EFFECTS OF EARLY AND LATE FALL CALVING OF BEEF COWS ON REPRODUCTION AND CALF GROWTH

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"I can do all things through Him who strengthens me." Philippians 4:13.

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CHAPTER I

INTRODUCTION

Most producers utilize spring calving in production systems in Oklahoma. This means calving any time between January and May. Cows have the greatest demand for nutrients between calving and breeding, and it is difficult to manage the body condition of cows during this time due to the lack of nutrients in warm season grasses. Cows need an increased amount of energy and protein during the final stages of gestation and during the initial stages of lactation, and nutrients are usually inadequate in dormant grasses at these times. Supplementation with protein and energy results in increased production costs. At the time of weaning in the fall, the value of calves is usually at the lowest point due to the number of calves being weaned and sold.

Minimal research has been conducted with fall calving production systems in the southern great plains. Producers that use fall calving systems often have a calving season which may occur any time between August and December. The Oklahoma climate is one that changes greatly between these months creating very diverse environments for calving and rebreeding. Oklahoma's climate allows warm season grasses to be present when fall calving cows need nutrients during early lactation and before rebreeding in cows calving in the fall. In addition, calf prices at weaning are usually higher in early summer than fall due to fewer calves being sold at that time.

Artificial Insemination (AI) is a tool that increases the genetic pool and allows producers to make more rapid genetic progress, decrease labor, increase uniformity, and increase profitability. In 1997, only 13.3 % of all beef producers used AI (NAHMS). Timed AI (TAI) does not require estrous detection. Provided that the body condition of cows is sufficient, 50% pregnancy rate to TAI is very attainable. Fall calving in Oklahoma is an optimum time to use TAI since more cows have adequate body condition and more likely to be cycling, compared with spring calving cows. The purpose of this study was to determine whether early fall or late fall calving is best suited for Oklahoma. In addition, timed AI was evaluated with fall calving.

CHAPTER II

REVIEW OF LITERATURE

Introduction

There are almost a 100 million beef cattle in the U.S., with a value of over 200 billion dollars in sales. Of these cattle, 5.4 million are located in Oklahoma (USDA, 2003). Oklahoma ranks second in the nation in the total number of beef animals. The importance of efficiently producing quality beef cannot be overemphasized.

Feed is the most costly input in beef production. In 2004, the break even cost was 95 cents per pound of weaned calf. Of this cost, 51 cents was for feed (Selk, 2000). One way to decrease feed cost is to graze higher quality forages longer during the time when animal requirements are greatest (Adams et al., 2000; Selk, 2000). A plan must be designed so that cows are utilizing the most nutrient rich forage when nutrient requirements are the greatest, such as at 60 d after calving (Adams et al., 2000). Cows must also calve in good body condition to minimize postpartum anestrous periods and allow for a 12 mo calving interval (Rakestraw et al., 1986; Selk et al., 1988; Lalman et al., 1997).

Artificial Insemination allows producers to take advantage of a larger gene pool than with natural service, and allows greater genetic progress in a shorter amount of time. Nevertheless, only 13.3 % of beef producers use AI technology

(NAHMS, 1997). Fifty-eight percent of producers do not use AI because of increased time and labor or AI is believed to be too complicated (NAHMS, 1997). In addition, detecting estrus and determining the optimal time for insemination adds to the frustration. One must use subjective clues to make the objective decision as to when to inseminate.

The Oklahoma climate is temperate with mild winters allowing for both cool and warm season grasses. The duration of the postpartum anestrous interval and pregnancy rate are directly effected by the body condition score (BCS) of cows at the time of calving. Fall calving cows tend to calve in better condition than spring calving cows and their calves tend to have a greater value at weaning. Since fall calving cows tend to have good BCS at calving, the use of TAI would be well suited for fall breeding programs.

Nutritional Regulation of Reproduction

Nutrition plays an important role in reproduction. Animals must have adequate body condition to become estrus. Most beef producers in Oklahoma utilize warm season grasses as the major forage source. Calving must be timed with high forage quality and availability. When forage is limiting, adequate supplementation must be offered.

Body Condition Score and Postpartum Reproduction

Amount of body energy reserves at parturition is directly related to reproductive performance of beef cows. When energy intake is inadequate during gestation, cows lose body weight and body fat reserves, and pregnancy rates are decreased (Wiltbank et al. 1962; Richards et al. 1986). Body energy reserves can be estimated by body condition score (BCS 1 = emaciated, 9 = obese; Wagner et al. 1988), and carcass fat is highly correlated with BCS (Wagner et al. 1988; Houghton et al. 1990; Yelich et al. 1995). Reproductive performance is optimal if mature cows calve with a BCS ≥ 5 and maintain weight after calving (Richards et al., 1986; Selk et al., 1988; Morrison et al., 1999). If cows calve with a greater BCS (6 or 7), optimal reproductive performance can occur although cows lose body energy reserves from calving to rebreeding (Rakestraw et al., 1986).

Cow-calf management in central Oklahoma

In addition to market trends and weather, forage quantity and quality are major factors determining the optimal time for cows to calve (Sprott, 2001). The climate in central Oklahoma is suited for both cool and warm season grasses which are optimal for grazing cow herds. Pregnancy rates of cows and growth was satisfactory, in Louisiana, when cows calved during elevated ambient temperatures with high humidity from July – September (Bagley et al, 1987). Cows and calves grazed coastal bermudagrass in the summer and ample cool season forages prior to 205 d of age.

A study was conducted in central Oklahoma to evaluate spring calving cows that grazed native range pastures and were fed either a protein or energy supplement during gestation (Marston et al., 1995). The energy treatment consisted of feeding 2.44 kg/d of a 20% CP supplement starting in November and continuing through calving the following spring. The protein treatment consisted of 1.22 kg/d of 40% CP supplement. The energy supplemented cows gained more weight throughout gestation compared with the protein fed animals and had a greater conception rate than cows fed the protein supplement. If energy is forage was inadequate during gestation, feeding additional energy improved subsequent reproductive performance. However, feeding additional energy after calving did not enhance pregnancy rate, and resulted in greater milk production.

Stage of production influences forage intake of cows. Purvis et al. (1996) weaned calves from fall (September – October) calving cows at either 70 d or 240 d of age. Dry Matter Intake (DMI) was measured precalving, preweaning, and at 130, 190, and 240 d of lactation. Cows weaned at 240 d of lactation were fed various amounts of 41% CP supplement to maintain a BCS greater than 5. Early weaned cows did not receive any supplementation except small amounts to gather the animals. Early weaned cows had lower BW and BCS than the normal weaned throughout the entire first year except at the time of weaning. At the beginning of the second year, the early weaned cows had greater BW and BCS. The DMI was greater for the normal weaned cows at precalving, preweaning, and at 130, 190, and 240 d of lactation compared with early weaned cows. Cows consumed 1.2% of their BW in DM intake per day at the initiation of the trial. During lactation, cows consumed 1.85% of their BW daily. This coincides with Marston et al (1995), Allison (1985), and NRC (2002) in that lactating and gestating cows will consume 10 to 20% more dry matter than dry cows.

