EFFECTS OF EARLY WEANING AND GRAZING SYSTEMS ON PRODUCTIVITY OF SPRING AND FALL-CALVING COWS

By

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Format of Dissertation

This dissertation is presented in the Journal of Animal Science style and format, as outlined by the Oklahoma State University graduate college style manual. The use of this format allows for independent chapters to be suitable for submission to scientific journals. Three papers have been prepared from the data collected for research in partial fulfillment of the requirements for the Ph.D. degree. Each paper is complete in itself with an abstract, introduction, materials and method, results and discussion, implications and literature cited section.

Chapter I

Introduction

Competition by the poultry and swine segments for the consumer's dollar has gradually increased interest in improving the efficiency of beef production. The beef industry needs to evaluate new technologies and management tools that will allow cattlemen to be more competitive with other sources of natural protein.

The cow-calf segment needs to strive towards lowering production cost.. The Standardized Performance Analysis (SPA) reveals that nationwide cow herds spend more money on land and feed to maintain their herd than any other cost (Northcutt, 1996). As animal scientists, we need to critically evaluate different management techniques that will lower these two inputs. Obviously, decreasing land requirements or feed inputs per kilogram of final product will help in this endeavor.

This research was conducted with the goal to decrease land requirements and feed inputs in both fall and spring-calving cows grazing native range. A systems approach was applied to determine the effects of early weaning and grazing systems, to determine year round cow productivity. Additionally, early weaning as a system poses practical ques tions for the management of the early weaned light weight calf which need to be addressed.

The information in this dissertation is divided into six chapters. Chapter two is a review of literature pertaining to the scope of the study. Chapter three discusses the effects of early weaning on productivity of spring-calving cows grazing native range. Three years of data were collected and reviews the effects of early weaning on cow productivity, postpartum interval, forage intake, and calf performance. Chapter four covers the use of early weaning and grazing management systems on performance of fall-calving cows. Two years of data were collected covering cow performance, calf weight gains, and herbage dynamics. Chapter five discuses the performance of early weaned fall-calves grazing wheat pasture over three years. Chapter six is a summary conclusion chapter.

Chapter II

Review Literature

Adaptive advantage

The ruminant animal is unique in its ability to digest cellulose and other fibrous carbohydrates. This has given the ruminant an adaptive advantage over other animals that require less complex substrates for life. Considering the fact that the majority of land on the earth is not tillable, the niche the ruminant animal holds becomes obvious. Ruminant animals have taken advantage of their unique digestive capability and evolved into many different shapes, sizes, and colors, in a wide variety of climatic conditions (Church, 1988). To date, little is known about the specific evolutional changes of ruminants, however archeological findings of ruminant animals have been found in nearly all continents with the exception of Antarctica and Australia.

Factors affecting intake of forages

Forage Quantity. Forage quality will affect dry matter intake in the grazing ruminant. Numerous workers have reported increased stocking rate will decrease animal performance (Langelands and Bowles, 1974 and Ellis et al., 1983). Reduced performance was related to decreased available forage. Cattle generally graze 6 to 12 hr with the remainder of the day resting and ruminating (Minson, 1990). As forage quantity decreases, cattle will increase their grazing time to a point, at which time additional grazing yields little nutrient benefit (Hepworth et al., 1991). This equates to less marginal nutrient return per unit of energy expended during the consumption of forage. Herbage intake can be defined as the product of eating rate (intake/bite and bite/unit of time) and accumulative grazing time. Allden and Whittaker (1970) found a close relationship between rate of intake and herbage mass. As herbage mass declined from 3000 to 500 kg/ha, there was a 4-fold decrease in intake and a 2-fold decrease in grazing time. Therefore, as forage quantity decreases, intake will decrease and animal performance will be limited.

Forage Quality. Leng (1990) defined low quality forages as those less than 55% digestibility and deficient in protein. Intakes of cattle grazing rangelands vary from 1.0 to 2.5 % of body weight over a growing season (Church, 1988). Obviously, season of the year will impact forage quality and quantity. Lawerance et al. (1995) reported a 28 % (4.8 - 17 % CP) change in forage crude protein and 60 % (45 - 75 IVOMD%) change in forage digestibility during a single grazing season on native range.

Conrad et al. (1964) proposed a relationship between forage intake and digestibility of the diet. The general premise made by the authors, is that two basic mechanisms limit intake. To the left of the peak (<66% digestibility), physical constraints or rumen capacity and passage of the digesta limits meal size. To the right (>66% digestibility) of the peak intake, is limited by chemostatic factors (i.e. hormonal, total energy balance, metabolic efficiency). Ketelaars and Tolkamp (1992) evaluated organic matter intake and digestibilities of a much wider range of forages and could not find a similar relationship as Conrad et al., (1964). Therefore, digestible organic matter intake will vary significantly from the 66% digestibility as suggested by Conrad et al. (1964). Conrad and co-workers knew that the inflection point did vary from 66%, and has been misquoted in many cases. They also reported that the inflection point in high milk producing cows was near 70% digestibility. The greater the energy requirements for the animal, the higher the inflection point will be before intake is controlled by the proposed metabolic regulation.

Physiological Status. Changes in intake are determined largely by the physiological requirements of the animal. There is a slight increase in intake by cows during gestation, however this is variable. Dry matter intake of cows will increase by 15 - 20% following parturition (Allison et al., 1982 and Marston et al., 1995). The NRC (1984) predicts a 10 to 15 % increase in dry matter intake of a 500 kg cow from gestation to lactation. Therefore, energy requirements and dry matter intake are higher during lactation in beef cows than at any other stage of production.

Supplementation and Substitution. Supplementation strategies are used to correct deficiencies in the diets of ruminant animals without negatively impacting other dietary components. As forage quality of dormant native range declines, crude protein concentration in the forage becomes limiting (McCollum and Horn 1990). Supplementation with an all-natural protein source increases dry matter intake in ruminants consuming low quality forages (McCollum and Galyean, 1985). This is a true supplementation effect in that the micro-organisms in the rumen lack available nitrogen. By increasing the ruminal N pool (ammonia or performed amino acids) growth of the micro-organisms was stimulated (Owens et al., 1986) and the passage rate and digestibility was increased of the dormant grass (McCollum and Galyean, 1985). The overall net result is increased intake of total digestible nutrients and protein flow to the small intestine. The increase in intake of low quality forages is in part due to increased ruminal digestibility of the forage. However, the possibility exists that postruminal supply of protein may directly impact dry matter intake as well. Egan (1977) found that voluntary intake of low quality forage increases with casein infusion into the duodenum. Therefore, the increase in protein flow to the small intestine may increase intake of low quality forages. However, it is likely that quality of protein and composition of available amino acids may impact this response.

Substitution, may negatively impact dry matter intake or digestive characteristics of the diet and animal performance may be reduced. Feeding increasing amounts of a grain supplement to ruminants will decrease fiber digestion. Depressed fiber digestion is thought to be linked to decreased activity of cellulolytic enzymes in the rumen and digestibility of the forage (Smith et al ., 1973, Chase and Hibberd, 1987).

Low starch by-product feeds can be used effectively in the grazing animal. Grigsby et al (1983) reported that steers fed brome hay and supplemented with a corn/soybean supplement or with a soybean hull supplement had depressed diet digestibility. Hibberd et al., (1986) wintered cows with isonitrogenous supplements consisting of corn or soybean hulls, and found that the corn based supplemented cows lost more weight compared with cows supplemented with the soybean hulls. Thrift (1994) evaluated feeding .5 to 2.0 kg of TDN/day from soybean hulls to spring calving cows. Hay organic matter intake decreased linearly as energy level increased, however total digestible organic matter intake was not affected. Horn and McCollum (1987) suggested that supplements could be fed up to a rate of 30g/kg of body weight before observing a significant decrease in forage intake. This equates to about .7% of the body weight in a 227 kg steer. This is in agreement with Grisby et al., (1992) who found similar results in supplementing steers consuming brome hay with corn or soybean hull based supplements.

Substitution may seem counter-productive. However if pasture is in short supply, this may be beneficial in "stretching" available forage. Additionally, it may be beneficial to increase precalving energy intake in cows grazing dormant native range. Marston et al. (1995) found that increased levels of precalving energy compared to an isonitrogenous (.56 kg CP/day) amount of soybean meal, resulted in more weight gain and less condition score loss prior to calving. This equated to an increase in reproductive performance (pregnancy rate) in cows that received additional energy during the gestation periods, compared with cows that received an isonitrogenous amount of protein.

Mature body size. The amount of energy needed to maintain an animal is related to the animals size (NRC, 1984). Many other factors affect this maintenance cost as well, such as breed (Ferrel and Jenkins, 1984), weather

(NRC, 1984), and milking potential (Ferrell and Jenkins, 1984). Large and small cows had similar maintenance requirements when expressed on a kg of weight basis (Ferrell and Jenkins 1984). However, specific differences in maintenance requirements between biological types were due to milk production potential. Therefore in a range environment larger cattle simply need more total caloric intake compared to smaller contemporary cows (i.e., similar energy intake /kg of body weight). However, animals with greater milk production potential require more energy intake/kg of body weight compared with animals with less potential. Large, heavy milking cows in a range environment may be at a disadvantage if they cannot consume enough low quality forage to meet their maintenance requirements.

Postpartum interval and early weaning.

Overview of postpartum interval. Postpartum interval to estrus in the bovine can be lengthy and highly variable (40-140 d). Currently in the United States, the annual calf crop is approximately 70-75% (USDA, 1988). Assuming a 95% calf crop is biologically attainable, studies have been designed to evaluate this significant loss in reproductive performance. Research in the last ten years has produced a plethora of information concerning postpartum reproduction.

Normal estrous cycles in the bovine are dependent on gonadal steroids produced by the ovary and concomitant feedback of the ovary on the hypothalamus. In the last trimester of pregnancy it is thought that placental steroids decrease the production of gonadotropins prior to and shortly following parturition (Short et al., 1990). However, gonadal function and storage of gonadotropin in the pituitary is fully functional two to four weeks following parturition (Short et al., 1979). Therefore other stimuli must be impacting the initiation of luteal cycles when average postpartum intervals vary between 40-150 d.

Suckling by the calf and the body reserves of the dam are considered to be the primary factors affecting the anestrous period. Calf removal stimulates the initiation of estrous cycles in beef cattle (Graves et al., 1968, Short et al., 1972, Lusby et al., 1981). It is thought that calf removal initiates the GNRH pulse generator in the brain which enables the release of gonadotropins in a pulsatile manner. Neural input via opioid peptides may be the cause for decreased gonadotropin release in the postpartum cow, and its inhibitory effects are negated after the cessation of the sucking stimulus (Williams et al., 1990).

The effects of opioids can be blocked utilizing potent antagonist such as Naloxone which increases the releases of LH from the pituitary (Gregg et al., 1986, Trout and Malven, 1988). However, Short et al., (1986) found that prolonged use of an opioid antagonist, luteinizing hormone release ceases and ovulation will not occur. Therefore the specific mechanism(s) that regulate the length of the postpartum anestrous interval is still unknown. However, suckling, adrenergic innervation, body reserves of the cow and the gonadal/pituitary axis play major roles in controlling luteal activity.

