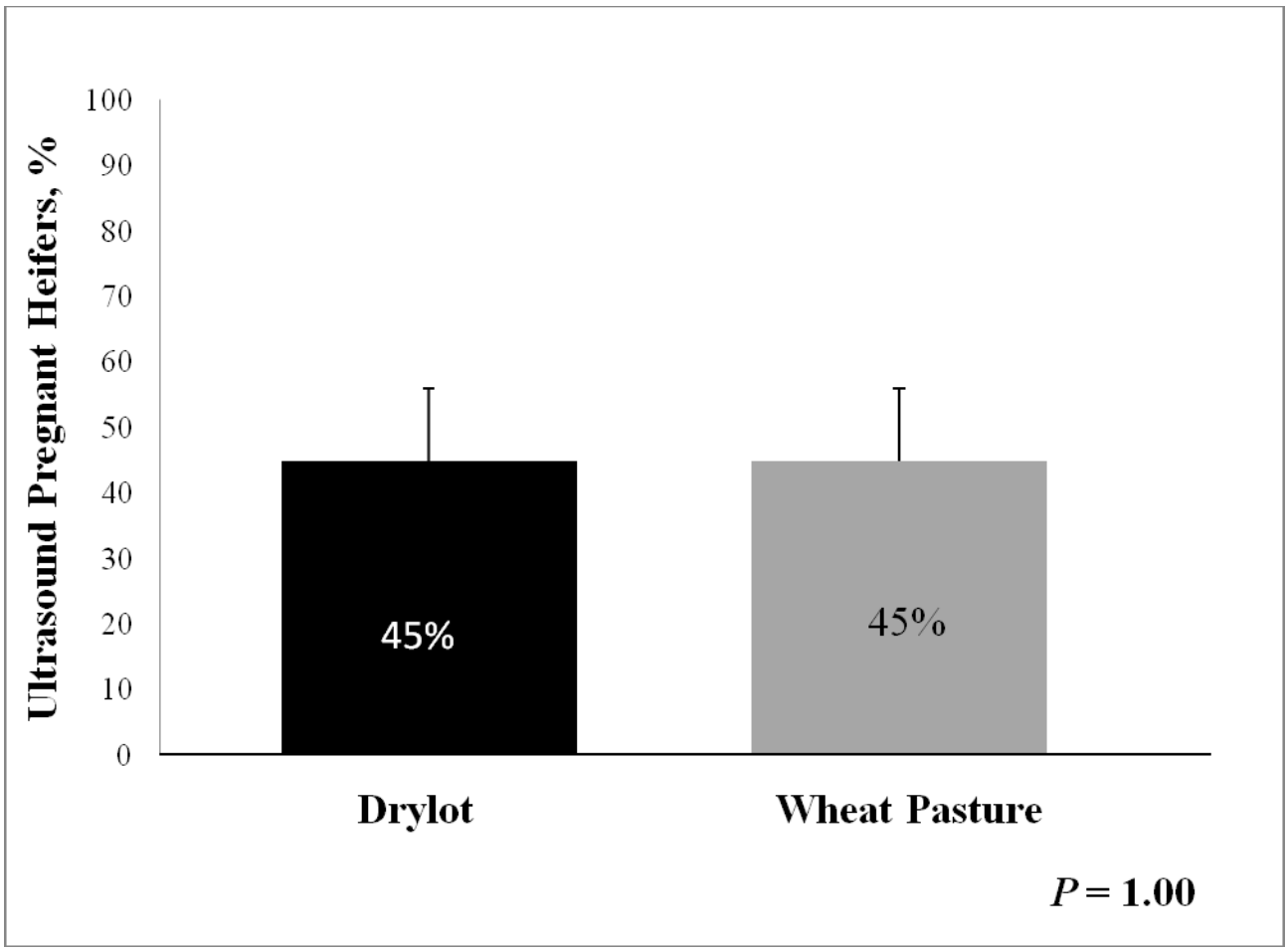
Appendix Figure 9. ADF of forage samples collected from wheat pasture during year one (2006-2007).



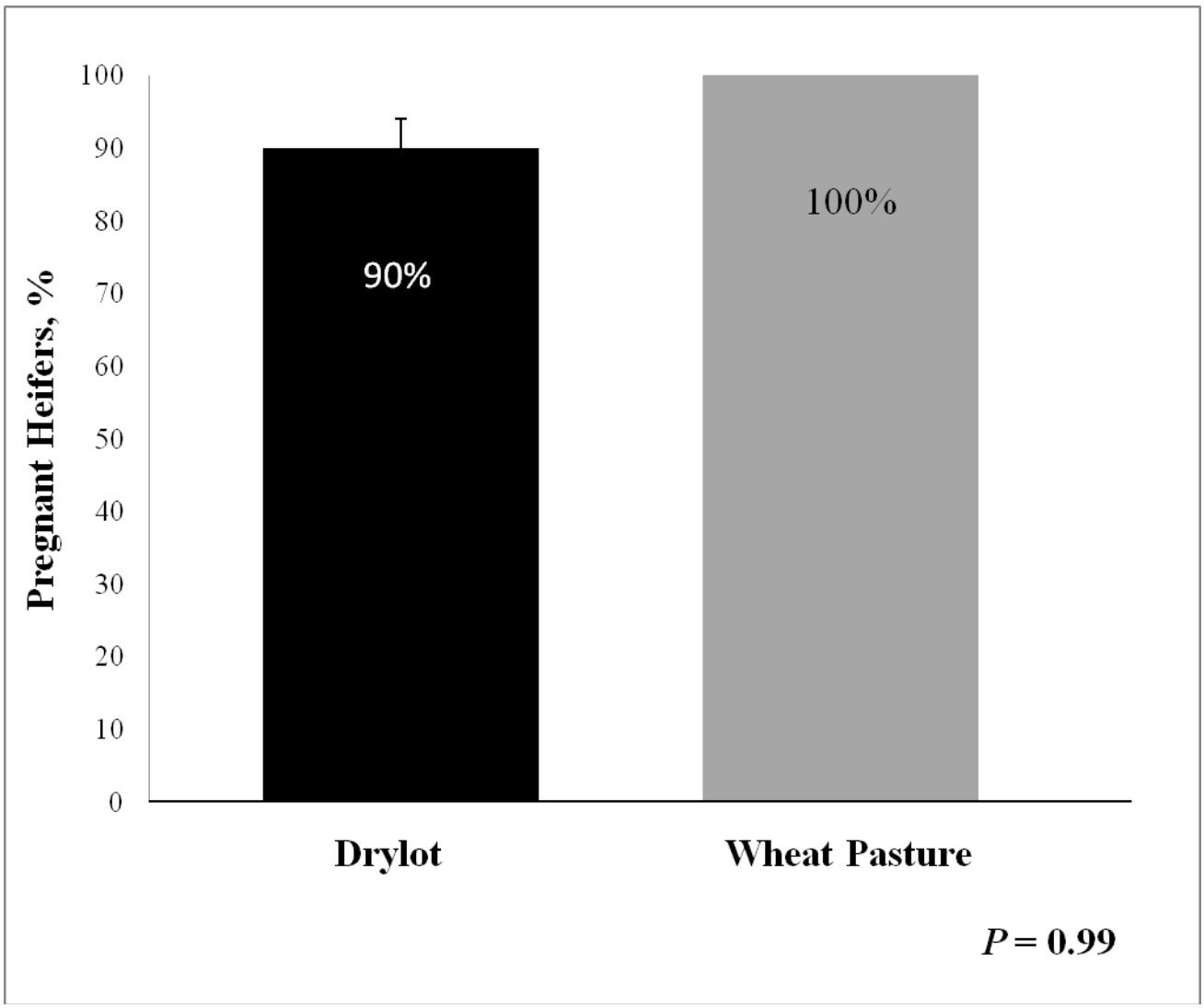
Appendix Figure 10. NDF of forage samples collected from wheat pasture during year one (2006-2007).