Rakestraw et al. (1986) found that if fall calving cows lost excessive body weight (BW) and BCS after calving, reproductive performance was reduced. If cows had a BCS less than 5 at the beginning of the breeding season more cows were anestrous and pregnancy rates were reduced. If cows had a BCS ≥ 5 at the start of the breeding season, and lost BCS during breeding, cows exhibited estrous but pregnancy rates were reduced. Cows losing BW must maintain a BCS of 5 during breeding in December in Oklahoma to achieve acceptable pregnancy rates.

Supplemental energy and protein for native range forages

Supplemental strategies are designed to correct deficiencies in the diets without negatively impacting other parts of the diet (Purvis, 1996). As forage quality decreases, protein content becomes the limiting factor (McCollum and Horn, 1990). By increasing the amount of protein in the diet, rumen micro-organisms increase in number thereby increasing the total digestible nutrients and protein to the small intestine (Owens et al, 1986, McCollum and Galyean, 1985). Marston (1995) found that by increasing energy intake during gestation less condition was lost before calving and pregnancy rates were increased at the following breeding season. However, the quality and availability of the supplements may impact the response (Purvis, 1996).

Factors influencing productivity of calving systems

The decision of when to breed cows affects production and financial outcomes due to seasonal changes that influence fertility and growth of calves (Sprott, 2001). Fifty-three percent of all producers do not have a defined calving season (Dargatz et al., 2004). Most of the calves are born in the months of February, March, and April, for producers in the US with a defined calving season. Producers usually base the decision of when to calve on weather conditions at the time of calving. The next most important factor is tradition. Forage availability at the time of calving was the most important factor for only 9.3% of all producers in 1996. Grass quality and quantity is largely dependent on environmental conditions and season of the year (Sprott et al., 2001). Other factors that influence the month of calving are market cycle, labor availability, weaning weights, and timing of livestock movements (Dargatz et al., 2004).

Influence of calving month on production of spring and fall calves.

There is not a universally accepted time to calve throughout the United States. The decision is largely based on forage availability which is dependent upon the latitude, longitude, and soil type (Sprott et al., 2001). Environments that receive spring and late summer rains lend themselves to fall breeding due to the increased nutrients before and during the breeding season. Richards et al. (1986) found that cows with a BCS greater than 4 at the time of breeding have a greater conception rates. Availability of nutrients between calving and breeding can influence conception rates even if cows have good BCS at the time of calving (Rakestraw et al., 1986). Year to year variation in cow performance can be attributed to forage availability (Sprott et al., 2001).

A study in New Mexico compared early summer and late summer calving, as well as supplementation during these times (Bellido et al., 1981). The early calving season was from April 15 through July 15 and the late season was from June 1 through September 1. Half of the cows in each season were supplemented starting 1 mo before calving until adequate grass was present. Season of calving did not influence gain of calves (60 d, 220 d). Supplemented cows weaned heavier calves and had shorter postpartum periods to conception. Forage availability and quality was greater for the late calving group and the early calving cows had more erratic weight changes. Sixty-three percent of the annual precipitation at the location occurred between June and September. Forage quality and quantity in this region is usually greater in mid to late summer than in the spring which is followed by elevated ambient temperature and little rain fall in summer (Sprott, 2001). Producers in the northern states tend to avoid breeding cows in the winter months to avoid cold stress while breeding.

Effects of heat stress on reproduction

Heat stressed Holstein cows have reduced conception rates, birth weights, and milk yield throughout lactation (Collier et al., 1982). The effect of providing shade on uterine blood flow was evaluated in dairy cows after administration of 200µg of estradiol. Cows that were provided with shade had 43% greater uterine blood flow compared with cows without shade (Roman-Ponce et al., 1978). Beef cows subjected to heat stress during 8-16 d after natural service had smaller corpus lutea and tended to have reduced conception rates (Biggers et al., 1987). Heat stress in the mid to last trimester of pregnancy can reduce calf vigor (Sprott, 2001). The temperature-humidity index (THI) is a better indicator of heat stress because it incorporates wind and humidity into the equation. Animals subjected to THI ranging from 79-83 are considered to be in a "danger" situation whereas animals subjected to THI over 84 are in the "emergency" range (Sprott, 2001). Danger or emergency situations at the time of ovulation or conception could decrease fertility.

Market trends for spring and fall born calves

Market value of calves can also affect the optimal month to calve. The net benefit of fall versus spring calving is variable from area to area. Higher weaning weights do not automatically equal a greater profit. Costs of supplemental feed must also be evaluated. Supply and demand accounts for most of the difference between the value of calves in spring and fall markets. The market reflects demand from backgrounders who want to buy calves to graze spring and summer grasses. Most of the variability in return on assets is related to the value of calves (Sprott et al., 2001). Bagley et al. (1987) proposed a model to compare fall versus spring calving systems. If it is assumed that the only monetary returns come from the calves, and the price of a cull cow equals the cost of a replacement heifer, fall calving yields a 7.3% greater income than spring calving. Input costs are also greater for fall calving, but fall calving systems result in greater net monetary returns than spring calving systems.

Systems of estrus and ovulation control for timed AI

A major problem with most AI production systems is the inability to get all animals bred in a short period of time. By having a shortened calving season, the producer has decreased labor costs, less variation in weaning weights of calves, and an opportunity to cull less reproductively competent animals. If estrous cycles of cows are synchronized at the beginning of the breeding season, cows have two opportunities to be bred in a 45 d breeding season and three times in a 63 day breeding season (Odde, 1990). The development of methods of synchronization which allow for fixed time insemination and adequate conception rates, should increase the use of AI (Patterson et. al., 2003). In order to successfully synchronize estrous cycles of cows, the system must control both the follicular and luteal phases of the estrous cycle.