Pituitary-Ovarian Axis. Postpartum infertility is caused by four major factors: general infertility, lack of uterine involution, short estrus cycles and anestrus. The anestrous period is the major component of postpartum infertility and is impacted by breed (Dunn et al., 1969), season (Smeaton et al., 1986), dystocia (Laster et al., 1973), nutrition and lactation demands (Randel, 1990). Uterine involution and short estrous cycles generally occur 20 to 40 d post partum (Short et al., 1990). Therefore, the secretion of luteinizing hormone or gonadotropin releasing hormone as well as uterine function seems to be limit the initiation of normal estrous cycles in the cow.

Pulsatile secretion of gonadotropins appears to be required for establishment and maintenance of luteal cycles. The normal intermittent release of GnRH into the portal vein is critical for the interaction of the pituitary and the gonad. Secretion of LH to the ovary and production of androgen and estrogen from the follicle set the stage for the preovulatory surge of LH. The pituitary support of the follicle will result in increased follicle size and release of estrogen which causes the surge of LH and hence ovulation. (Rahe et al., 1980). Prior to and shortly after parturition pituitary store of gonadotropins are depleted, presumably due to placental steroid production (Moss et al., 1981). However this depletion is short-lived as pituitary stores are replenished within two to four weeks following parturition. Pituitary stores are not a limiting factor in the initiation of normal estrous cycles. However, the releases of GnRH is lacking in the postpartum cow. Following uterine involution, short cycles (which may not happen in all cows) and production of gonadotropins (all take place < 40 d PP) lack of normal gonadotropin release from the pituitary is due to decreased GnRH release from the hypothalamus. The observation that early weaning shortens the post partum interval reflects the release of some inhibitory affect on the GnRH pulse generator.

Nutrition and Lactation. Nutrition of the dam and the initiation of lactation are thought to be the major factors involved in extending the postpartum anestrous. Body reserves at the initiation of calving are negatively correlated with postpartum interval. Greater body reserves in a cow at calving will generally shorten the postpartum interval (Wiltbank et al., 1964, Dunn et al., 1969, Selk et al., 1988) . The interactions between the calf and nutritional status of the cow are not fully understood. However, the requirements for milk production are high, and the support of the calf outweighs the need for reproduction, hence longer postpartum period. Removal of the calf for 48, 72, 96 hr (Walters et al., 1982), or permanently (Lusby et al., 1981, Parfet et al., 1986) will hasten the onset of cyclic behavior in beef cows. There is also an interaction of body reserves and early weaning.

Wettemann et al., (1986) found that temporary calf removal in thin (4.3) body condition score (BCS, 1=emanciated 9=obese) had longer PPI compared to cows maintained at a higher (5.2) condition score coupled with early weaning. Therefore, the cows precalving nutrition impacts the response observed in early weaned cows in terms of luteal activity.

The importance of postcalving nutrition can be overlooked due the emphasis and obvious importance on precalving nutrition. Rakestraw et al., (1986) found that fall-calving cows that lost 10% of their body weight postcalving had a longer postpartum interval than cows fed to maintain weight during the breeding season.

***Calf Factor*.** Recent studies have involved the calf as an independent factor instead of suckling per se. Williams et al. (1990) recently summarized a number of studies that involved cow and calf interrelationships. They proposed the presence of the calf and the recognition of the calf via maternal factors may be responsible for the decrease in gonadotropin release. It has been shown that mastectomized cows pseudo-suckled by their calves exhibited anovulatory periods similar to intact cows (Viker et al., 1993). However cows maintained with their own calves that were muzzled showed an increase in LH secretion. Calves that were "alien" to a cow yet forced to suckled did not attenuate the suppression of LH. Additionally, cows that were weaned and cows that were suckled by alien calves had similar PPI (Vicker et al., 1993). The exact roles of the calf-presence can be debated. Maternal instinct and the calf relationship should be noted and could be impacting the postpartum period. The interaction between nutritional state of the cow and early weaning shows that possibly two factors (different but not mutually exclusive): nutritional status, and suckling of the calf, are affecting the onset of luteal activity.

Possible Links Between Neural Control and PPI This discussion has mainly covered the practical understanding and utilization of early weaning as it pertains to PPI. The one question that remains unanswered is the exact mechanisms impacting PPI utilizing early weaning. Pituitary stores, and uterine involution, and possibly short cycles should be complete prior to day 40 PP.

Therefore the calf, suckling, energy utilization, and neural control may be impacting the post partum anestrous.

There are four sources of nerves in the bovine mammary system: inguinal nerve, consisting of the ventral branches of the second, third, fourth lumbar nerves serves as the primary innervation . The ventral branch of the first lumbar, as well as the second branch of the lumbar nerve innervates the gland and skin of the forequarter (Williams 1990). The perinieal nerve is a small branch from the pudic nerve which passes over the ischial arch, which innervates the skin on the posterior part of the udder. Stimulation of these nerves via suckling may evoke distinct reflexes. The innervation of these nerves may cause the releases of specific neurotransmitters which modulate hypothalmic function. The chronic presence (suckling) of this stimulus may increase the sensitivity of the hypothalmic to opioid peptides. The increased sensitivity of the hypothalamus to opioids would decrease spontaneous firing of GnRH neurons. It is thought that catecholamines mediate the inhibitory affects on gonadotropins via afferent innervation (Karla et al., 1986). The ability of an opioid agonist such as Nalaxone to block opioid suppression of LH secretion in the anestrous cow links opioid regulation with LH secretion

Grazing Systems

Grazing systems in animal production have gained much interest in the past years. Obviously, one of the most important components of the beef cattle industry is the harvest of forages. Proper management in terms of grazing systems are required to assure feed resources are available for consumption and maintenance of the cow herd. When evaluating a grazing management, one must consider the components of the collective system which involves: type of animal, number of animals, grazing schedule, and distribution of grazing. Rotational grazing would allow the producer to improve intensity and frequency of defoliation (Hinnant and Kothmann, 1986). Controlling defoliation of the plant community would allow for better management of resources and should, in theory, improve range condition over time (Allison, 1985).

Grazing Systems and Stocking Rate. Early reports on grazing systems claimed an increase in rangeland production and increased carrying capacity utilizing rotational grazing (Savory and Parsons 1980). In theory this would allow producers to increase range quality while increasing returns per acre. However a review of the literature indicates that stocking rate accounts for the majority of the variation of animal performance in grazing situations. Therefore the blanket statement that a grazing system will increase carrying capacity has lead to numerous studies evaluating this interaction.

Bryant et al. (1970) evaluated the effect of increased stocking rate on animal and herbage performance. They found that increasing stocking rate limited available forage and diet quality decreased. Decreased quality limited individual animal performance. Similar to the prior section on forage quantity, more grazing pressure exerted on an area leads to more defoliation of the plant community and decreased forage quality and intake.

Numerous studies have evaluated the effect of grazing systems on animal performance. Knight et al. (1987) compared continuous and deferred rotational grazing in beef cows and found that stocking rate had a greater effect on cow-calf production than did grazing system. Similar results where noted by Heitschmidt et al. (1990) where increased stocking rate generally decreased cow performance and increased variability in net returns. Additionally, the lowest reproductive rates where seen in the two heaviest stocking rate treatments. Cassels et al. (1995) compared short duration grazing and continuous grazing and different stocking rates on performance of yearling cattle. They found that stocking rate (127 vs 222 kg of live weight/ha) had a greater effect on standing crop than did grazing system. Derner et al. (1994) found that defoliation of little bluestem was less in rotational grazed paddocks compared to continuous paddocks. As grazing pressure increased defoliation increased in both grazing systems.

One problem with many studies concerning grazing systems and stocking rate is the confounding of a wide range of stocking rate across both continuous and rotational grazing systems. A recent study Gillen et al., (1992) compared the performance of stocker cattle over a wide range (.11-.20 steers/ha) of stocking rates. They found that rotational grazed animals had a 17% reduction in daily gain compared to continuous cattle over all stocking densities. Increasing stocking density did not improve gain per/ha as suggested earlier literature (Savory and Parson, 1980) and resulted in less gain /ha and lower net returns/ha at all stocking densities.

Forage Quality Forage quality may be increased by rotational grazing if stocking density is high. Heitschmidt et al., (1987) found that heavily stocked cells generally had greater quality than moderately stocked cells, but attributed this to less total dead forage compared to moderately stocked pastures. Additionally, total standing crop was greater for the moderately stocked compared to the heavily stocked treatment. It should be noted that increased stocking rate will impact animal performance as noted previously. Hirschfeld et al., (1996) found that diet quality was greater for rotationally grazed cattle compared with cattle grazing continuously in central North Dakota. They attribute differences in their findings compared to other studies (Kirby and Webb, 1987, Walker et al., 1989) to the moderate stocking rates. Stocking rates where not high enough to limit forage quality and animal intake.

Overall grazing systems may improve range utilization (Heitschmidt et al. 1987). However, it appears that stocking density has a greater effect on animal performance than does grazing system per se. The adaptation of such practices should be utilized if rangeland improvement or sustainability is of primary interest. Increasing carrying capacity of rangeland may be warranted if the plant community is altered to maintain greater grazing pressures.

In concluscion many biological factors impact the overall performance of the cow. Reduced supplementation during the winter months, coupled with early weaning should lower the amount of total energy intake need to maintain a cow for a production year. Early weaning should offset the lower body condition at the time of calving following restriction of winter supplement. Overall, harvested and purchased feed should be greatly reduced, while lowering annual cow cost and possibly allowing for some increase in stocking rate.

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Chapter III

Running Head: Early weaning and performance of spring calving cows

Effects of early-weaning and body condition score (BCS) at calving on performance and forage intake of spring calving cows[1]

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Abstract

In a 3-year study 93 spring-calving cows were used to determine the effects of reduced nutrient intake of cows during the winter and early weaning of calves on cow and calf performance. Cows where stratified by age BCS assigned to three treatments; normal management fed to attain a 5.0 body condition score (BCS) at calving (NOR); normal management coupled with early weaning 65 d post partum (NOREW), or nutritionally restricted to attain a body condition score of 4.0 at calving coupled with EW 65 d post partum (LOWEW). Normally managed cows were individually fed 1.36 kg/d of a 41% protein supplement beginning in mid November through mid April. LOWEW treatment cows were

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fed .11 kg/d of a 41 % protein supplement from mid November through mid April. NOREW were fed like NOR until calving when supplement was to that fed to LOWEW cows. Early weaned calves were weaned in two weaning replications at a mean age of 65 days, grazed native range pasture and were fed a 25% protein pellet (1.13 kg/d) in replicated groups. There was a significant treatment x year interaction for weight and BCS at initiation of supplementation, weight at calving, and weight at normal weaning (205 d). Weight and BCS loss where greatest prior to calving for LOWEW treatment, during year one. However, accumulative effects of early weaning increased BCS and weight of LOWEW similar to NOR at the time of calving during year two and three. NOREW cows where generally heavier and had greater BCS than NOR or LOWEW throughout the trial. Weight and BCS at a normal 205 d weaning where greater for NOREW and LOWEW during all years. Weaning weights of calves at a normal 205 d weaning favored NOR compared with NOREW and LOWEW (220 vs 207, 202 $P<.05$). Pregnancy rates were not influenced by treatments. Four intake studies over the production year found an overall savings in dry matter intake of 15% in LOWEW (7.4 kg; $P<.05$) and 5% in NOREW (8.1 kg; $P<.05$) compared with NOR cows (8.5 kg). Body condition at calving was negatively correlated ($r = -.69$, $P=.01$) with days to luteal activity following early weaning and negatively correlated ($r = -.32$, $P=.05$) with days from calving to initiation of luteal activity. Overall cows that have their calves weaned can be successfully nutritionally restricted during winter supplementation without subsequent reproductive failure. Cow weights and condition scores of cows that are early weaned will increase during the spring and summer to allow adequate condition score at the time of calving the following calving season. Reduced winter supplementation coupled with early weaning resulted in similar cow but reduced calf performance.