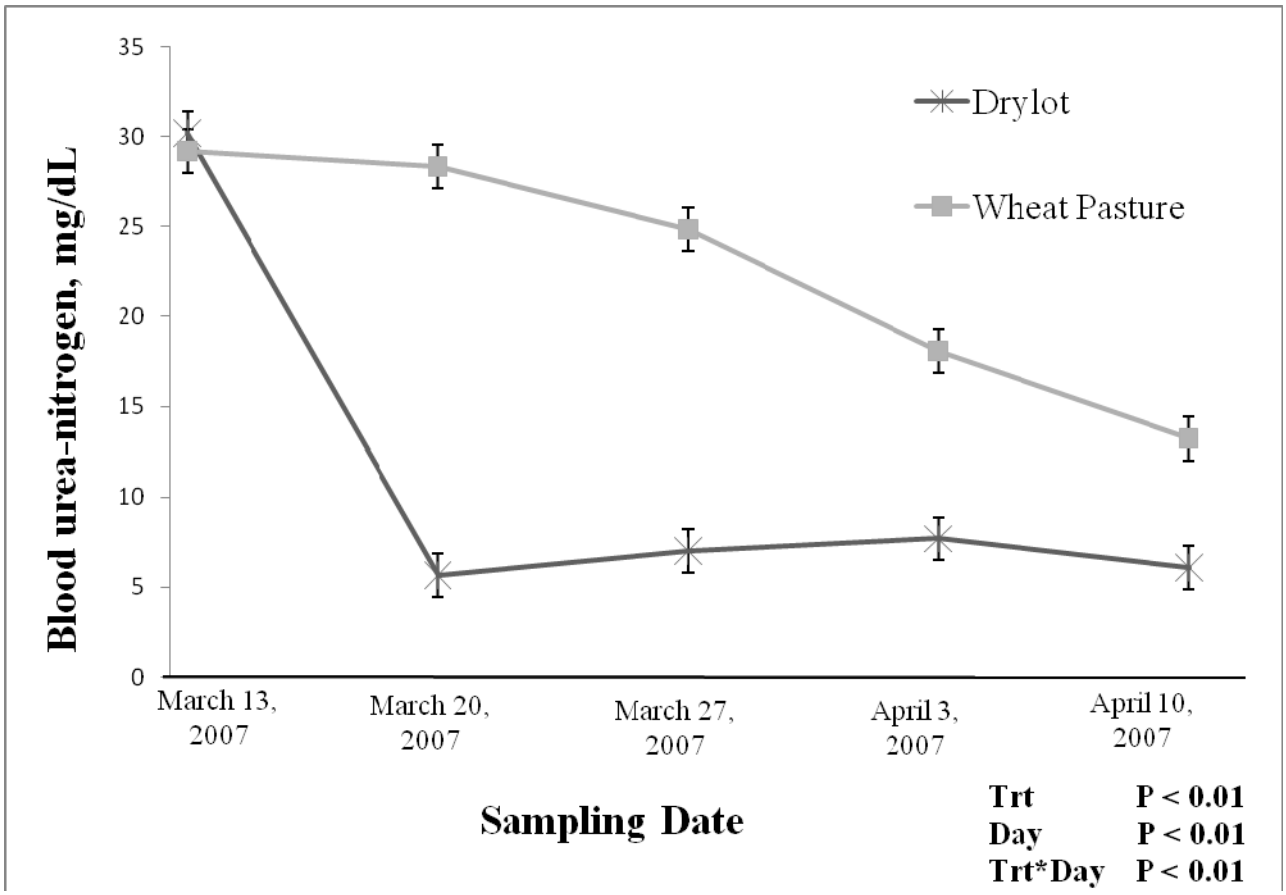
Appendix Figure 11. Luteal activity of heifers in drylot (indicated by black bar) or grazing wheat pasture (indicated by grey bar) during year one (2006-20007). Standard error = 11%.



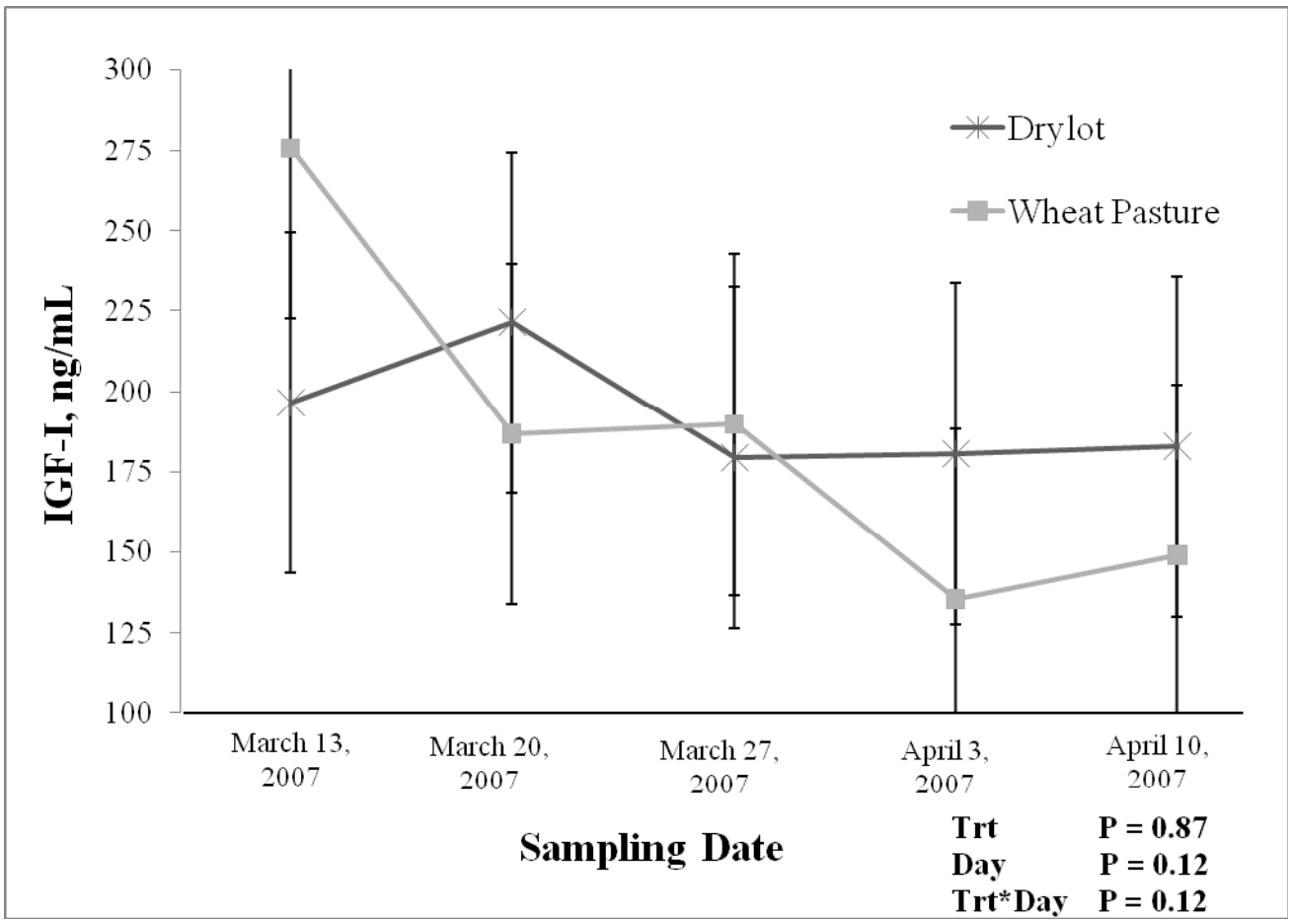
Appendix Figure 12. Percentage of heifers pregnant to fixed time AI that were either in drylot (indicated by black bar) or grazing wheat pasture (indicated by grey bar) during year one (2006-2007). Standard error = 11%.