Evolution of synchronization

There were six distinct phases in the evolution of synchronization of estrus and ovulation (Patterson et al, 2003; Johnson, 2005). The first phase was discovered by administering progesterone to lengthen the luteal phase and prevent estrus (Ulberg et al., 1951). It was also discovered that if the progesterone was given too long the conception rates were decreased (Patterson et al., 1995). Phase two was when estrogens and gonadatropins were added to the use of progestagens (Patterson et al., 2003). Prostaglandin ($PGF_{2\alpha}$) was found to be luteolytic in cattle bring about the third phase of evolution. Phase four was when progestagens were used with $PGF_{2\alpha}$ to control the luteal phase (Brown et al., 1988; Patterson et al., 1992). Up to this point the occurrence of follicular waves was not discovered in cattle. Transrectal ultrasonography allowed the evaluation of follicular waves. The fifth phase utilized gonadatropin relasing hormone (GnRH) as well as $PGF_{2\alpha}$ to control follicular waves and luteal function. This was in response to the inability of PG alone to initiate estrus in anestrous females or in a short synchronized period of time. The initial GnRH results in the development of a preovulatory follicle that ovulates in response to a second GnRH-induced LH surge 48 h after the PG injection (Ovsynch; Pursely et al., 1995). This innovation greatly increased the estrous synchronization rate for TAI in beef and dairy cattle. A drawback to the system was that some animals were estrus too soon thereby eliminating the possibilities of successful timed insemination. The latest phase in the evolution is the progestagen-GnRH- PG phase. By adding progestagens to the previous systems of synchronization, those animals that became estrus before treatment with $PGF_{2\alpha}$ would be held out of estrus until the removal of the progesterone source. In addition, the initial GnRH injection develops a preovulatory follicle that would ovulate from the LH surge created by the second GnRH injection.

Timed artificial insemination (TAI)

There is much variation in pregnancy rates with the use of TAI. A study involving 2598 suckled beef cows at 14 locations evaluated different combinations of TAI that resulted in pregnancy rates ranging from 43 to 58% (Larson et. al., 2006). Alnimer et al. (2002) attained a cumulative conception rate of over 80% with TAI. MGA was fed to 231 beef heifers for 14 d . (King et al., 1994) Prostaglandin was administered 7 d later and the heifers were TAI 72 h after the PG injection. Pregnancy rates varied greatly between trials 1, 2, and 3 at different locations (29, 37, and 61 percent respectively). Most authors attribute variation in response to TAI (percentage of anestrous cows) to body condition, heat stress, suckling stimulus, age, and days postpartum (Alnimer et al., 2002; De Rensis et al., 2003; Geary et al., 2001; Odde, 1990).

Methods to synchronize estrus and ovulation

Throughout the years there have been many systems developed to attempt to tightly synchronize follicular growth and ovulation as well as luteal regression. Before the wide use of GnRH, TAI was accomplished through the use of MGA and PG. Typically the MGA was fed for 14 d. Fourteen to nineteen days after the last feeding of MGA, PGF was given and the cattle were inseminated 48 to 72 h following treatment with PGF (reviewed by Johnson, 2005). With this system, conception rates varied from 46 to 67%. The downfalls of this system were that the animals had to eat their allotted amount of MGA every day. In addition, it required over 30 d to synchronize animals. Typically, heifers lend themselves to this type of synchronization more than cows because they can be more easily maintained in confinement pens (Odde, 1990). Similar results have been reported using the Synchro- Mate- B protocol incorporating fixed insemination (Spitzer et al., 1981).

Recently, TAI has focused on using CO-Synch and Ovsynch to synchronize cows. The GnRH-PG-GnRH protocols were developed for TAI by creating a new follicular wave emergence with the first GnRH injection. The PGF injection removes the corpus luteum to end the luteal phase 7 d after the initial GnRH injection. Forty-eight hours after PG administration, a second GnRH injection is given to induce ovulation of the dominant follicle created by the initial GnRH injection via an LH surge (reviewed by Patterson et al., 2003). The difference between Ovsynch and CO-Synch is the time of insemination. TAI is performed either 16 – 24 h after the last GnRH injection with Ovsynch and at the time of the last GnRH injection with CO-Synch. Pregnancy rates for Ovsynch have ranged from 32% in dairy cows to 54% in beef cows (reviewed by Patterson et al., 2003). Pregnancy rates using CO-Synch ranging from 37 to 50% in beef cows (Larson et al, 2006). Ovsynch and CO-Synch use GnRH and PG to synchronize follicular waves and luteal activity to allow for TAI.

Table 1. Number of cows and heifers ovulating following the second injection of 100µg of GnRH with an Ovsynch protocol[a]

Experiment	Hours after the second injection of GnRH					Not Synchronized
	24	26	28	30	32	
Cows (n=20)	0	1	12	3	4	0
Heifers (n=24)	0	8	9	1	0	6

[a]Adapted from Pursley et al. (1995).

Pursley et al., (1997) evaluated the ovarian response to the Ovsynch protocol in dairy cows and heifers. The first GnRH injection caused ovulation in 18 of the 20 cows and 13 of the 24 heifers. It successfully initiated a new follicular wave in all the cows and 18 of the heifers. All of the cows and 18 of the heifers had regressed corpus luteum after the PG injection. The final GnRH injection was given 24 h after or 48 h after the PG injection for the heifers and cows respectively. It was successful in ovulating follicles in all the cows and 18 of the heifers. Table 1 summarizes the number of cows and heifers that ovulated following the second GnRH injection. Vasconcelos et al., (1999), also found that 64% of lactating dairy cows had an induced ovulation from the LH surge induced by the initial GnRH injection. The PGF injection was 93% effective and the final GnRH injection resulted in ovulation in 87% of the cows. Six percent of the cows ovulated before the second GnRH injection and 7% did not ovulate at all. Pursley et al., (1995), varied the time of PG injection in relation to the final GnRH injection in lactating dairy cows. When the PGF injection was given at - 48, -24, or 0 h in relation to the GnRH injection, conception rates were 55, 46, and 11%, respectively. GnRH – PG - GnRH is an effective means to begin a follicular wave, regress the CL, and cause ovulation of the recruited dominant follicle, thus ideal for TAI.

One shortcoming of the Ovsynch and CO-Synch protocols is that 10-15% of cows come into estrus before the last GnRH injection (Kojima et al., 2000; Vasconcelos et al., 1999; Baitis et al., 1998). Progesterone added to the CO-Synch or Ovsynch system will prevent estrus before PG administration (Roche et al., 1999) or the second GnRH injection. Stevenson et al., (2000) determined that with the addition of a norgestomet implant in the ear, more cows were detected in estrus, including cows that were determined previously anestrus. Pregnancy rates were increased over the typical Cosynch protocol through the use of a CIDR from d 0 –7 (Lamb et al., 2001). More cows and heifers were detected in estrus during a 3 d period with the use of a CIDR-PG protocol compared with a PG only protocol (Lucy et al., 2001).