(Key Words: Beef Cattle, Reproduction, Early Weaning.)

Introduction

Cow-calf producers face increasing challenges to maintain profitability. New technologies and production systems that allow producers to decrease production costs must be evaluated. Practices thar reduce feed requirements and/or land requirements would greatly enhance production opportunities for cattle producers. The use of early-weaning may be a useful management tool to reduce both land and feed requirements (Peterson et al., 1987) while maintaining reproductive performance (Lusby et al., 1981). The objectives of this study were to evaluate the effects of reduced feed intake and early weaning on cow productivity over several years. Forage dry matter savings and calf growth reproductive parameters where investigated.

Materials and Methods

Ninety-three spring calving Angus x Hereford cows were allotted by weight, age, and condition score to one of three treatments. Treatments were: cows normally managed to attain a mean BCS of 5.0 at calving (NOR), cows managed to calve at a BCS of 5.0 coupled with early weaning at 65 days post partum

(NOREW), and cows maintained to calve at a mean BCS of 4.0 coupled with early-weaning 65 d post partum (LOWEW). Cows remained on the same treatments throughout the duration of the trial to observe long term effects of reduced winter supplementation and early weaning on cow productivity.

Cows were originally assigned to treatment on November 9, 1993 and were managed as one herd while grazing native range at the Range Cow Research Center 24 km west of Stillwater, OK. Cows were individually fed in covered stall barns 3 d/wk, and feeding rates were prorated to provide the daily supplementation rate. The LOWEW cows were placed in the stall barns at the same time as NOR and NOREW to equalize effects of handling. Supplemetation of NOR cows consisted of 1.36 kg/day of a 41% crude protein cottonseed meal pellet (CSM) commencing November 9, 1993, November 10, 1994, and November 12, 1996 through April 19,1994, April 10, 1995, and April 23, 1996. Cows on LOWEW treatment were supplemented with .11 kg/day CSM during the same time as NOR and NOREW. The supplementation rate of .11 kg/d CSM was used to pacify cows on LOWEW treatment while in the stall barn. The LOWEW feeding rate was increased to .91 kg/day CSM beginning March 4, 1994 through April 19, 1994 during year one only due to large loss in body weight and BCS during the winter. Cows on the NOREW treatment received the same supplementation as NOR cows up to calving at which time they were switched to the same supplementation rate as LOWEW. All cows had access to water, salt and a trace mineral mix fed at a rate of 56 gram/d (Salt 63.5%;

dicalcium phosphate 33.3%; copper sulfate; .40%; zinc oxide .43 %; mineral oil 2.85%, and 120 mg chlorotetracycline) while on pasture.

Cows were weighed every 28 d following a 16-h withdrawal from both feed and water. Body condition scores (BCS, scale 1=emaciated, 9=obese, Wagner et a. 1987) were assigned by two independent evaluators in November, January, April, July, and October. All calves were weighed within 24 hr of birth and before weaning at intermittent intervals when dams were weighed, following a 16 hour shrink. Early weaned calves were weighed within 48 hr of the NOR calves in October were considered weaning weights for early weaned and NOR calves.

Early weaning of NOREW and LOWEW calves that were born early in the calving season (prior to March 3, 1994, March 10, 1995, and March 12, 1996) took place on May 3, 1994, May 5, 1995 or May 6, 1996 respectively. The calves born later in the calving season were weaned on June 1, 1994, June 5, 1995, and June 6, 1996. During year one, early weaned calves were allowed free access to native hay and were fed .91 kg of a 40% all natural protein pellet during the first two weeks post-early weaning. During year two and three, calves were managed differently during the drylot period as explained by Purvis and Lusby, (1996). Following this two week adjustment period calves were allowed access to native range and had free access to water and salt. At approximately 0700 on Monday through Friday, calves were sorted into 14 feeding replications and supplemented with 1.36 kg /d of a 25 % protein supplement prorated for 5 d a week feeding. All early weaned calves were supplemented throughout the grazing season until weaning (October 6, 1994, October 10, 1995, and October 11, 1996).

All cows where exposed to three mature bulls beginning May 3, 1994, May 5, 1995, and May 6, 1996. Following the second early weaning NOREW and LOWEW cows where moved to an adjacent pasture with two bulls and one bull remained with NOR through July 25, 1994, July 28, 1995, and July 30, 1996 for all treatments while grazing native range. Cows on NOREW and LOWEW were maintained separately on summer native range and exposed to two mature bulls for the same period as the NOR cows. Pregnancy was determined on all cows via rectal palpation at the time of normal weaning in October for all years.

Milk production. During year three daily milk production was determined in all cows (n=93) by the weigh-suckle weigh technique (Beck et al., 1979). Milk production was determined in conjunction with early weaning on May 6, 1995 (weaning replication one) and June 6, 1995 (wean replication two) at averages of 64.6 and 66.4 days of lactation respectively.

Intake determination. Thirty multiparous cows were selected by weaning treatment, based on original (1993) weight, BCS and previous calving date (1994) for intake determination. Four separate intake trials were conducted during the production year. The precalving intake (PRECAL) was initiated prior to calving on January 13, 1995. The early lactation intake was performed on April 13, 1995 before early weaning on May 5. Late lactation intakes were performed at an average of, 120 d of lactation (LAC120 June, 23, 1995), 180 d of lactation (LAC180, September 23, 1995.

All cows were adapted to the same native hay which they would consume during the intake period for 7 d in a drylot. Prior to PRECAL intake, cows were randomly assigned by treatment to individual stalls (.77 x 2.50 m) in a covered stall barn. Each cows were fed in the same stall for the 7 d intake measurements each of the four intake periods. Cows had access to native hay from approximately 0700 - 1100 and from 1300 - 1700 during each of the collection periods. When the animals were not in the stall barn, they were placed in a drylot and had access to water. Calves of the NOR cows remained in the drylot while their dams were in the stall barn. Supplementation to NOR and NOREW during the PRECAL consisted of 1.36 kg of CSM during the morning intake collection. However, only NOR received supplementation during the PREW intake.

Sample collection. Average daily DM intake was average forage intake for each 7-d collection period. Hay samples were collected during each of the intake periods and analyzed for CP, ADF, NDF, and invitro determination, and all intakes are reported on a DM basis.

Samples where collected and dried in a force air oven at 60°C for 48 h, ground through a 2 mm screen and stored in plastic bags at -20° C. Crude protein content of the feed samples was determined as Kjeldahl N multiplied by 6.25 and ash content was determined as described by AOAC, (1980). Neutral detergent fiber and ADF concentrations where determined by the nonsequential procedure of Goering and Van Soest (1970), with the exception that decalin and sodium sulfite where omitted from the neutral detergent reagent (Robertson and

Van Soest, 1981). Invitro digestibility of the hay samples where determined as described by Tilley and Terry (1962).

Post partum interval. Weekly blood plasma samples were obtained via tail vein and analyzed for progesterone (Viscarra et al., 1996) from all cows beginning on April 19, 1994, March 15, 1995 and March 10 continuing through July for all three years. Onset of luteal activity was defined as the first of two consecutive plasma samples with progesterone greater than 1 ng/ml.

One hundred thirty-two (Angus x Hereford, 66 per year) cows on the NOREW and LOWEW where assigned retrospectively to two treatments at the time of calving, treatments where: cows that calved with a moderate BCS equal to or greater than 5.0 (MODER), and cows that calve with a BCS less than 5 (THIN). These groups where created to evaluate the responses to BCS a the time of calving on return to estrus following early weaning.

Statistical Analysis.

Data for the production trial were analyzed using general linear models of SAS (1985). The final model include the effects of calving date, weaning management treatment, weaning replication, year , year x treatment and weaning replication x year interaction. When the F-tests for treatments where significant (P<.05), comparisons of treatment where made utilizing protected *t*-test (SAS, 1985). Dry matter intake data were analyzed as a split plot design with repeated measurements. Treatment was tested with cow(trt) as the error term. Period and the two way interaction of treatment x period was tested with residual error. Regression analyses (SAS, 1985) were used to determine the relationship of BCS at the time of calving and initiation of luteal activity following early weaning, with days from calving to initiation of luteal activity. Simple correlation (SAS, 1985) was utilized to examine relationships between body condition at calving, days to luteal activity, date of calving the subsequent year.

Results

Cows weighed 490±6 kg with an average BCS of 5.27±.12 at the beginning of the trial during year one (Figure 1). However there was a year x treatment interaction (P<.01) for November weight and condition score. At the beginning of supplementation for year two, NOREW and LOWEW cows where heavier (P<.01) compared with NOR. Body condition scores for the precalving period (February) for year two where greater (P<.05) for NOREW (6.2) followed by LOWEW (5.9), which was greater (P<.05) than NOR (5.2). At the initiation of supplementation for year three NOREW and LOWEW where again heavier and had greater BCS compared with NOR.

Cows on the LOWEW treatment lost more BCS (Figure 2) prior to calving compared with NOR and NOREW cows during year one. (-.88, vs .08, and .02±.08; P<.05). However, cows BCS of the LOWEW prior to of calving was similar to NOR. Additionally, NOREW cows had greater (P<.05) BCS than NOR and LOWEW prior to calving during year two (5.7 vs 5.2 and 5.3±.12; P<.05). Similar results during year three where noted with NOREW having greater BCS at calving compared with NOR and LOWEW.

Prior to calving during year one LOWEW cows weighed less (P<.05) than NOR and NOREW (454 vs 495 and 502±12 kg). However, body weight prior to calving was greater for NOREW compared with NOR and LOWEW during year two (547, vs 505 and 490±.17; P<.05). During year three NOREW was heavier than LOWEW (599 vs 556±14 kg P<.05) and LOWEW was heavier than NOR (556 vs 535±14 kg; P<.05).

Even with decreased supplementation after the initiation of lactation, weights and BCS of NOREW cows were similar (Table 1) to NOR cows at the end of the supplementation. Cows on the LOWEW treatment weighed less and had a lower (P<.05) BCS compared with NOR and NOREW at the end of supplementation. Cows on the NOREW and LOWEW treatment gained more weight and condition score compared with NOR during the breeding season. At normal weaning (October 6, 1994, and October 10, 1995,) NOREW and LOWEW cows were heavier and had greater BCS compared with the NOR cows.