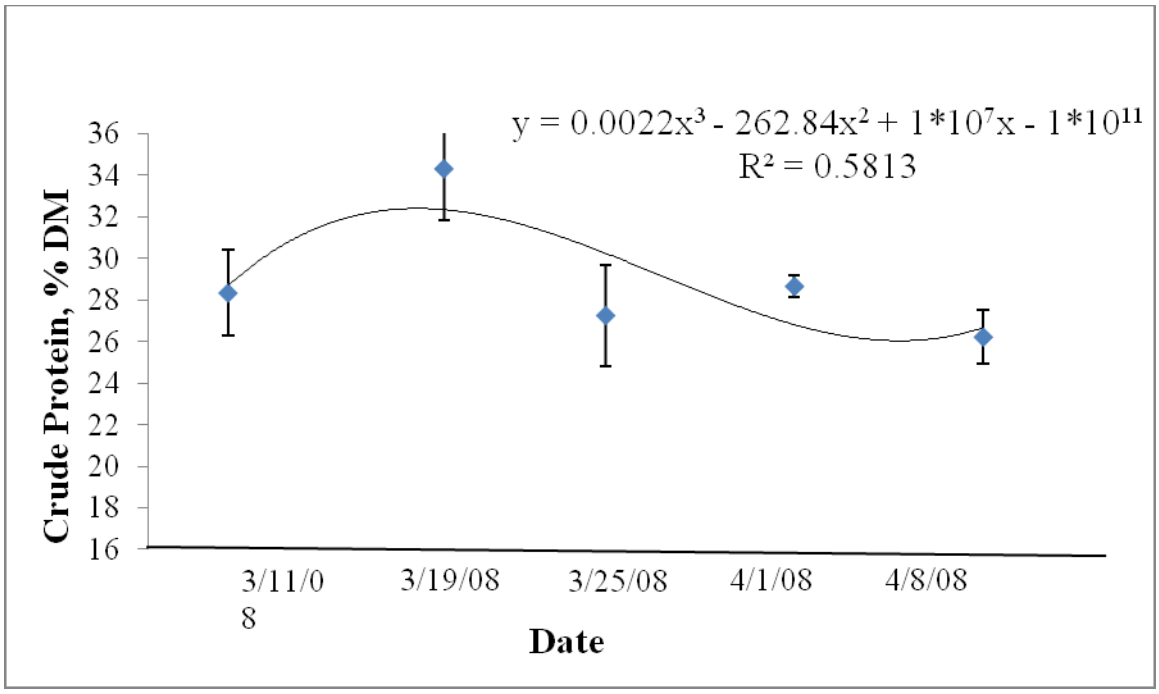
Appendix Figure 13. Final pregnancy rate of heifers in drylot (indicated by black bar) or grazing wheat pasture (indicated by grey bar) during year one (2006-2007). Standard error = 4%.



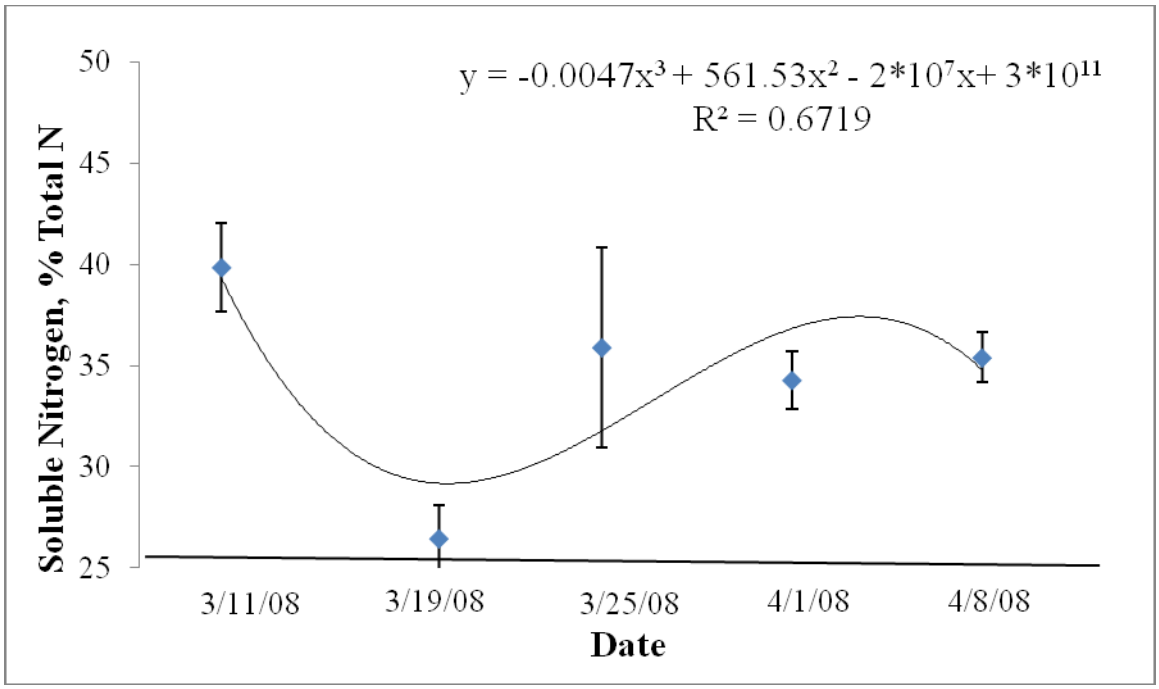
Appendix Figure 14. Blood urea-nitrogen concentrations of heifers in drylot (indicated by black line) or grazing wheat pasture (indicated by grey line) during year one (2006-2007).