Summary

Central Oklahoma's climate is well suited for fall calving. It has cold winters and hot summers, neither well suited for breeding or calving. Calves weaned in the fall tend to bring higher market prices than spring born calves. Since fall calving cows tend to be in better condition at the time of calving and breeding than spring calving cows, fall calving systems are well suited to TAI. Little information is present on the benefits of calving either in early or late fall in central Oklahoma. The purpose of this study was to evaluate whether calving, August - September, or October - November is better suited for central Oklahoma.

CHAPTER III

EFFEECTS OF EARLY AND LATE FALL CALVING OF BEEF COWS ON REPRODUCTION AND CALF GROWTH

ABSTRACT: Effects of early and late fall calving on gestation length, pregnancy rate, and weaning weight were evaluated in Angus x Hereford cows during 4 years. Sixty fall calving cows were blocked according to age and prior calving date, and allocated for insemination in late fall (Nov. 7-8) or winter (Jan. 4-7). Control of ovulation was accomplished with the Ovsynch protocol. All cows grazed native grass pastures and were fed supplemental protein in the winter to control body condition scores (BCS, 1=emaciated and 9=obese) such that cows maintained a BCS of at least 5 during breeding, 4 or greater at the end of winter supplementation, and greater than or equal to 6 at calving. The percentage of cows with ovarian function at the start of breeding and percentage of cows pregnant were not significantly different for the early and late calving seasons. Early fall born calves were exposed to higher ambient temperatures and had shorter gestation lengths ($P < 0.05$) than late fall born calves. Early fall born calves had similar birth weights as late fall calves, however, weaning weights were greater ($P < 0.01$) for late fall born calves compared with early born calves. Similar feed requirements and reproductive performance for early and late fall calving cows, with

greater weaning weights for late calving cows, indicates that late fall calving is more profitable in central Oklahoma.

Introduction

Spring of the year is the predominant calving time in Oklahoma. Maintenance of adequate body condition is often difficult with spring calving due to the lack of quality and quantity of warm season grasses between the time of calving and breeding. When energy intake is inadequate during gestation, cows tend to lose body weight and fat reserves which results in extended intervals from calving to estrus and decreased pregnancy rates (Wiltbank et al. 1962; Richards et al. 1986). The Oklahoma climate supports growth of both warm and cool season grasses. Producers can decrease feed costs by supplying cows with higher quality forages for more months of the year and pairing nutrient levels within the forages with animal requirements (Adams et al. 2000; Selk 2000).

Little research has been done on fall calving in Oklahoma. Those producers that do use a fall calving system have very diverse calving dates ranging from August through December. The climate in Oklahoma allows pairing of nutrients in the warm season grasses with nutrient demands of fall calving cows. In addition, calf prices at the time of weaning in late spring are usually greater than spring born calves.

Greater genetic progress can be made in a shorter amount of time through the use of artificial insemination (AI). It allows for a larger gene pool to be used than with natural service. It is estimated that only 13.3% of beef producers use AI technology due to increased costs and labor as well as the need for estrous detection (NAHMS, 1997). Estrous detection requires subjective clues to be used to make an objective decision as to when to inseminate a cow. Timed AI (TAI) without estrous detection, eliminates some of these problems.

The environment in Oklahoma is well suited for fall calving. Since fall calving cows usually have greater body condition at the time of calving and breeding than spring calving cows, fall calving cows in Oklahoma are well suited for TAI. The purposes of this study were to determine whether early or late fall calving is best suited in central Oklahoma and to evaluate the utilization of TAI with fall calving beef cows managed under range conditions.

Materials and Methods

Animals

The effects of time of fall calving were evaluated during four consecutive years in central Oklahoma. Hereford x Angus cows (3 to 8 years of age) that calved in September and October of 2001 (n = 60) were blocked by calving date and assigned to breeding groups to calve early (E, August-September) or late, (L, October-November) in subsequent years. Cows were maintained in the same breeding groups throughout the experiment. Approximately 20% of the cows were culled in each of the calving groups each year, and were replaced with 3 or 4 year old cows. Body condition scores (BCS; 1=emaciated and 9=obese; Wagner et al., 1988) and body weight were determined monthly after 16 h without feed and water. Each treatment group grazed one of four 65 hectare pastures, and groups were rotated among pastures every two weeks. During the winter months, when protein content of the grasses was inadequate, a 40% crude protein supplement was fed to maintain a BCS $\geq$ 5.0 until the end of breeding and a BCS $\geq$ 4.0 was maintained until green grass was available in the spring. The desired BCS at different management times during the year are summarized in Table 1. Hay was fed only if snow or ice covered pastures. Table 2 gives the amounts of supplemental protein fed during different periods each year.

Estrous Synchronization and Breeding

Control of ovulation was accomplished via the Ovsynch protocol (Pursley et al., 1995). On d 0, 100 µg of gonadotropin releasing hormone (GnRH, Cystorelin, Merial) was administered intramuscularly (i.m.) Prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$, Lutalyse, 25 mg, Pharmacia Animal Health) was administered i.m. on d 7. On d 9 (48 h after $PGF_{2\alpha}$), a second 100 µg of GnRH (i.m.) was given and cows were AI. In years 1,3, and 4, an intravaginal progesterone-releasing insert (CIDR; Pharmacia Animal Health) was inserted on d 0 and removed on d 7. Cows were TAI to one of two bulls, in each calving group, each year. Cows were exposed to two fertile bulls 8 d after TAI for 36 d. Pregnancy was determined 4 mo after AI by rectal palpation.

Progesterone in Plasma

Concentrations of progesterone in plasma were quantified in samples collected on d -7, 0 (initiation of estrous synchronization by GnRH injection and CIDR insertion), 7, 9, and 16. Blood was collected via tail venipuncture into 15 mL blood collection tubes containing EDTA as an anticoagulant. Following collection, samples were cooled and centrifuged within 4 h at 2500 x gravity for 15 min. Plasma was aspirated and stored at -20° C until quantification of progesterone (Coat-A-Count Progesterone Kit, Diagnostic Products Corp., Los Angeles, CA; Vizcarra et al., 1997). Concentrations of progesterone ≥ 0.5 ng/ml in any of the plasma samples collected on d -7, 0, 9, and 16 indicated that a cow had luteal activity and had initiated estrous cycles after calving.

Sire Determination

Concentrations of progesterone in plasma and gestation length were used to determine if a calf was produced by AI or natural service. If a calf was born 291 d or less after (AI), and the cow had a normal progesterone profile (progesterone concentrations ≥ 0.5 ng/mL on d 7, ≤ 0.5 ng/mL on d 9 and ≥ 0.5 on d 16), the calf was designated as sired by an AI bull. All other calves were designated as sired by natural service. Calves were weaned at approximately 9 mo of age in May (early group) or in July (late group). The calves were weighed the day of weaning (penned with cows cows for 17 h without feed and water) and 36 h after weaning (access to feed and water). Then a shrunk weaning weight was taken after access to feed and water was restricted for 12 h. The shrunk weight was used in analyses.