Birth weights of calves from LOWEW cows were lighter (P<.05) than NOR (38.5 vs 40.3±1.3 kg; Table 2) and similar to NOREW. Decreased nutritional status in the last stages of pregnancy in the LOWEW cows decreased fetal growth compared to NOR. Weight of calves at early weaning where greater for NOR compared to NOREW and LOWEW (102 vs 91 and 86±4.5 kg; P<.05). Additionally, calf gains from birth to early weaning were greater for NOR calves than NOREW and LOWEW (61 vs 51 and 48 kg, P<.05). Time of weaning or season of birth affect calf performance prior to early weaning. Calves weaned during the first weaning replication weighed less and had lower preweaning gains than calves weaned during the second weaning replication (86, 47 vs

100±5.3, 60±2.5 kg; Table 3). Calves where of similar ages therefore stage of lactation was similar for cows and should not have been a factor.

There was a significant weaning replication x treatment effect on milk production of cows during year three (Table 4). Cows weaned during the first weaning replication where similar in milk production across treatments. However, during the second weaning replication NOR cows produced more (P<.05) milk compared with NOREW anf LOWEW. This may be related to timing of lactation coupled with available forage during early lactation for weaning replication two cows. Calves from NOR cows gained more weight from the time of early-weaning to normal weaning than with NOREW and LOWEW calves. Final weights at 205 d of age were greater (P<.05) for NOR calves (220 kg) compared with NOREW and LOWEW (207 , 202±6 kg).

Forage dry matter intake/cow performance. Cows averaged 518 kg at the initiation of the first collection period (Table 5). There was a significant treatment x period interaction for weight and BCS therefore only means by treatment within period are compared. Body weight but not BCS was different between all treatments at the PRECAV period (507 NOR, 530 NOREW, 517±10 kg LOWEW; P<.05). This is reflective of accumulative weight changes due supplementation and early weaning as all cows where similar in both body weight and condition score at the initiation of the trial during year one. At the PREW intake NOR cows where heavier (P<.05) compared to NOREW, and LOWEW where lightest. Body condition at this time was greater (P<.05) for NOR compared to NOREW or LOWEW. Body condition and weight were similar between treatments at the time of the LAC120 intake. Prior to the final LAC180 intake NOREW and LOWEW cows where heavier and had more BCS than NOR (560, 6.1, 553, 6.0 vs 503±10 kg, 5.4±.12; P < .05).

Forage dry matter intake. Composition of hay as determined by chemical analyses utilized to determine DM intake is in Table 6. There was a significant treatment x period interaction for forage dry matter intake (P<.01), but when forage intake was expressed as an percent of body weight the interaction was not significant (P>.20). Forage dry matter intake PRECAL were greater for NOR and NOREW cows compared with LOWEW (8.1 and 8.4 vs 7.5±.56 kg; Table 7). Intake expressed as a percent of body weight at the PRECALV forage intake was not significantly influenced by treatments. Prior to early weaning, NOR cows had the highest (P<.05) forage dry matter intake compared to NOREW and LOWEW (9.4 vs 8.2, 7.3±.56; P<.05). Additionally, NOREW cows consumed more hay than LOWEW (P<.05). Intake as a percent of body weight was greater during this period for all treatments than at any other sampling time. The increase in forage DMI intake for all treatments during the PREW intake compared with PRECAL intake is due to the initiation of lactation after parturition (Marston et al., 1995). Additionally, NOR cow received 1.36 kg of CSM compared with NOREW during the PREW intake. Absolute dry matter intake and intake as a percent of body weight during LAC120, was greater for NOR than NOREW and LOWEW (8.0, 1.6 vs 7.1, 1.4, 6.9±.56 kg, 1.4±.09%; P<.05. During the final intake period (LAC180) dry matter intake did not differ (P>.05) between treatments. However, forage intake expressed on a percent body weight basis was higher for NOR compared with NOREW or LOWEW (1.6 vs 1.4, 1.4±.09%; P<.05). This reflects the increase in body weight of early weaned cows in the fall. Overall, the savings due to early weaning was about 5% for NOREW and about 15% in LOWEW.

Postpartum Interval. More (P<.05) cows on the NOR and NOREW treatment had luteal activity before to early weaning compared with LOWEW (52, 66 vs 28%; Figure 3). Additionally, more NOR and NOREW cows had luteal activity compared with LOWEW at 2 and 4 wk following early weaning. At 28 d following early weaning treatments did not influence the percentage of cows with luteal activity. There was no difference in the number of days to luteal activity between NOR and LOWEW cows (71 and 76 days). However, NOREW cows had luteal activity sooner compared with LOWEW (69 vs 76±3 days, P<.05). The number of days from weaning until luteal activity was not different (P>.10) between NOREW and LOWEW treatments (26 vs 27±2 days).

Due to the increased number of NOR and NOREW cows that returned to estrus before LOWEW, calving date could be impacted in the following year. However, Julian calving date following the first year was not influenced by treatments for year two and three (NOR 73, 72, NOREW 69±2, 71±3 and LOWEW 70, 73 day). There was a significant effect of time of weaning on return to luteal activity. Cows that calved early in the breeding season and were weaned during May had longer (P <.05) postpartum anovulatory intervals than cows that calved later in the calving season (78 vs 64±1 days, P<.05).

Pregnancy rates were not influenced by treatments (NOR 87, NOREW 90 and LOWEW 88±2%).

Initiation of Luteal Activity in early weaned cows. Body condition scores of the cows ranged from 3.5 to 6.7 at the time of calving. The MODER cows had a shorter ($P<.05$) postpartum interval to luteal activity compared with THIN cows (83 vs 71±2 d). Body condition score at calving was negatively correlated (-.32; $P=.05$) with days to luteal activity (Figure 4, $y = 97.5 + -.81(x)$ $r^2=.32$ $S_{y\bullet x}=56.1$).

Cows in the MODER body condition treatment initiated luteal activity sooner ($P<.05$) following calf removal than THIN cows (13.4 vs 28.5 days). Additionally there was a negative correlation (-.69, $P=.01$) between BCS at calving and the interval from early weaning to initiation of luteal activity. Body condition at calving was negatively related with luteal activity following early weaning (Figure 5, $y = 77.4+ -11.2(x)$ $r^2=.49$; $S_{y\bullet x=43.1}$). Cows that had greater in BCS at calving returned to luteal activity sooner than cows in thinner body condition. This is in agreement with the negative correlation between BCS and return to luteal activity following early weaning. Therefore, cows that calve with a body condition score greater than 5 will initiate luteal activity sooner than thin cows following early weaning.

Cows that calved early in the calving season had a longer postpartum interval than cows that calved later in the season. Calving date was negatively correlated (-.53, $P<.05$) with the duration of the postpartum anovulatory period. Animals that calve early in the calving season may have a longer interval before luteal activity than cows that calve later in the season. The THIN cows had a longer return to luteal activity compared with MODER cows following early weaning. This reveals that even with the cessation of the suckling stimulus there is an effect of body condition on the initiation of luteal activity. Using these regression equations one can predict the return to estrus in spring-calving cows based on body condition at calving if the cows are weaned 65 days postpartum (Table 8).

Discussion

Body weight and BCS. Maintaining the cow herd in good body condition is the goal of many producers (Wiltbank, 1962; Dunn et al., 1969). Body condition score at the time of calving accounts for a significant amount of the variation in the likelihood of estrus by 90d after calving (Short et al. 1990). In the current study winter supplementation rates where drastically reduced in LOWEW cows which resulted in large fluctuations in weight and condition scores during the year(Figure 6). Cows on the LOWEW treatment were never above a suggested minimal condition score of 5.0 (Richards et al., 1986; .Selk et al., 1988) at the time of calving during any year. Although BCS at calving were always at least a five for NOR and NOREW pregnancy rates were similar between all weaning treatments.

Decreased supplementation of the LOWEW cows increased the use of body reserves and resulted in thin cows at the time of calving and lactation. However, during the subsequent calving seasons of 1995 and 1996 LOWEW where similar to NOR cows. Decreased metabolic demands following early weaning allowed both NOREW and LOWEW to gain more weight and body condition during the summer months prior to the next calving season. From a management standpoint increased BCS following early weaning may allow for a delay in the initiation of winter supplementation or altering supplementation to allow for gradual loss of condition over the winter. Additionally, Early weaning may be a viable option when dealing with thin cows at calving or when forage is in short supply.

Forage dry matter intake and stocking rate. The driving force behind any management system is reproductive success at minimum cost. Early weaning allows for sufficient rebreeding rates even with a reduction in winter supplementation. Utilizing a forage base growing system for the early weaning calves resulted in reduced 205 d weaning weights compared with normal weaned calves. Additionally, the added cost of supplementing light weight calves on native range may be similar in cost as wintering the cow. Therefore, increasing stocking rate may offset some loss in per head performance.

Normal weaned cows had a 13% increase in forage DMI compared to compared to NOREW prior to early weaning. Increased low quality forage DMI with supplementaion agrees with cow intakes of winter forage (Thrift., 1994) and steer on low quality prairie hay (McCollum and Galyean, 1985). The reduction in dry matter intake during the lactation period observed in the early weaned cows is due to the cessation of the nutrient demand for milk synthesis. Lacational values are similar to the values found by Marston et al., (1995) and Ovenell et al., (1991) in spring calving cows.

Cows in the current study had an estimated dry matter intake savings of 5 for NOREW and 15% for LOWEW compared to NOR. It is doubtful that in practice a treatment such as NOREW would be implemented because of the cost of supplement alone. Even though intake on a percent body weight basis was lower for NOREW compared with NOR cows, absolute dry matter intake was similar during three of the intake collections. Early weaning increased the body weight NOREW cows and thus total dry matter intake increased as well.

The LOWEW treatment may warrant an increase in stocking rate over time. Cows on the LOWEW treatment had less total dry matter intake during three collection periods. Lower dry matter intakes for LOWEW cows where observed during the spring and summer which may allow for more forage growth and increased carrying capacity. Intakes where similar for LOWEW and NOR cows during the last collection prior to winter dormancy. However that is the beginning of the dormant season and reduced supplementation probably limit any intake in the LOWEW cows. Stocking rate should be monitored carefully due to the negative impacts on both animal a plant performance. Heitschmidt et al., (1990) found that increased stocking rate generally decreased cow performance and increased variability in net returns. Additionally, the lowest reproductive rates where seen with the two heaviest stocking rates. Therefore direct application of DM savings in the current trial does not equate into an 5-15% increase in stocking rate. Other factors such as current stocking rate, current herd management, grazing system, herbage mass, and herbage quality should be considered prior to altering current stocking rate.

Postpartum interval. Body reserves at calving were negatively correlated with days to luteal activity in the current trial. Additionally, cows with a BCS less than 5 at calving, and early weaned had a longer period of anestrous following calf removal compared with cows with a BCS greater than 5. Therefore early weaning may allow thin cows to return to luteal activity, but length of time from calf removal to luteal activity is still dependent on body reserves.