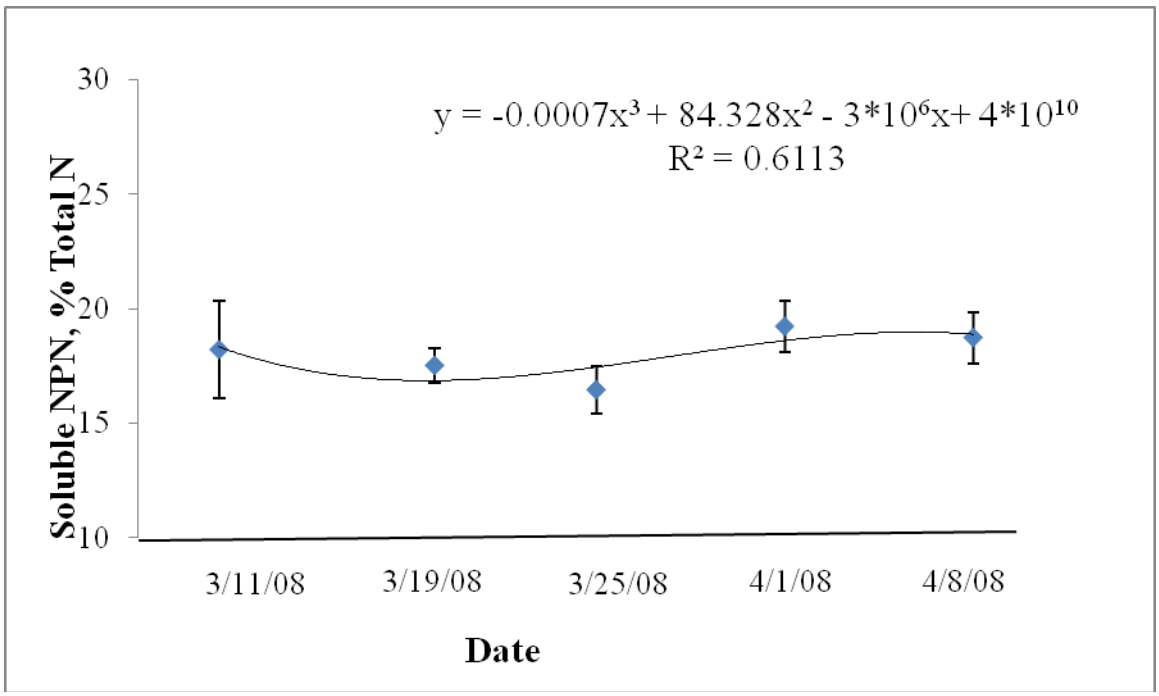
Appendix Figure 15. IGF-I concentrations of heifers in drylot (indicated by black line) or grazing wheat pasture (indicated by grey line) during year one (2006-2007).



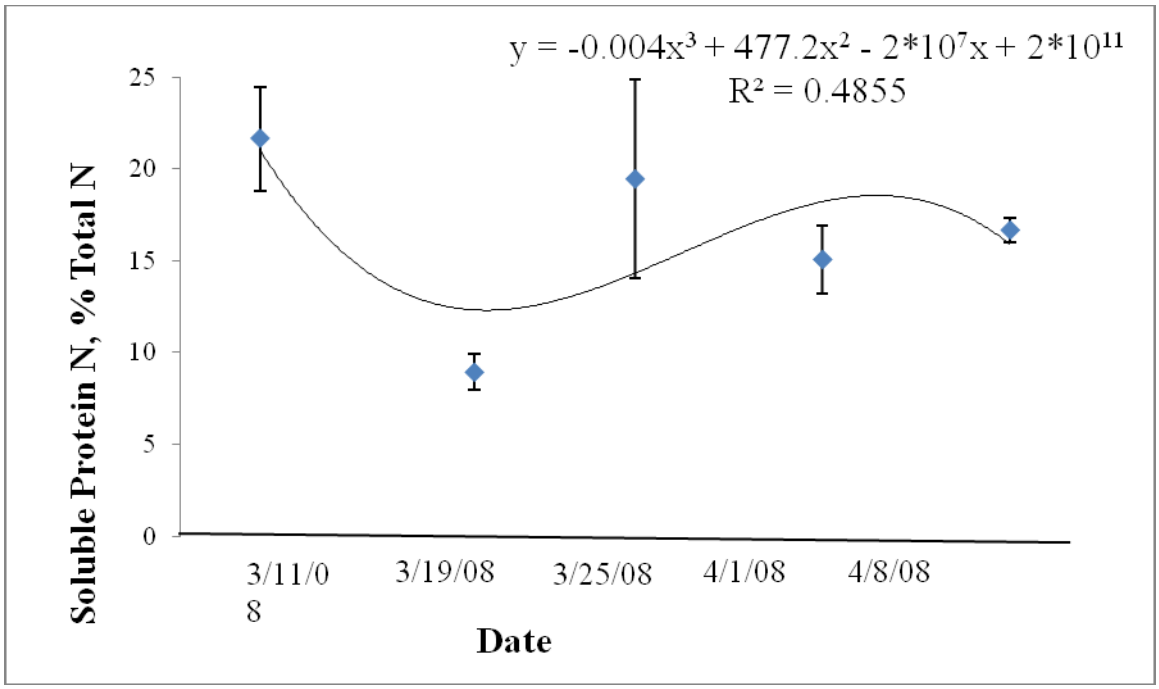
Appendix Figure 16. Crude protein of forage samples collected from wheat pasture during year two (2007-2008).