Statistical Analysis

The effects of season of calving on total pregnancy was evaluated using GEN MOD procedure (SAS Institute Inc., Cary, NC). Season (early and late), year (1, 2, 3, or 4), and season x year were included in model. Season was fixed and year was random. Birth weight, weaning weight, and gestation length of AI sired calves was analyzed with

PROC MIXED of SAS with season, year, calf sex, and the interactions in the model. Season and calf sex were fixed and year was random. Factors influencing postpartum interval at AI, BCS and BW, by month, were analyzed using PROC MIXED with season, year, (month when appropriate), and season x year in the model. Season was fixed and year was random. If the interactions were significant, PDIFF of SAS was used to compare means.

Results

Cows weighed 550 ± 7 kg with an average BCS of 5.3 ± 0.1 at the time of breeding in the initial year (AI to create early and late calves; Figure 1). At the time of calving, E and L cows had similar BCS (5.7 ± 0.7 vs. 5.5 ±0.7). Early cows had a BCS of 5.2 ± 0.3 and the late cows had a BCS of 5.6 ± 0.3 at weaning. In years 1 and 2, cows had similar BCS and BW at AI, calving, and weaning without significant effects of season or year (Figures 1 and 2). BCS ranged from 5 to 6 in all years except weaning year 3 and calving year 4 (Figure 3).

Total supplemental protein fed each year was similar for the E and L cows (Table 2). Feeding of supplemental protein began in October and was continued until early April.

Birth weights of calves resulting from AI were not influenced by season of calving or year (Table 3; $P > 0.1$). Calving season influenced gestation length of AI calves (Figure 2). Early calves had a 3 d shorter gestation than L calves (278 ± 0.8 vs. 281 ± 1.0; $P < 0.05$). The maximum daily ambient temperature during the week prior to calving was greater ($P < 0.01$) for E than for L calving cows (Table 5). Ambient temperatures in the E seasons ranged from 28.3 to 37.3 C, year 2 was the coolest and year 4 was the hottest. Average ambient temperature during the L calving season ranged from 16.1 in year 1 to 23.3 C. The shortened gestation length of the E cows compared with L cows, was associated with increased ambient temperatures the week before calving.

Season of calving affected ($P < 0.01$) weaning weight. Calves for E cows weighed 228.7 ± 3.7 kg at weaning whereas the L calves weighed 282.1 ± 4.0 kg at weaning. In central Oklahoma, green grass was present in the pastures in early April. The E calves were weaned about this time and had only a short time to benefit from the new grass. The L calves were still nursing and were able to utilize the nutrient rich forages as well as milk from the cow.

Days postpartum at AI was not significantly influenced by season of calving after the initial year (Table 4). The initial L cows had a longer postpartum interval at AI than any other year ($P < 0.01$). This was because the calves were all born in one season that year and were inseminated at different times to create two calving seasons. For the same reason, the E cows in the initial year had a shorter postpartum interval at AI than during the other years. Ninety-seven or 100% of the cows on both treatments had initiated estrous cycles at AI during all years. Percentages of cows pregnant to TAI were not influenced by calving season, however, year influenced pregnancy rate ($P < 0.01$) to TAI. The year effect was associated with reduced TAI pregnancy rates in year 2 compared with the other years. Total pregnancy was similar for the first 4 years and reduced ($P < 0.05$) in year 4.

Discussion

Assessment of BCS is an effective method to determine the amount of supplemental protein necessary to achieve adequate reproductive performance of grazing beef cows (Selk et al., 1988). Rakestraw et al. (1986) determined that fall calving cows in Oklahoma should maintain a BCS ≥ 5 through the breeding season for optimal reproductive performance. The supplemental protein fed to E and L cows achieved the desired BCS during rebreeding (Table 1 and Figure 1). Following AI, BCS of the fall calving cows was allowed to decrease through the time of weaning. Following weaning, cows gained an average of one BCS before calving. This was due to ample quantity and quality native range forage during the summer. Cows calved with an average BCS ≥ 5 in all 5 years. This was critical for the productiveness because reproductive performance is optimal if cows calve with a BCS ≥ 5 and maintain weight after calving (Richards et al., 1986; Selk et al., 1988; Morrison et al., 1999). Following calving, cows maintained or lost a slight amount of body condition. At the times of AI, at calving, and at weaning, cows maintained a BCS ≥ 5, except at weaning in year 2.

Since cows maintained a BCS ≥ 5, the amount of energy in the grass was sufficient. When forage quality decreases the limiting nutrient becomes protein (McCollum and Horn, 1990). However, energy may be limiting in some situations. Marston et al. (1995) found that cows supplemented with 20 % crude protein gained more body weight and BCS during gestation than cows given a 40 % crude protein supplement containing half the amount of energy. In the current experiment, cows were able to meet their dietary requirements in the winter months with the dormant grasses and 40 % crude protein supplementation (Table 2). In most years, the supplemental protein was fed earlier in the season to the E cows than the L cows. Early calving, lactating cows were deficient in protein earlier in the fall compared with L cows. The supplement fed to the E cows was reduced after breeding in December and after breeding of L cows in February. All protein supplementation ceased when quality grass was available, about April 1st. The average amount of supplemental protein fed to E cows was not different from the L cows (206.1 ± 15.2 kg/hd/yr vs. 193.3 ± 21.3 kg/hd/yr, respectively ($P > 0.1$).

Days postpartum at TAI were not significantly different between treatments in years 1,2,3, and 4 (Table 4; $P>0.1$). The postpartum period to TAI in the initial year was longer for the L cows than the E cows (115.9 and 59.6 for E and L treatments respectively) because the cows calved in one 60 d season, and cows were AI to result in early or late calving seasons the next year. In all 5 years, the percentage of cows that had initiated normal luteal activity at TAI was greater than 97 % for both treatments. The total pregnancy rates for both season for years 2, 3, and 4 were adequate and similar to those reported for the cows who maintained good condition through breeding (Rakestraw et al., 1986). The loss in BCS of E and L cows after breeding did not influence pregnancy rates.