The observation that numerically fewer NOREW and less (P<.05) LOWEW animals where not cycling prior to weaning compared with NOR at 65 d postpartum may reflect decreased post calving energy intake. Somerville et al., (1979) found that cows that lost only 16% of there precalving weight by breeding maintained satisfactory rebreeding rates compared to cows that lost 21%. In the current study NOR cows lost an average of 12% of precalving weight compared to 16% in NOREW and 20% in LOWEW. The importance of loss of body weight during the early postpartum period is important, however, early weaning offsets some of the negative impact that may be realized if calves are not weaned.

Season or time of calving significantly affected the return to estrus. Cow that calved earlier in the calving season had longer postpartum anestrous periods than those that calved later in the season. These data would agree with Warnick et al (1955) and Buch et al., (1955) who found that cows calving later in the spring had shorter postpartum anestrous interval. The possibility the bull (Zalesky et al., 1984) exposure cannot be ruled out as late calving cows where exposed to bulls earlier in their postpartum period compared to earlier calving cows

Implications

Early weaning spring calving cows following reduced winter supplementation can result in similar reproductive efficiency as that observed for normal supplemented cows weaning in the fall. Early weaning allows spring calving cows to store adequate reserves during the summer and fall for the following calving season. Cows that are thin at the time of calving will not return to luteal activity as quickly following calf removal as cows with high condition scores at calving. Therefore, return to luteal activity is dependent on BCS even if the calf factor is removed. The date or season that a calf is born impacts the postpartum anestrous interval independent of condition score. Weaning weights of early weaned calves where significantly less than those normal weaned calves. Reduced supplementation coupled with the cessation of lactation will yield a savings of about 5-15% in dry matter intake over a production year. This savings may equate into an increase in stocking rate to offset calf performance.

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Table 1. Body weight and BCS for spring calving cows that were normal or early weaned.

	Treatments[1]			
	NOR	NOREW	LOWEW	SE
End supplement weight, kg (April)	453 ^{a}	455 ^{a}	415 ^{b}	12.1
End supplement BCS[2]	4.9 ^{a}	5.1 ^{a}	4.4 ^{b}	.09
End breeding weight, kg (July)	470 ^{a}	506 ^{b}	495 ^{b}	9.2
End breeding BCS	4.6 ^{a}	5.1 ^{b}	5.0 ^{b}	.07
Weight at normal weaning date, kg (October)				
Year one[3]	507^{a}	551^{b}	527^{c}	10.5
Year two	495^{a}	571^{b}	558^{b}	11.1
Body condition at normal weaning (October)	5.1^{a}	5.8^{b}	5.7^{b}	.08
205 d weaning weight	220	207	202	6.0
Pregnancy Rates %	88	90	89	

^{a,b,c} in the same row not sharing a common superscript differ (P<.05).

[1] NOR=normal management; NOREW normal management and early wean; LOWEW=restricted nutrition and early weaned

[2] Body condition 1=emaciated 9=obese

[3] Treatment X Year interaction P<.01

Table 2. Body weight gains of early or normal weaned calves.

	Treatments[1]			
	NOR	NOREW	LOWEW	SE
Birth weight, kg	40[a]	39[ab]	39[b]	1.3
Weight at early-weaning, kg	102[a]	91[b]	86[b]	4.5
Pre-early wean gain, kg	61[a]	51[b]	48[b]	3.1
Ending weight, 205 day weaning (October)	220[a]	207[b]	202[b]	5.4

[a,b] Means in the same row not sharing a common superscript differ (P<.05).

[1] NOR=normal manage NOREW normal manage and early wean LOWEW=restricted nutrition and early wean

Table 3. Effect of weaning date on performance of spring calves.

	Weaning replication		
	One	Two	SE
Calf age, d	64	66	3.4
Calf weight at early weaning, kg	86[a]	100[b]	5.3
Pre-early weaning gain, kg	47[a]	60[b]	2.5

[a,b] Means in the same row not sharing a common superscript differ ($P<.05$).

[1] One= calves early weaned in may, Two=calves early weaned in June

Table 4. Effect of supplementation, weaning treatment and season on milk production of spring calving cows.

	Treatments[1]			
	NOR	NOREW	LOWEW	SE
Weaning replication one (May 6, 1996)				
Milk production, kg	4.1	4.3	4.0	.67
Cow weight, kg	477 ^{a}	449 ^{b}	446 ^{b}	5.1
Cow body condition	4.8	4.7	4.6	.09
Weaning replication two (June 5, 1996)				
Milk production, kg	6.3^{a}	5.6^{b}	5.6^{b}	.70
Cow weight, kg	499^{a}	438 ^{b}	429 ^{b}	12.9
Cow body condition	5.3 ^{a}	4.8 ^{b}	4.8 ^{b}	.06

^{a,b} Means in the same row not sharing a common superscript differ (P<.05)

[1] NOR=normal manage; NOREW normal manage and early wean; LOWEW=restricted nutrition and early wean

Table 5. The effects of weaning treatment on BCS and weight changes in spring-calving cows.

	Treatment[1,2]		
Intake Period	NOR[1]	NOREW	LOWEW
Precalving (1/13/95)			
weight, kg.	507[a]	530[b]	517[c]
BSC[3], units	5.4	5.6	5.5
Pre-early weaning (4/13/95)			
weight, kg.	460[a]	433[b]	410[c]
BSC, units	5.0[a]	4.8[b]	4.7[b]
Lactation 120 days (6/23/95)			
weight, kg.	492	487	483
BSC, units	5.2	5.2	5.1
Lactation 180 days (9/23/95)			
weight, kg.	503[a]	560[b]	553[b]
BSC, units	5.4[a]	6.1[b]	6.0[b]

[abc] Means in the same row not sharing a common superscript differ P<.05

[1] NOR=normal manage NOREW normal manage and early wean LOWEW=restricted nutrition and early wean

[3] SE weight = 10 kg , SE for BCS= .12 units

[2] Scale 1=emaciated 9=obese

Table 6. Chemical composition of native grass hay fed during intake determination for spring calving cows.

Item[a]	Native grass hay
Dry matter	95.4
Ash % DM	6.3
CP % DM[b]	4.6
NDF	74.6
ADF	42.6
IVOMD	45.6

[a]Chemical analysis
[b]CP=Kjeldahl x 6.25

Table 7. The effects of supplementation weaning treatment on DM intake of native hay by spring-calving cows.

	Treatment[1]		
Period	NOR	NOREW	LOWEW
Precalving (1/13/95)			
DM intake, kg[2]	8.1[a]	8.4[a]	7.5[b]
Intake, % BW	1.6	1.6	1.5
Pre-early weaning (4/13/95)			
DM intake, kg	9.4[a]	9.0[a]	7.3[b]
Intake, % BW	2.1	2.1	1.7
Lactation 120 days (6/23/95)			
DM intake, kg	8.0[a]	7.1[b]	6.9[b]
Intake, % BW	1.6	1.4	1.4
Lactation 180 days (9/23/95)			
DM intake, kg	7.7	7.9	7.8
Intake, % BW	1.6	1.4	1.4

[ab] Means in the same row not sharing a common superscript differ P<.05

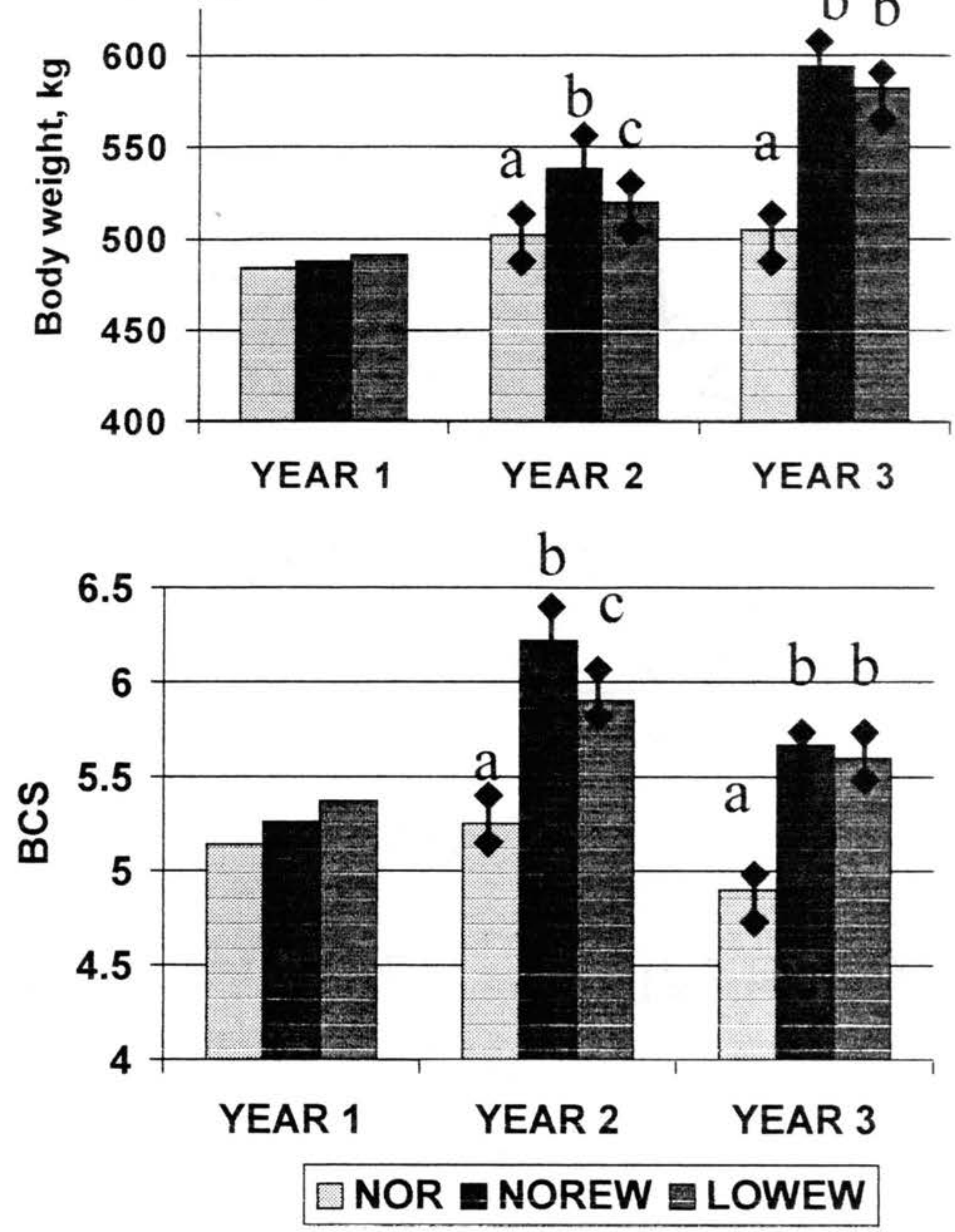
[1] NOR=normal manage NOREW normal manage and early wean LOWEW=restricted nutrition and early wean

[2] treatment x period P<.05

Table 8. Predicted duration to onset of luteal activity following early weaning at 65 days postpartum based on body condition at calving in spring-calving cows.