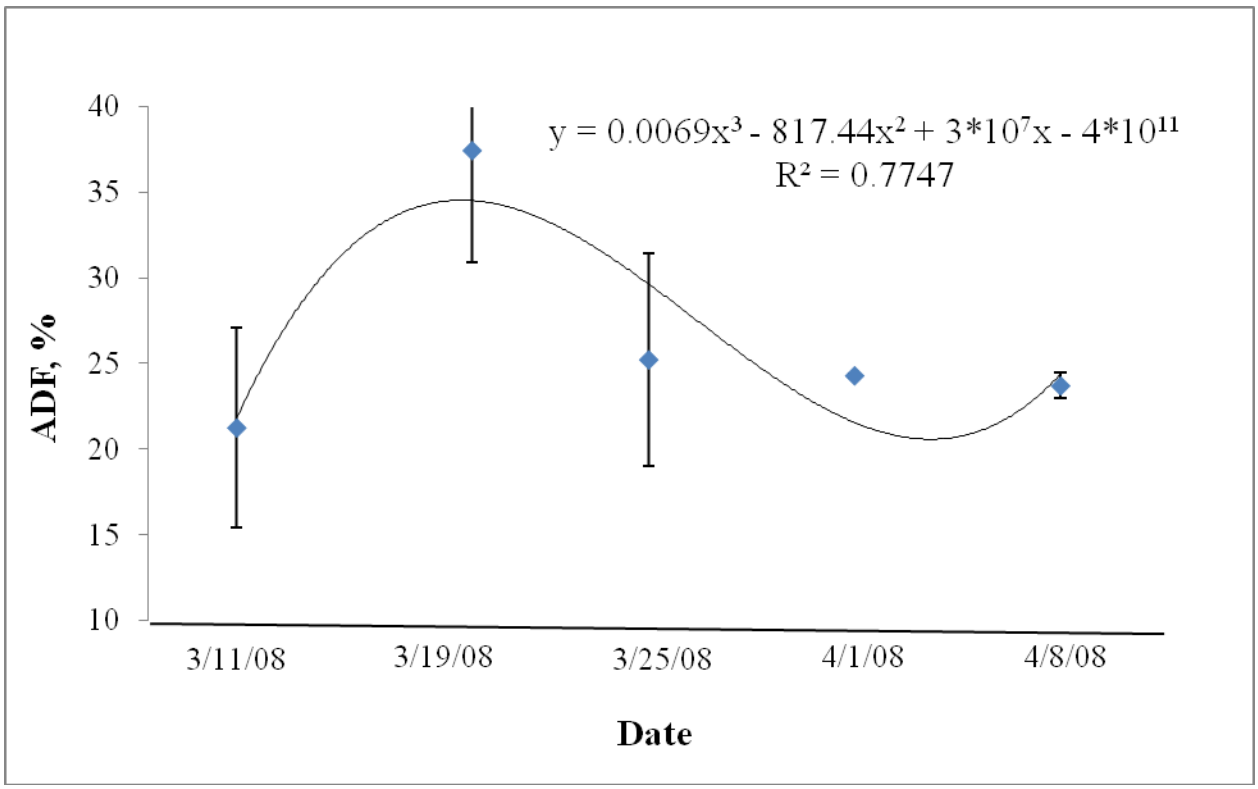
Appendix Figure 17. Soluble nitrogen fraction of forage samples collected from wheat pasture during year two (2007-2008).



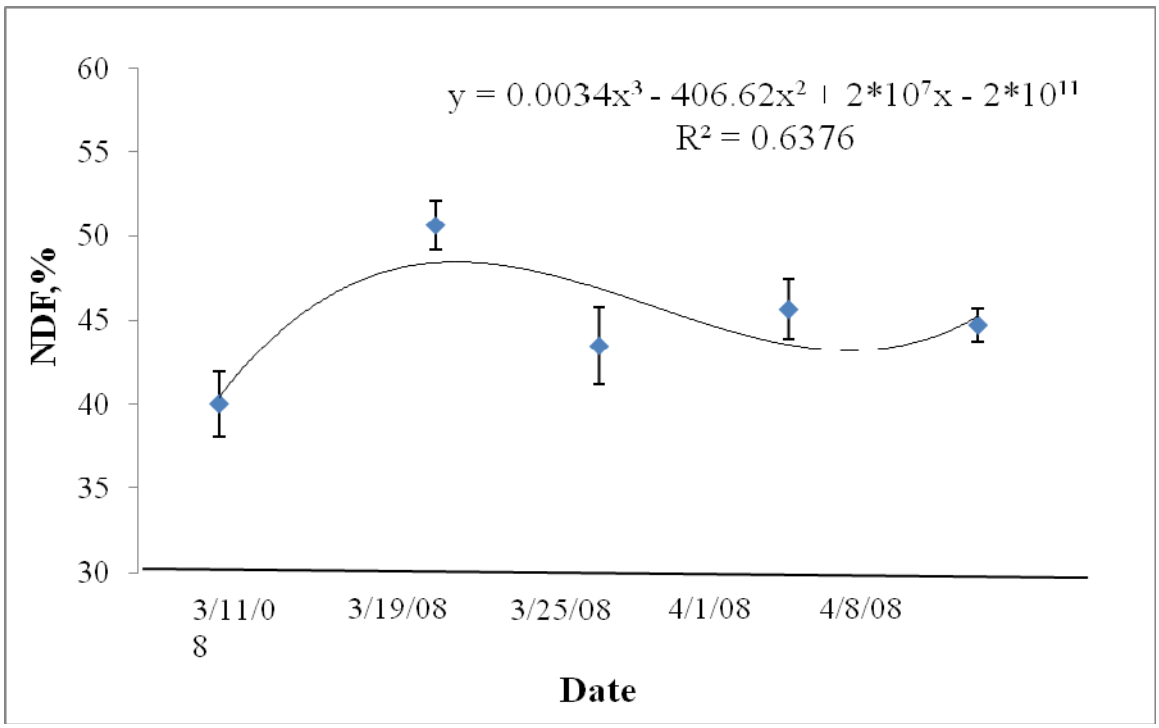
Appendix Figure 18. Soluble non-protein nitrogen fraction of forage samples collected from wheat pasture during year two (2007-2008).



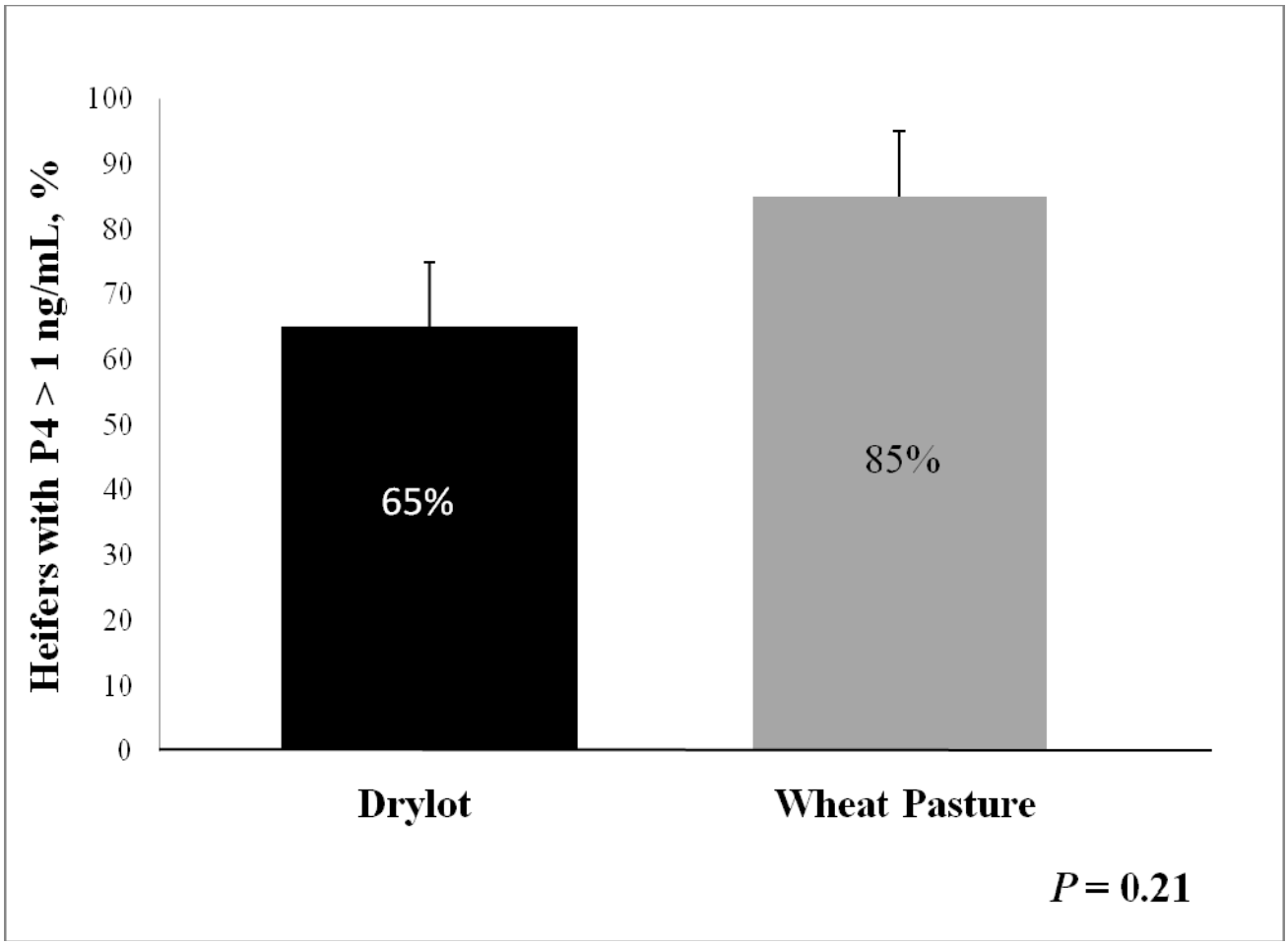
Appendix Figure 19. Soluble protein nitrogen fraction of forage samples collected from wheat pasture during year two (2007-2008).