Pregnancy rate to TAI was not affected by season of calving ($P > 0.1$) and was similar to rates observed by Patterson et al. (2003) and Larson et al. (2006). In year 2, TAI pregnancy rate was 21% compared with an average of 38% for the other 4 years. The reduced pregnancy rate to TAI in year 2 was not related to a decreased number of cows cycling and the total number of cows pregnant was not different from other years. Semen quality may have influenced pregnancy to TAI in year 2. There was a tendency for some cows to become pregnant later and later throughout the years, and this resulted in a tendency for decreased postpartum interval from calving to AI. A decrease in pregnancy rates could occur if cows were estrus before the 2nd dose of GnRH was administered (Kojima et al., 2000; Vasconcelos et al., 1999; Baitis et al., 1998). It cannot be determined if this was the case since onset of estrus was not determined in this experiment. In years 1, 3, and 4 cows were synchronized with the use of a CIDR, which may initiate estrus in anestrous cows at the time of insemination (Stevenson et al., 2000). Total pregnancy rates were similar to AI pregnancy rates in year 4 (36.6, 34.2, and 36.6, 38.5; E, and L percent AI, E and L total pregnant, respectively). One of two bulls used for pasture mating in year 4 was infertile and only one cow was pregnant to natural service.

Ambient temperature at the time of calving was significantly greater for the E compared with the L treatment and gestation length was shorter for E cows without an effect on birth weight. Maximum daily ambient temperature one wk prior to calving averaged 10 C greater for the E than the L calving cows (Table 5). Cows on both treatments were exposed to heat stress during the last third of gestation. A total of four calves died after premature birth and extreme heat in late gestation. Calves exposed to elevated ambient temperatures at birth have decreased performance and calf vigor (Sprott, 2001). None of the calves died at the time of birth in the late calving season. Gestation length was significantly shorter in the E calving season compared with the L calving season. Cows exposed to elevated ambient temperatures have decreased uterine blood flow (Roman-Ponce et al., 1978). The shortened gestation could be due to decreased blood supply to the fetus due to heat stress.

Weaning weights were affected by season of calving. Calves were weaned at approximately 9 mo of age in both seasons. Calves born in August and early September, and weaned in May were lighter than calves born in October and November and weaned in July. In central Oklahoma, warm season grasses are usually of excellent quality and are usually in ample supply starting in May and June. Thus the L calves grazed high quality forages during May, June and half of July, allowing for greater daily gain and weaning weights. The E season calves were not exposed to the same quantity and quality of forage as L calves, for the 2.5 mo before weaning. Sprott et al. (2001) observed the return on assets were closely related to the value of calves at weaning. The L fall calving cows achieved greater weaning weights and required the same amount of supplemental protein as the E fall calving cows.

Implications

Cows grazing native range forages in central Oklahoma require protein supplementation during the winter months to maintain a BCS ≥ 5 at the time of calving and breeding to achieve profitable pregnancy rates. Cows calving in September-October require the same amount of supplemental protein in the winter months as cows calving in November-December. TAI, using the Ovsynch protocol, is not an economical practice for fall calving cows in a range setting in central Oklahoma. Increased ambient temperature at the time of calving may have increased death loss at calving, and shortened gestation length of the calves without affecting birth weights. Weaning weights were greater for the L fall calving cows than the E fall calving cows. With similar protein supplementation requirements, decreased calf loss, and greater weaning weights, fall calving in November-December is more profitable than calving in August-September in central Oklahoma.

Table 1. Preferred Body condition score for early and late fall calving cows at various times of the year.

	Early		Late	
	Date	BCS	Date	BCS
Start of calving	August 3	6	October 3	6
Start of breeding	November 7	5	January 9	5
End of breeding	December 20	5	February 21	5
End of winter feeding	April 1	4	April 1	4
Weaning	May 1	4	July 1	5

Table 2. Feeding Schedule for early and late fall calving cows to achieve preferred body condition scores (kg/day).

Date	Early	Late
Initial Year		
10/19/01 to 12/19/01	1.4	1.4
12/20/01 to 2/13/02	1.4	1.8
2/14/02 to 4/15/02	1.4	1.4
Year 1		
11/1/02 to 11/30/02	1.8	1.4
12/1/02 to 12/31/02	1.8	1.8
1/1/03 to 2/14/03	1.4	1.8
2/15/03 to 3/31/03	0.9	0.9
Year 2		
10/17/03 to 11/14/03	0.9	0
11/15/03 to 1/14/04	1.8	1.4
1/15/04 to 2/19/04	1.4	1.8
2/20/04 to 4/2/04	0.9	0.9
Year 3		
10/20/04 to 12/2/04	0.9	0
12/3/04 to 1/6/05	1.8	1.4
1/7/05 to 2/14/05	1.8	1.8
2/15/05 to4/1/05	0.9	0.9
Year 4		
11/1/05 to 12/1/05	0.9	0
12/2/05 to 1/1/06	1.8	1.4
1/2/06 to 2/1/06	1.4	1.8
2/2/06 to 3/1/06	0.4	0.9
3/2/06 to 4/4/06	0.4	0.9
Total kg Fed (per year)	**206.1 ± 15.2**	**193.3 ± 21.3**

Table3. Birth weights and weaning weights of calves for early and late fall calving cows (kg).

	Season	
Characteristics	Early	Late
Birth Weight	37.2 ± 0.8	37.0 ± 0.7
Weaning Weight	228.7 ± 3.7 [a]	282.1 ± 4.0 [b]

[a,b] Least square means in a row with different superscripts differ (P<0.01).

Table 4. Month of calving and year effects on days postpartum at AI, percentage cycling, percentage pregnant to TAI, and total pregnancy rate.[c]

	Year					
Season	Initial	1	2	3	4	MSE
Days PP at AI [a]						
Early	59.6 (25)[b]	76.3 (30)	78.5 (32)	71.3 (23)	72.1 (28)	159.6
Late	115.9 (26)[b]	79.6 (25)	68.7 (25)	67.2 (23)	67.8 (31)	
% Cycling						
Early	96	97	97 (31)	100	100	--
Late	100	96	100 (25)	100	100	
% AI [a]						
Early	40.0	46.7	22.0 (7)	35.0	36.0	21.1
Late	50.0	36.0	20.0 (5)	22.0	34.0	
% Total						
Early	92.0	86.7	75.0 (24)	87.0	39.0	10.9
Late	80.8	96.0	92.0 (23)	91.0	39.0	

[a] Season not significant P> 0.1). Year significantly different (P<0.01).
[b] Cows in prior year were bred through natural service over a 4 mo period.
[c] Number of cows in parentheses.

Table 5. Average maximum ambient temperature during the wk prior to calving for early and late fall calving cows.