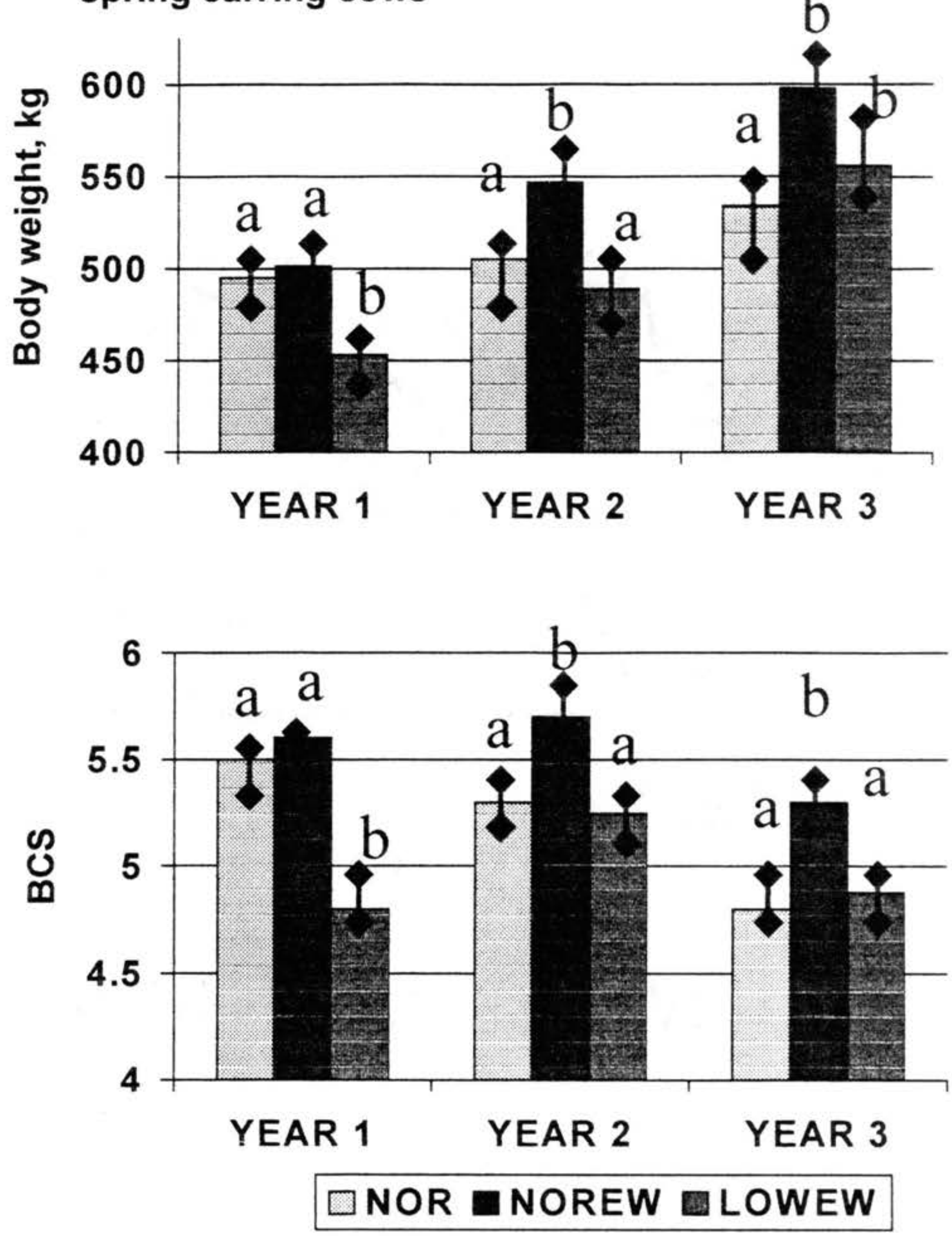
Body condition at calving	4.0	4.5	5.0	5.5	6.0	6.5
Predicted return to estrus, days	31.6	26.0	20.4	14.8	9.2	3.6

Figure 1. Effects of supplementation and weaning treatment on November weight in spring calving cows



abc Means within a set of columns not sharing a common superscript differ P<.05

Figure 2. Effects of supplementation andweaning treatment on precalving weight and BCS in spring calving cows



abc Means within a set of columns not sharing a common superscript differ P<.05

Figure 3. The effect of supplementation and weaning treatment on percentage of cows cycling relative to early-weaning.

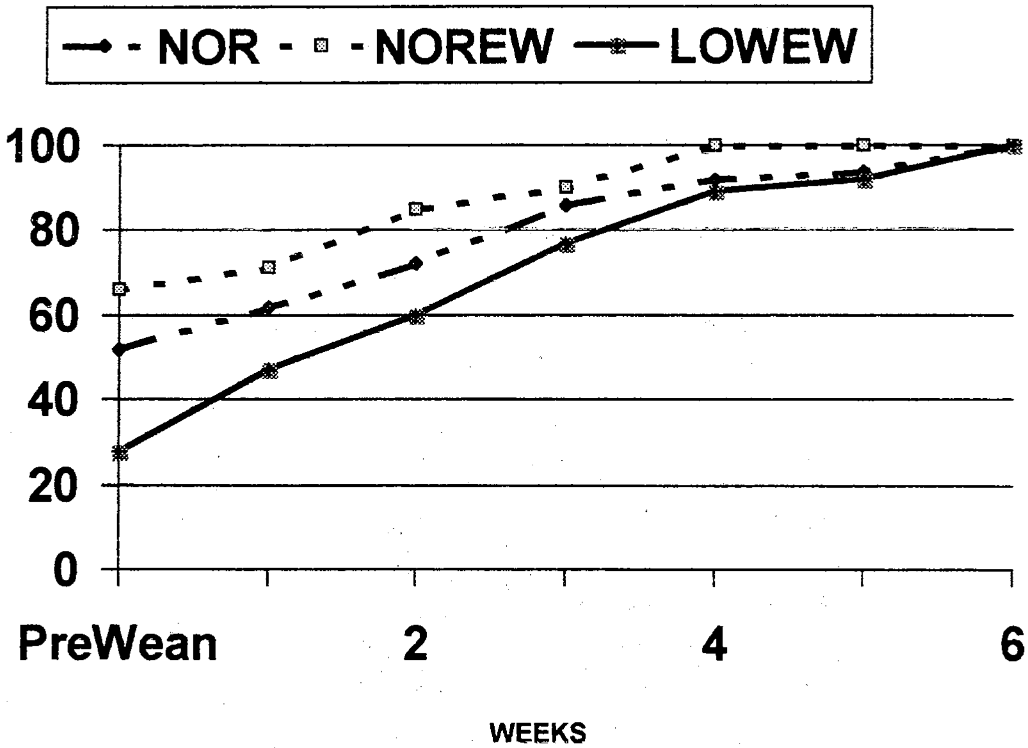


Figure 4. Relationship between postpartum interval and body condition score at calving in spring calving cows early weaned 65-d postpartum.

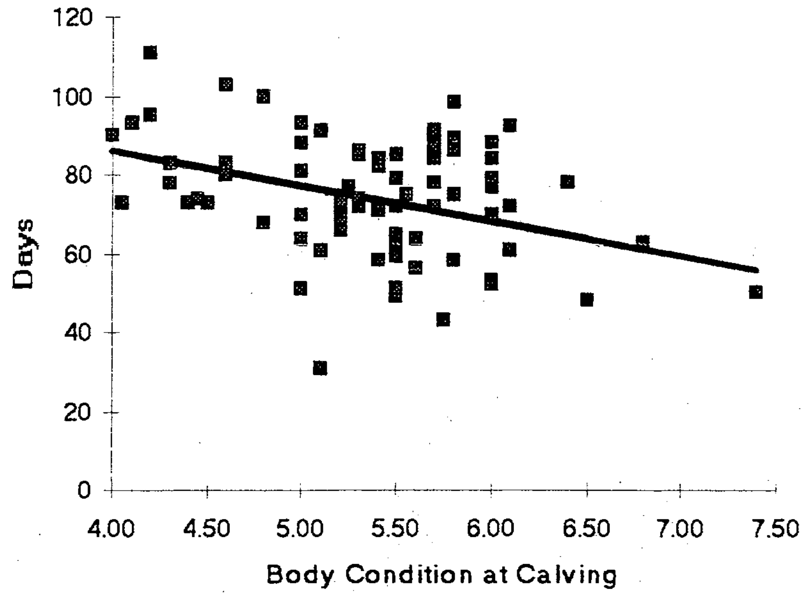


Figure 5. Relationship with days to luteal activity and BCS at calving following calf removal at 65-d postpartum.