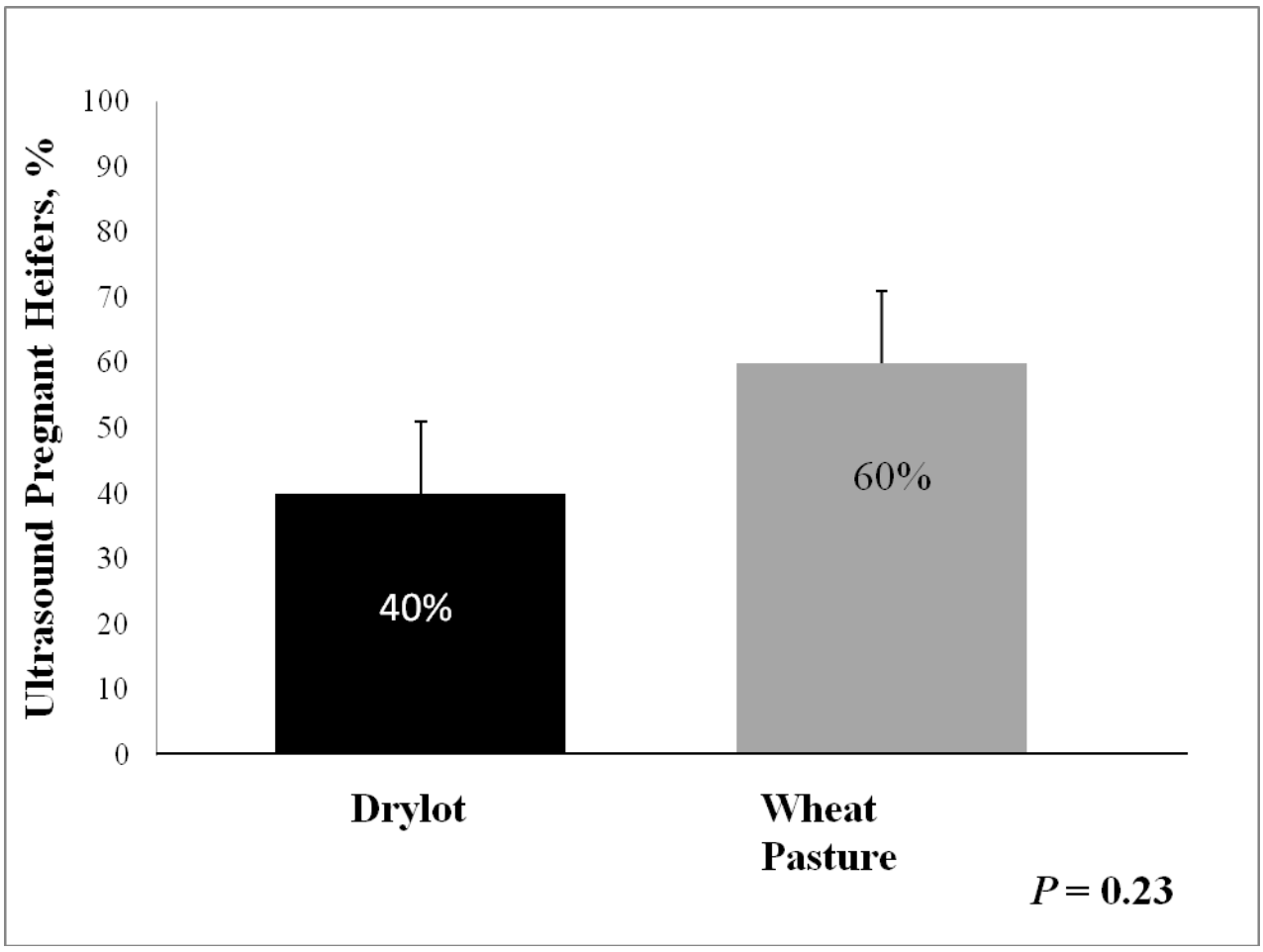
Appendix Figure 20. ADF of forage samples collected from wheat pasture during year two (2007-2008).