	Year					
Season	1	2	3	4	5	MSE
Temperature, C° [a]						
Early	33.4	32.0	28.3	31.8	37.3	10.7
Late	16.1	19.8	19.7	23.3	21.9	

[a] Season significantly different (P<0.01)

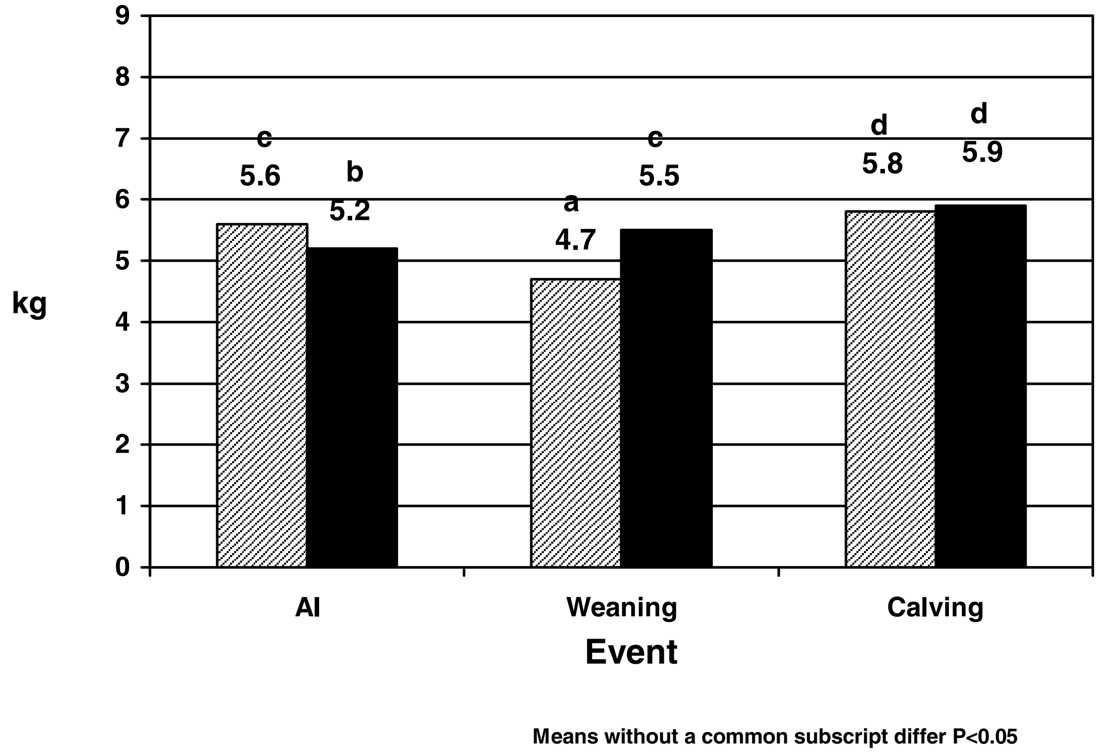

Figure 1. Body Condition Score of fall calving at AI, calving, and weaning years 1 and 2.

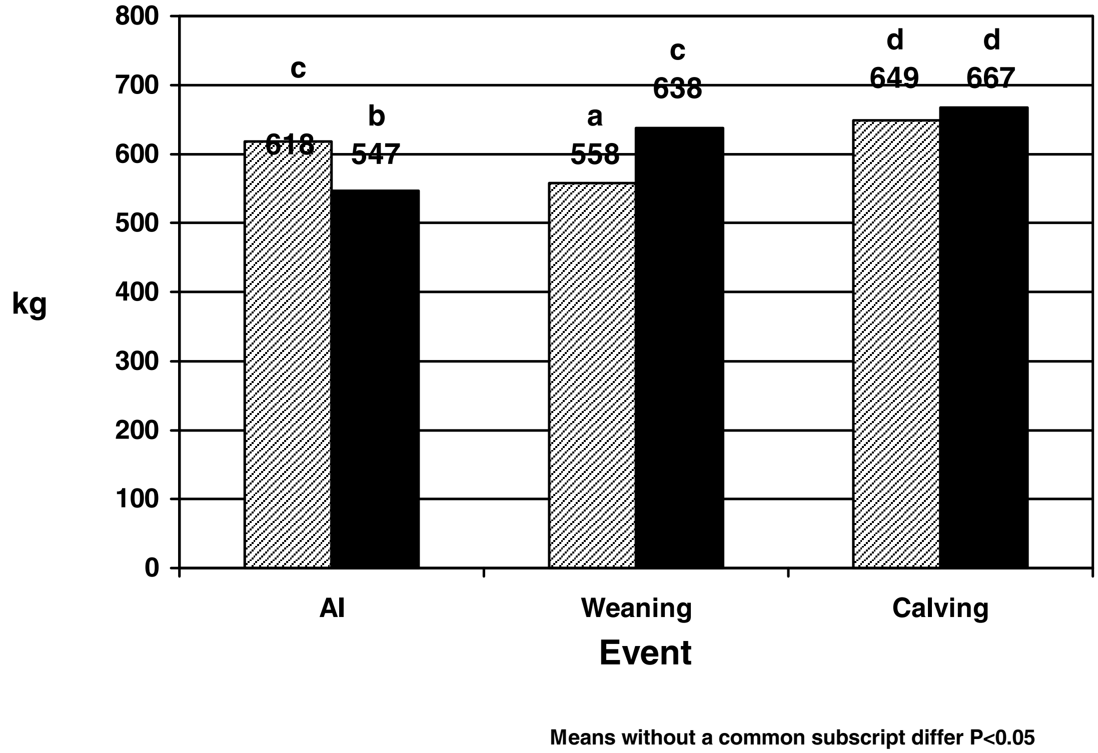

Figure 2. Body Weight of fall calving at AI, calving, and weaning years 1 and 2.