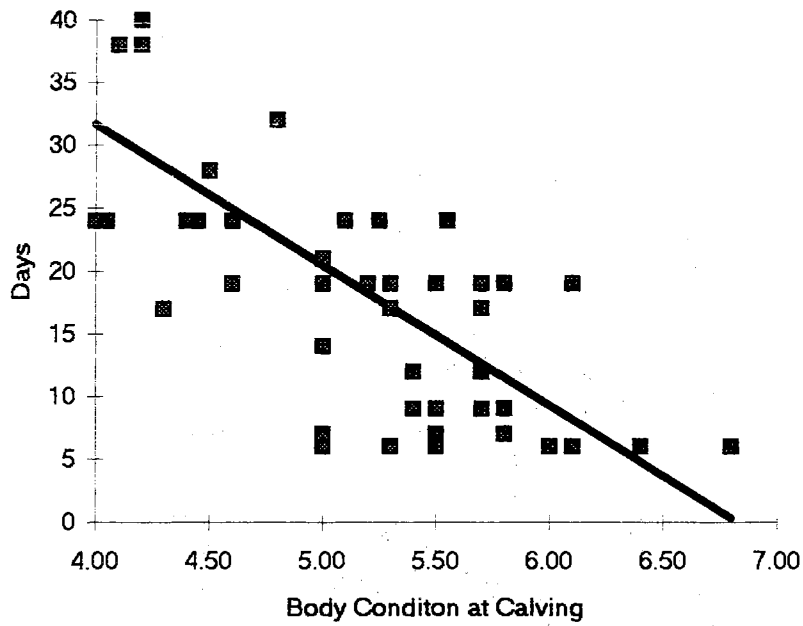
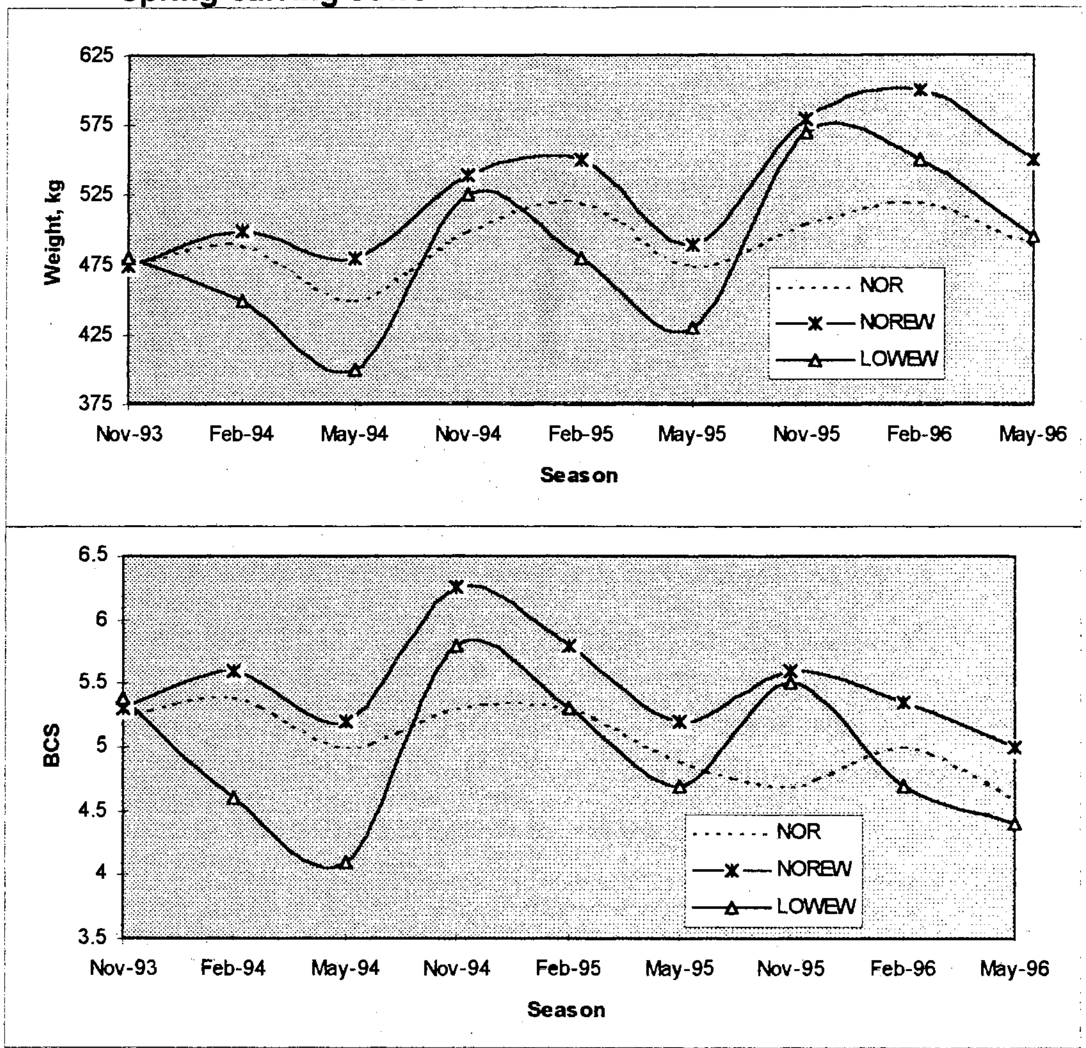


Figure 6. Accumulative effects of early weaning and nutrient restriction on BCS and body weight changes in spring-calving cows



BCS 1=emaciated 9=obese

Chapter IV

Running Head: Grazing systems and early weaning in fall cows

The effects of grazing system and early weaning on productivity and intake of fall calving cows[1].

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Abstract

Two trials where utilized to evaluate the effects of early weaning and grazing treatment on cow productivity and dry matter intake (DMI) of fall calving cows. In trial 1 82 fall calving cows were allotted in a 2 x 2 factorial arrangement of treatments replicated over two years to: grazing systems continuous (CONT), or rotational (ROTATE), and normal weaning (NW) or early weaning at 70 days (EW). Cows on NW received .45 kg of 41 % protein supplement daily beginning in October 1, .91 kg daily beginning November 1, and 1.36 kg daily beginning December 1. Cattle on the EW treatment did received .11 kg of 41% protein supplement fed to gather and observe the cows. All supplements were prorated for 3 d/wk feeding. Early weaned calves grazed wheat pasture from weaning

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until May. In trial 2, 18 fall-calving cows where managed similarly to those in the production trial and the effects of early weaning on dry matter intake were evaluated. Forage intake were evaluated precalving (PRCALV), post calving/pre-early weaning (PREW), 130 days of lactation LAC130), 190 days of lactation (LAC190), and 240 days of lactation (LAC240). There was no grazing treatment x weaning treatment interaction for any independent variable. Precalving and early weaning BCS and weight were not significantly affected by weaning treatment at calving in year one. However, EW cows were heavier and had higher BCS precalving and at early weaning compared with NW during year 2. At the time of normal weaning EW cows where heavier and had greater BCS compared to NW cows. Rotationally grazed cattle were thinner at the time of early weaning and prior to summer grass compared with continuous grazed cattle. Weaning weights (205 day) where similar for EW and NW calves (223 vs 227±9 kg; P=.23). Pregnancy rates where not significantly affected by either weaning or grazing treatment. In trial 2 there was no difference (P > .20) in DM intake (7.7. vs. 7.8±.10 kg.) between EW and NW during the precalving period intake. During the PREW intake NW cows consumed 22 % more (P<.01) native hay than EW cows. During the LAC130, LAC190, and LAC240, EW cows consumed less (P<.01) feed than NW. Mean dry matter intakes for EW cows were 7.7 kg. compared with 9.6 kg for NW during the trial. Early weaning fall calving cows allows for increased storage of body reserves before winter with a significant reduction in supplemental feed without altering reproductive performance. Early weaning results in a 20 % savings in dry matter intake when cows are compared with normal weaned and managed cows.

(Key Words: Fall calving, Beef Cows, Grazing system, Early weaning)

Introduction

The greatest costs to maintain a cow are generally the land required per animal unit year (AUY) and purchased feed inputs. The use of early weaning may decrease cost by allowing increased stocking rates and decrease the requirement of supplement feed (Peterson et al., 1987). Additionally, reduced animal requirements could permit the use of grazing systems that allow increased stocking densities and increase profit per acre. One of the problems facing this type of system is the management of the light weight calf in terms of acceptable gains (Purvis et al., 1995). Fall calving in Oklahoma provides a unique situation where high quality winter wheat may give alternative feed resources for the early weaned calf. The objectives of this trial were to evaluate the use of different weaning regimens and grazing systems on performance of fall calving cows and their calves, and on efficiency of utilization of forage resources.

Materials and Methods.

Trial 1

Experimental treatments .In a two year trial eighty-two multi and primiparous cows were randomly assigned on July 20, 1994 by weight, body condition score (BCS), and age in a 2 X 2 factorial arrangement of treatments. All treatments were replicated within a year to account for pasture differences. Treatments were: grazing system, continuous (CONT) or rotational grazing (ROTATE) and weaning treatment, normal wean, 205 d of age (NW) and early wean at approximately 70 d of age (EW).

Stocking rate and grazing system. The study area is located on Oklahoma State University Animal Science Research Range 21 km southwest of Stillwater, Oklahoma. The climate is continental with an average frost-free growing period of 204 d. Average precipitation during the study was 931 mm, higher that the average 831 mm. The range site study area is primarily, shallow prairie (28%), loamy prairie (25%) and eroded prairie (27%) and the remainder being sandy savannah.

Stocking rate was set at a constant 2.8 ha per AUY. Traditional stocking density's of 4.0 per AUY is considered moderate stocking rate for native grass pasture in Payne County, Oklahoma. Treatments were managed separately with approximately 32.3 ha per treatment. Rotation treatment cattle were moved through a four paddock rotational system with a minimum rest of 28 d per pasture. Continuous grazing systems had full access to their land area at all times. The only exceptions were during the breeding seasons, November 29, 1994 and 1995 through January 30, 1995 and 1996. Cattle within weaning treatment were mixed and allow access to paddocks within replication to facilitate the use of four bulls. Bulls were rotated between treatments every seven days to allow equal days for each in the combined treatments. Grazing days were calculated and animals were rotated between replication pastures so that equal utilization in terms of AUD would be realized. Following the end of the breeding season all cattle were sorted and returned to their respective experimental units

Management and feeding of cows. Cows grazed native range in their appropriate grazing systems for the duration of the trial. Winter supplementation began October 1, 1994 with NW cows receiving .45 kg of a 41% protein supplement (pelleted cottonseed meal) prorated for a 3-day/week feeding. Supplementation rate was increased to .91 kg daily in November, and again in December to 1.36 kg daily for NW cows. Supplement was reduced on March 1 of both years to .91 kg daily and remained at that rate through end of supplementation on April 18, 1995 and April 16, 1996. Early weaned cows were fed .11 kg daily beginning October 1 in both years through April 18, 1995 and April 16, 1996, 3-day a week. This amount was not used directly as a supplement, but rather for gathering cattle. Hay was fed to all cows for 8 d during year one and 14 d during year two due to extreme cold temperature and snow covering the standing forage. All treatments received hay during these periods and this was the only supplemental forage utilized during the trial. Pregnancy rate was determined at normal weaning via rectal palpation.

Calf management. Calves on all treatments were managed similarly up to the time of early weaning. All calves were implanted with Calfoid (Ivy Laboratories, Kansas City, KS) at the time of early weaning. Early weaned calves during year one were then moved 8 km to drylot pens and received for 15 days prior to the initiation of wheat pasture grazing. During year two early weaned calves where moved to drylot and fed a concentrate diet for 40 d prior to wheat (Purvis et al, 1996). All calves received a second implant (Synovex-C, Syntex, Des Moines, IA) approximately 90 d after the initial implant. Calves remained on wheat pasture through May 10, 1995, and May 24, 1996.

Cows had free access to trace mineral salt which provided 200 mg of cholrotracycline (salt 63.5%; dicalcium phosphate 33.3%; copper sulfate; .40%; zinc oxide .43 %; mineral oil 2.85%) and water (exception below) throughout the trial. All cow weights were taken after a 15-hr shrink without feed and water. Additionally, BCS were calculated as the average of two independent evaluators. Weights of NW and EW calves were considered shrunk even though they remained with their dams during the shrinking of cows at the time of early weaning. The 205-day weaning weight was determined after the NW calves were shrunk with their dams, and the EW calves were restricted from feed and water for 14 h.

Dry matter disappearance. Total standing crop at the initiation of the dormant period (October) and spring (March) growing season were determined. Forty .1 m^2 plots were clipped per grazing unit, dried, and weighed to estimate forage removal over winter dormancy.

Trial 2

Animal management. Eighteen fall-calving cows were randomly assigned by weight and BCS to one of two treatments: normal weaning (205 d) and normal protein supplementation, early weaning (70 days) and nutritionally restricted. All cows grazed native range and were managed as a single herd during the study with the exception of the supplementation period. Supplementation of the normal weaned cows began October 1, 1994 when cows received .45 kg of a 41% protein cube consisting of pelleted cotton seed meal. Feeding rate was increased to .91 kg on November 1, and to 1.36 kg on December 1, 1994. Supplementation continued at 1.36 kg per head through April 1, 1995 when supplementation was stopped. Early weaned cows did not receive supplement during the winter months. Therefore, during the supplementation period cows were managed as two separate herds. Hay was given to all cows during a few days in March when snow covered the standing forage. All cows had access to minerals free choice (same as production trial) and water throughout the trial. Cows were exposed to mature bulls from November 27, 1994 through January 29, 1995. Bulls were rotated between treatments weekly. Pregnancy rate was determined via rectal palpation approximately 70 d following bull removal.