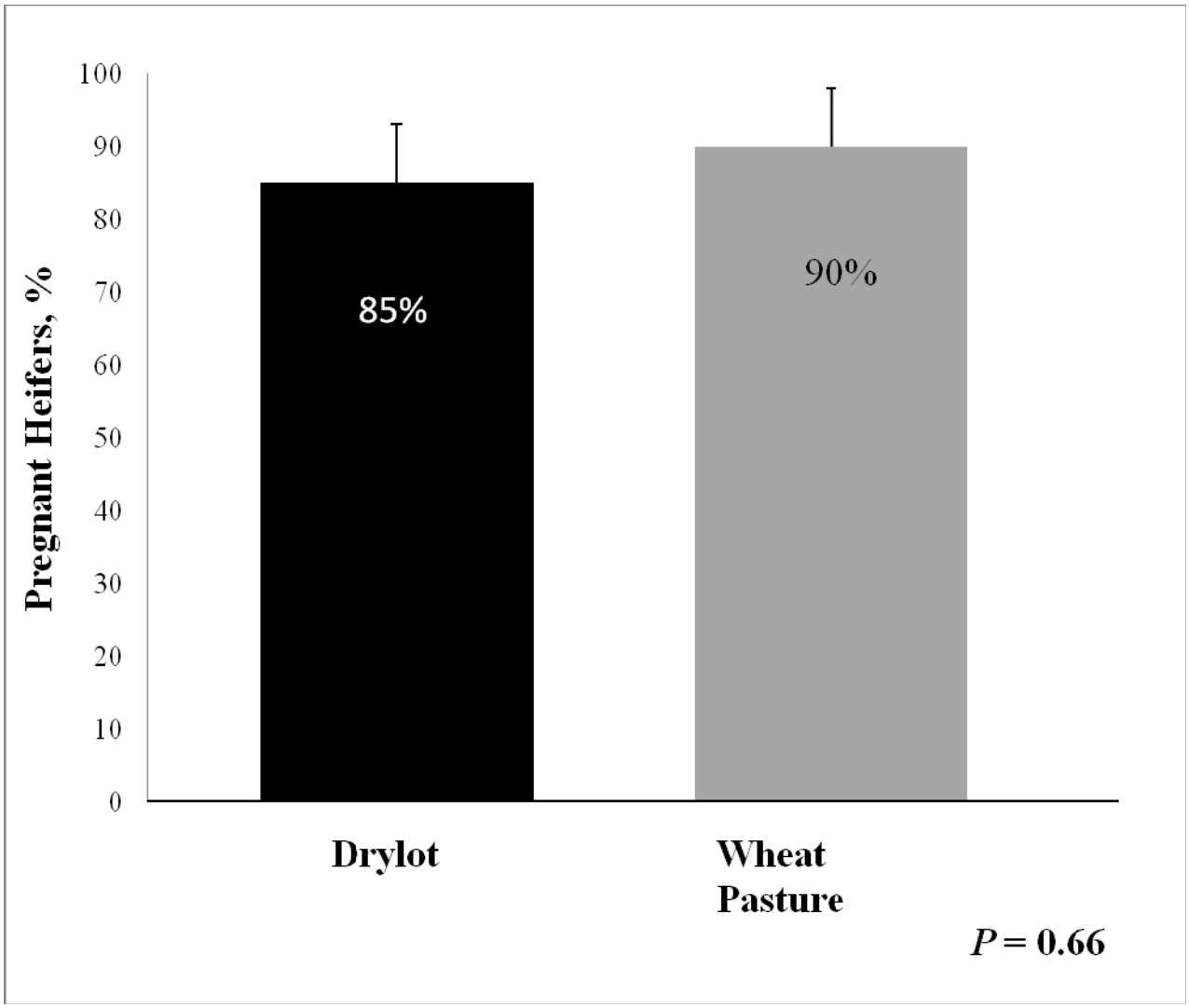
Appendix Figure 21. NDF of forage samples collected from wheat pasture during year two (2007-2008).



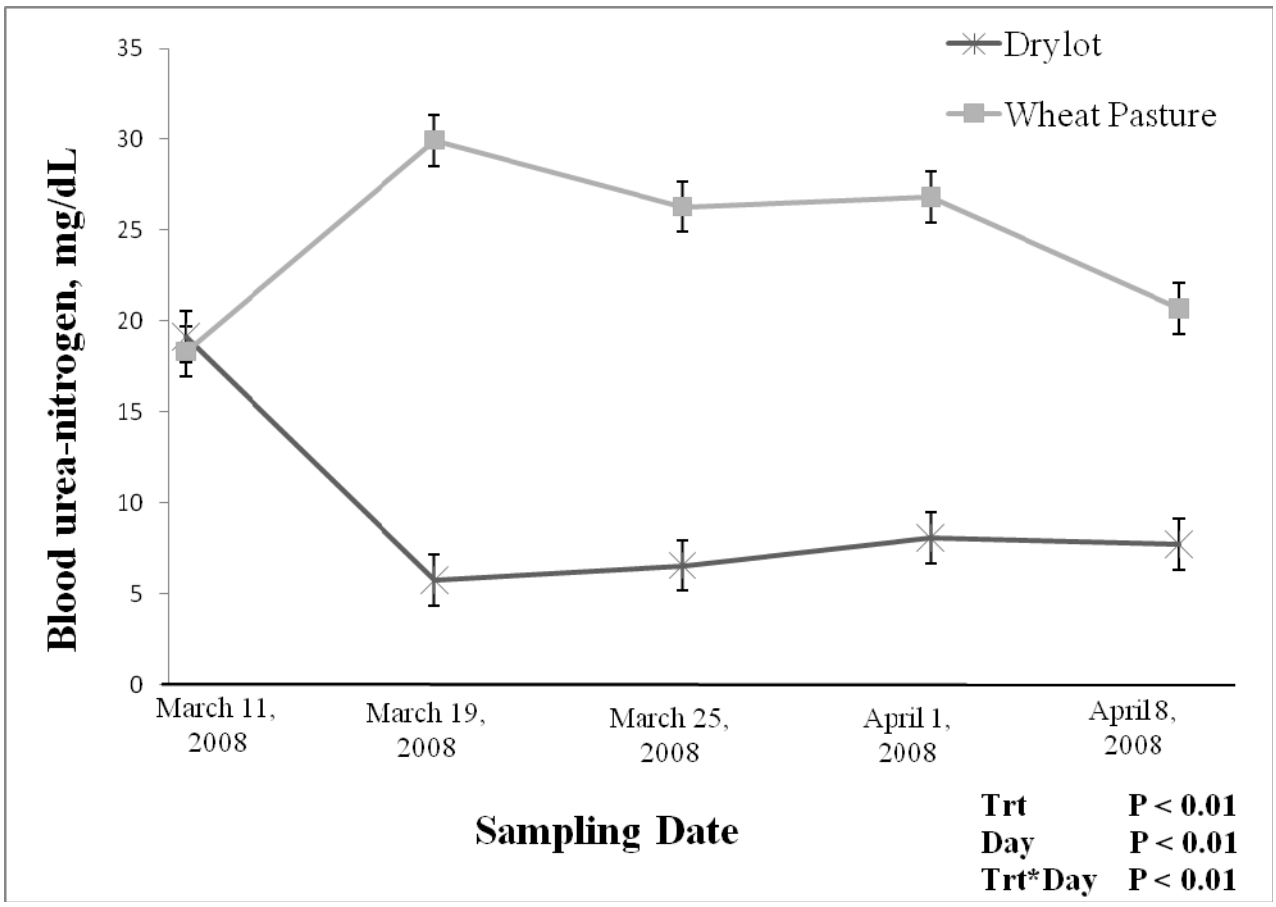
Appendix Figure 22. Luteal activity of heifers in drylot (indicated by black bar) or grazing wheat pasture (indicated by grey bar) during year two (2007-2008). Standard error = 10%.