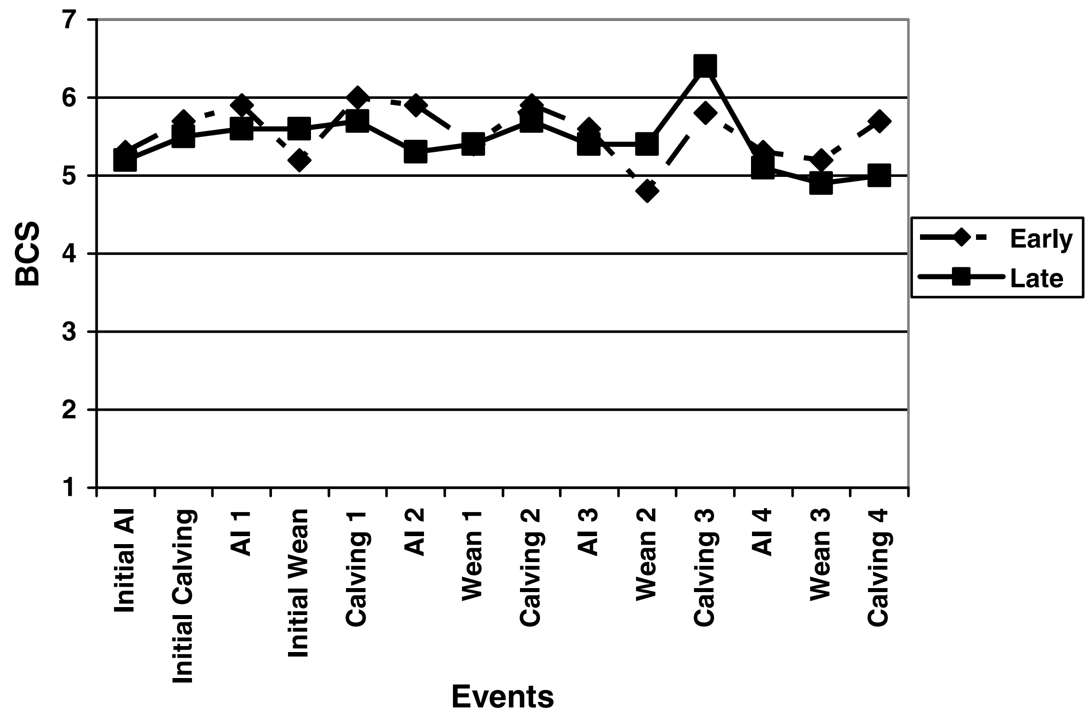

Figure 3. Body Condition Score of fall calving at AI, calving, and weaning.

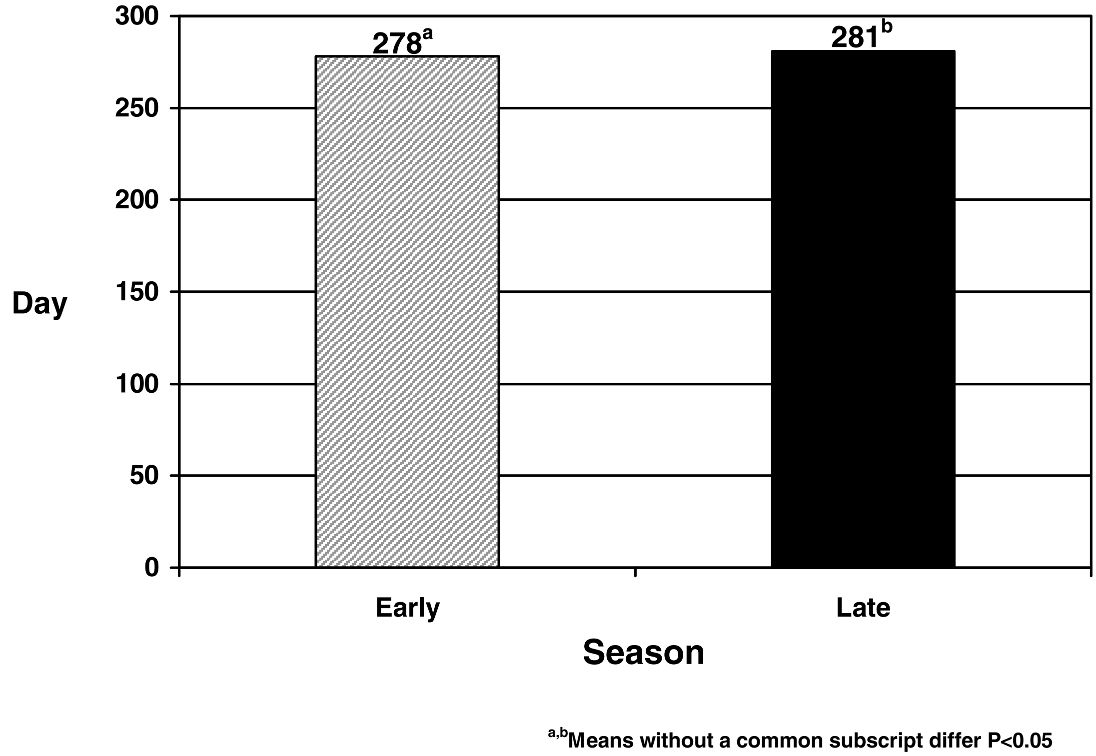

Figure 4. Gestation length of early and late fall calving cows

CHAPTER IV

SUMMARY AND CONCLUSIONS

A fall calving management system that required cows to maintain a BCS ≥ 5 from calving to breeding and then allows BCS to decrease until warm season grasses are present was achieved in the current experiment. At the times of breeding, calving, and weaning, cows maintained a BCS ≥ 5. This required about 200 kg/hd of a 40% CP supplement during the months of October through March. Most cows had luteal activity at the time of breeding and were considered to be cycling. The percentage of cows pregnant was adequate in all years except 4, due to an infertile bull. Pregnancy rates to TAI were less than 50 percent. A producer would have to produce an AI calf much more valuable than the herd sire in order to make it economical to perform TAI in a range setting.

The ambient temperature difference between the E calving seasons was greater compared with the L season and may have caused shortened gestation lengths but similar birth weights in the E and L fall calving cows. Elevated temperatures may have increased the amount of death loss at the time of or shortly after calving in the E fall, whereas the L fall calving cows experienced no calf death loss at calving. Weaning weighs were also affected by season. The L calves had access to better grass for 2.5 mo before weaning and L claves were 54 kg heavier at 9 mo of age than the E calves.

Most producers utilize a spring calving system rather than a fall calving system. Oklahoma has a climate that is well suited for fall calving. Through the use of fall calving, a producer is better able to match nutrient requirements of a cow with the forage available, limiting the amount of supplemental protein required. Fall born calves tend to be worth more at the time of calving due to market demands. The E calving cows required a similar amount of feed, and weaned lighter calves than the L calving cows. In central Oklahoma, cows calving in October - November would be more profitable compared with cows in August - September. At this time, TAI is not an economical practice for fall calving range cows.

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VITA

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Major Field: Animal Science

Scope and Method of Study:

Effects of early and late fall calving on gestation length, pregnancy rate, and weaning weight were evaluated in Angus x Hereford cows during 4 years. Sixty fall calving cows were blocked according to age and prior calving date, and allocated for insemination in late fall (Nov. 7-8) or winter (Jan. 4-7). Control of ovulation was accomplished with the Ovsynch protocol.

Findings and Conclusions:

Early fall born calves were exposed to higher ambient temperatures and had shorter gestation lengths ($P < 0.05$) than late fall born calves. Birth weights were similar between seasons, however, weaning weights were greater ($P < 0.01$) for late fall born calves compared with early born calves. Similar feed requirements and reproductive performance for early and late fall calving cows, with greater weaning weights for late calving cows, indicates that late fall calving is more profitable in central Oklahoma.

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