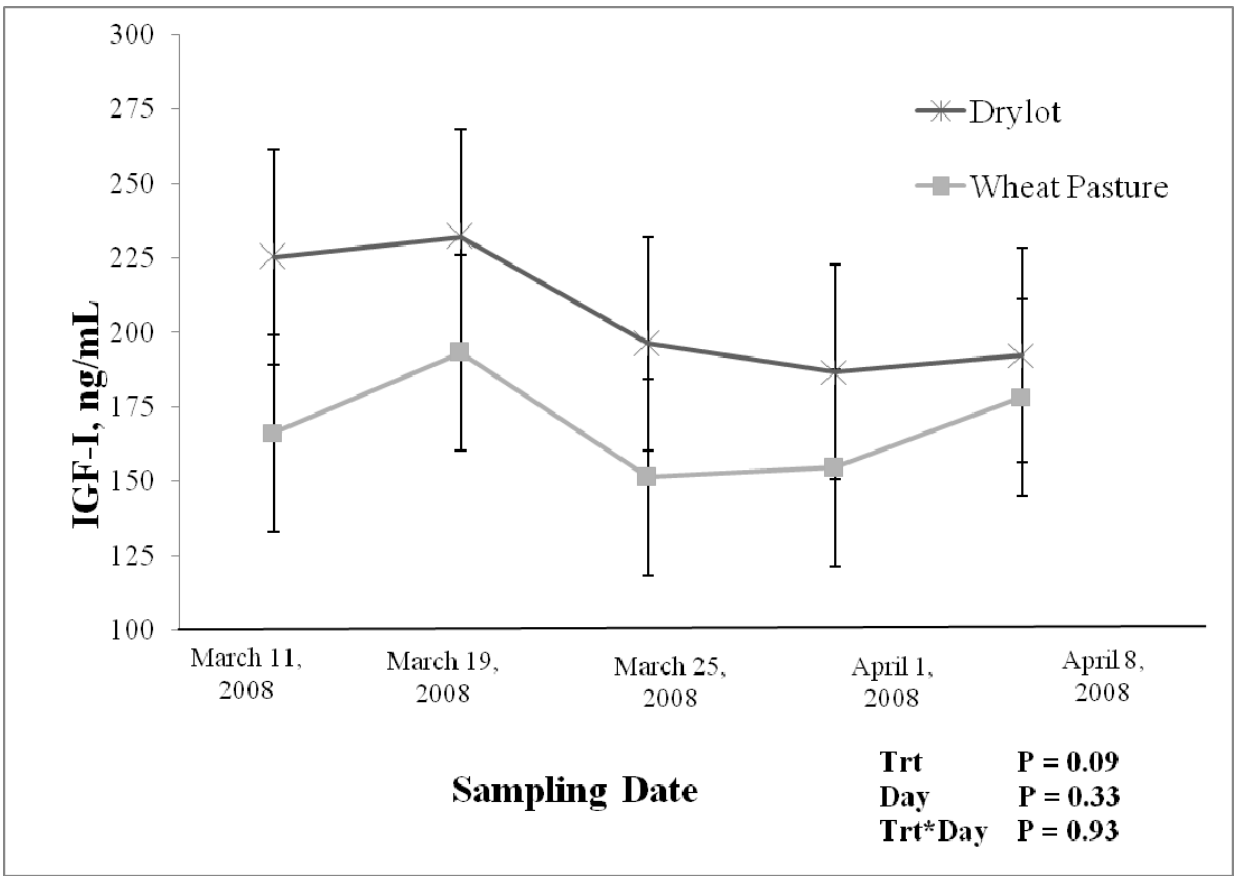
Appendix Figure 23. Percentage of heifers pregnant to fixed time AI that were either in drylot (indicated by black bar) or grazing wheat pasture (indicated by grey bar) during year two (2007-2008). Standard error = 11%.



Appendix Figure 24. Final pregnancy rate of heifers in drylot (indicated by black bar) or grazing wheat pasture (indicated by grey bar) during year two (2007-2008). Standard error = 8%.



Appendix Figure 25. Blood urea-nitrogen concentrations of heifers in drylot (indicated by black line) or grazing wheat pasture (indicated by grey line) during year two (2007-2008).



Appendix Figure 26. IGF-I concentrations of heifers in drylot (indicated by black line) or grazing wheat pasture (indicated by grey line) during year two (2007-2008).

VITA

Marsha H. Bryant

Candidate for the Degree of

Master of Science

Thesis: EFFECT OF GROWING BEEF REPLACEMENT HEIFERS ON WHEAT PASTURE BEFORE AND DURING BREEDING ON REPRODUCTIVE PEFORMANCE

Major Field: Animal science

Biographical:

Personal Data: Born in Albuquerque, New Mexico, on June 27, 1985, the daughter of Garry and Karen Bryant

Education: Graduated from Moriarty High School, Moriarty, New Mexico, in May 2003; received Bachelor of Science degree in Animal Science and Industry from New Mexico State University, Las Cruses, New Mexico, in May of 2007.Completed the requirements for the Master of Science in Animal Science at Oklahoma State University, Stillwater, Oklahoma in July, 2009.

Experience: Completed an internship at the Samuel Roberts Noble Foundation, in Ardmore, Oklahoma. Employed by Oklahoma State University Department of Animal Science as a graduate research and teaching assistant.

Professional Memberships: American Society of Animal Science

Name: Marsha H. Bryant Date of Degree: July, 2009

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: EFFECT OF GROWING BEEF REPLACEMENT HEIFERS ON WHEAT PASTURE BEFORE AND DURING BREEDING ON REPRODUCTIVE PEFORMANCE

Pages in Study: 103 Candidate for the Degree of Master of Science

Major Field: Animal Science

ABSTRACT: Unsatisfactory breeding performance has been reported when replacement heifers have been exposed to bulls or AI while grazing small grains. The objective of this study was to compare reproductive performance of heifers grazing wheat pasture before and during breeding with heifers grazing wheat pasture until approximately 3 weeks before breeding. In each of two years, 40 spring-born Angus and Angus crossbred heifers were placed on wheat pasture in December and randomly assigned to one of two treatment groups in mid March. Group one (WP; n=20) remained on wheat pasture (mean CP 26.6 %) through estrus synchronization and fixed-time AI (FAI). Group two (DL; n=20) was placed in drylot and had free choice access to a corn-based growing ration (11.1% CP) through estrous synchronization and FAI. Heifers were exposed to fertile bulls 10 d after FAI for 45 d. Conception after FAI was determined at 32 d post-AI by ultrasonography. Five weekly blood samples starting 5 wks before FAI were obtained to describe luteal activity prior to estrous synchronization and for analysis of urea-N concentrations before and during estrous synchronization and FAI. Reproductive data were analyzed using the PROC GLIMMIX procedure of SAS. Concentrations of urea in plasma or serum, and insulin like growth factor-I were analyzed with the mixed model procedure of SAS with year and sampling block as random variables. The percentage of heifers with luteal activity was 75% and 55% for WP and DL, respectively ($P = 0.08$). Drylot heifers were heavier than WP heifers (408 vs. 394 kg ± 4.49) at the time of AI ($P < 0.01$) but were similar ($P = 0.43$) when final body weight was measured on native range (417 vs. 414 kg ± 5.26). Conception rate to FAI was similar ($P = 0.38$) for WP (53%) and DL (43%) and final pregnancy rate was similar ($P = 0.34$) for WP (98%) and DL (95%). Concentrations of urea were less (5.77 mg/dL vs. 29.15 mg/dL, $P < 0.01$) for DL heifers during all weeks after treatments were imposed. Reproductive performance of heifers grazing wheat pasture during estrous synchronization and FAI was similar to heifers consuming a corn-based growing diet in drylot.

Key words: beef replacement heifers, wheat pasture, reproduction

ADVISER'S APPROVAL: Dr. Gerald Horn