Intake determination. Five separate intake trials were conducted throughout a production year. The precalving intake (PRCALV) was initiated prior to calving on August 10, 1994. The second or post calving/pre-early weaning (PREW) intake was performed on November 11, 1995. Early weaning took place November 22, 1994. Following the PREW intake, three lactation intakes were performed, 130 d of lactation (LAC130 January, 11, 1995), 190 d of lactation (LAC190, April 7, 1995), and 240 d lactation (LAC240, June 23, 1995).

All cows were adapted for seven days in a drylot to the same native hay which they would consume during the intake period. Prior to PRECAL intake cows were randomly assigned by treatment to individual stalls (.77 x 2.50 m) in a covered stall barn. Cows were confined to the same stall throughout all five of the intake measurements. Cows had access to native hay at approximately 0700 - 1100 and again from 1300 - 1700 during the collection periods. When the animals were not in the stall barn they were placed in the drylot were they had access to water. Calves of the NW cows remained in the drylot while their dams were in the stall barn. During the PREW and LAC130 intakes NW cows were fed protein supplement daily (.45 and 1.36 kg, respectively) during the morning intake collection.

Sample Collection. Daily DMI of hay was during the 7-day collection period. Hay and ort samples were collected during each of the intake periods and analyzed for CP, ADF, NDF, and invitro digestibility determination. All intakes are reported on a DM basis.

Samples where collected and dried in a forced air oven at 60°C for 48 h, ground through a 2 mm screen and stored in plastic bags and stored at -20° C. Crude protein content of the feed samples where determined as Kjeldahl N multiplied by 6.25 and ash content as described by (AOAC, 1980). Neutral detergent fiber and ADF concentrations where determined by the nonsequential procedure of Goering and Van Soest (1970), with the exception that decalin and sodium sulfite where omitted form the neutral detergent reagent (Robertson and Van Soest, 1981). Invitro digestibility of the hay samples where determined as described by Tilley and Terry (1962).

Animal Measurements. All cows were weighed prior to and after the intake periods following a 15-h shrink without feed or water. Body condition scores were taken at the first weigh period for each intake period.

Statistical Analysis. Data for trial one were analyzed with General Linear Model of SAS (1985) as a 2 x 2 factorial with replications. Model included year, treatment, age, and all two and three way interactions. There was no wean treatment x grazing treatment interaction and only main effects are reported. When the F-test for treatments where significant ($P<.05$) comparisons where made utilizing protected *t*-test (SAS, 1985). In trial 2. data were analyzed as a split plot design with repeated measurements. Treatment was tested with cow(trt) as the error term. Period and the two way interaction of treatment x period was tested with residual error. Calf weights were analyzed as a completely randomized design (SAS, 1985). Dry matter intakes were regressed over intake period for prediction of responses to treatments (SAS, 1985). Means were compared by protected paired *t*-test (SAS, 1985).

Results and Discussion

Effects of grazing system on cow performance. Initial weights and condition scores (July 20, 1994) did not differ for cows in the various treatments (Table 1). Grazing treatment did not affect cow weights precalving or at early weaning weight. However, there was a significant year by grazing treatment interaction for BCS at the time of early weaning. During year one, ROTATE cattle tended (P=.10) to have greater BCS compared with CONT cows (6.0 vs 5.8). However, during year two, CONT cows had greater (P=.01) condition compared with ROTATE cows (6.0 vs 5.7±.07). It is doubtful that this difference in BCS would influence reproduction or performance since the mean BCS of ROTATE cows was greater than 5. Research has indicated that a minimal BCS of 5 is required to assure that body composition will not hinder the postpartum return to estrus (Selk et al., 1987). Following bull removal both ROTATE and CONT cattle where similar in BCS and body weight. Body condition and body weight were lower for ROTATE compared with CONT cows prior to spring grazing. This may be attributed to restricted diet selection in rotational grazing situations (Heitschmidt et al., 1986). Cow weight and BCS at a common 205-day weaning did not differ (P >. 20) between grazing systems. Pregnancy rates where similar for CONT and ROTATE (90 vs 88; P=.91).

Cow performance was not influenced by grazing system as long as growing forage was available. Numerous researchers have reported that rotational grazing decreases animal performance (Allison, 1985, Knight et al., 1987, Gillen et al., 1992). Significant differences were only noted in the current study in the late dormant season prior to summer grazing. During winter dormancy ROTATE cows lost more weight and condition score prior to summer grazing compared with CONT cow. This may be the result of decreased herbage selection in the ROTATE treatment during the dormant period. The benefits of a grazing system on herbage dynamics may only be realized during the growing season. Discontinuing the grazing schedule during the winter months may offset reduction in animal performance during the dormant period with little effect on the vegetation.

Effects of weaning treatment on cow performance. Body condition score and weight of cows were similar (P=.83; Table 2) for the weaning treatments at the initiation of the trial (July 20 1994). There was a significant weaning treatment x year interaction for both precalving weight and BCS. During year one both precalving weight and BCS were similar (P>.20) between treatments. However, during year two, EW cows were heavier and had greater condition scores compared to NW (646, 7.1 vs 586±5 kg, 5.9±.21). Weight at early weaning was similar between treatments. There was a weaning treatment x year interaction for BCS at early weaning. During year one, NW cows had greater (P=.01) BCS at the time of early weaning compared than EW. This was not unexpected since EW cows were not supplemented during the winter months. Reduced protein intake would result in lower intake in the EW treatment as rumen N was probably limited (McCollum and Galyean, 1985, McCollum and Horn 1990). However the following year, EW cows had greater (P=.01) BCS than NW cows. Prior to spring grass EW cows where lighter (P=.05) and thinner (P=.03) than NW. Up to that point, EW cows had lost more weight (P=.01) and BCS (P=.03) during the winter dormancy (-129, -1.5 vs -81 kg -.85). At the time of normal weaning (205 d) EW where heavier (P=.04) and had more

(P=.01) BCS than NW cows. Pregnancy rate was similar (P>.20) for EW (92%) and NW (88%).

The largest difference between treatments in cow weights and BCS for both years occurred following the winter period. However, this response would be expected with the reduced supplementation of EW cows during this period. During year two EW cows had greater BCS and body weight at calving. With the cessation of suckling EW cows where able to gain more weight and BCS from the time of spring grass to precalving time the subsequent year. This additional weight and condition score carried over to year two to allow for more body reserves at subsequent calving season. The accumulative affects of early weaning coupled with reduced supplementation are shown in Figure 1.

Dry matter disappearance. Weaning treatments did not influence dry matter disappearance. However, ROTATE pastures tended (P=.07) to have less disappearance than CONT pastures (Figure 2) during the winter dormancy period. This is in agreement with Caslses et al., (1995) that found under a similar range situation standing crop was greater for rotational grazed paddocks compared with continuous grazed paddocks. Additionally the authors suggested that increased standing crop was partly due to decreased herbage intake. Our performance data would suggest that ROTATE cows consumed less herbage during the winter period because they lost more (P<.05) weight and BCS than CONT cows.

Calf data. Neither grazing treatment or weaning treatment affected birth weight or weight at early weaning. Purvis et al., (1996) reported that spring calving cows on a similar nutritional regimen as EW cows had calves with decreased birth weight of calves compared with NW cows. Reduced birth weights in the spring cows are probably due to nutrient restriction in relation to the season the last trimester of pregnancy. The last trimester of pregnancy of fall calving cows was during late summer versus early winter for the spring calving cow. Performance of the light weight early weaned calf must be similar to NW calf for this system to be viable. The management of the light weight calf in terms of immune function needs to be considered further. Early weaned calves experienced a 10% mortality, and 32% morbidity during year one and 2% mortality and 12% morbidity during year two. Weaning treatment had no difference in 205 day weaning weight (218.2 vs. 225.9 kg) of the calves.

Trial 2

Animal Performance. Cows weighed 639±12 kg at the initiation of the trail (Table 3). Additionally, there was no difference in initial BCS between treatments (7.3, EW vs. 7.3 NW P=.74). Body weight was less ($P < .01$) for EW cows compared with NW at the time of the PREW and LAC130 intakes. Body weight tended to be less ($P = .10$) for EW compared with NW during the LAC190 intake period, and body weight were similar at the LAC240 intake.

Body weight and BCS loss for EW cows were greater compared to the NW cows. This reflects the difference in the nutritional regimen that was imposed on the EW cows compared with NW. Restricting supplement to the EW cows would impact their ability to maintain enough energy for maintenance and therefore body weight loss would reflect tissue being utilized for energy similar to the production trial.

Dry Matter Intake. Dry matter intake of the native hay (Table 4) was not influenced by treatments during late gestation (P=.89; Table 5). During the PREW intake EW cows consumed less (P < .01) hay compared with. Additionally, DM intake in EW (8.5 vs. 7.7±1.1 kg) and NW (11.3 vs. 7.8±1.1 kg.) cows were greater (P<.01) than the PREW intake compared with the PRECAL intake. The increase in forage DMI for both treatments during the PREW intake compared with PRECAL intake is due to the initiation of lactation after parturition (Marston et al., 1995). The difference in intake between treatments during the PREW is due to the supplemental protein which was fed during this period. Normal weaned cows had a 15% increase in DMI compared to EW cows. Similar responses to supplementation have been reported in steers consuming low quality prairie hay (McCollum and Galyean, 1985). Forage DMI during LAC130, LAC190 and LAC240 was greater (P < .01) for NW compared to EW. The reduction in forage dry matter intake during lactation observed in the EW cows is due to the cessation of the nutrient demand for milk synthesis. Normal weaned cows had higher forage DMI during the entire lactation period compared with EW (Figure 3). Mean DM intake for EW cows was 7.7. vs. 9.6±1.1 kg for NW cows (P < .01). Overall this relates to about a 20% decrease in forage intake in EW cows.

Initial intakes were about 1.2 % of body weight in both NW and EW cows. These values are considerable less than earlier reports by Marston and Lusby

(1993) who found that intake during gestation to be about 1.6 % BW in cows consuming native hay. Our estimate of DM intake during the PRECAL period may be biased due to the high condition scores and body weights at the initiation of the trial (Table 3). Following the PRECAL intake period, the DM intake for EW cows were about 1.5 % of BW though the remainder of the trial, which is similar to the values found by Marston and Lusby (1993) in spring calving cows. Intake during lactation periods for the NW cows were about 1.85 % BW, which agree with Marston and Lusby, (1993) and Thrift et al., (1993) who found that cows consuming native hay or grazing dormant native range consumed around 1.8 - 2.2 % body weight during lactation.

There was no difference (P > .20) in pregnancy rate between treatments. Calf birth weight was similar (P = .87) between EW and NW cows (40 vs 40 kg, Table 6). Additionally, at the time of early and normal 205 d weaning calf weights were similar.

Implications

The use of early weaning in fall calving cows can be an alternative management practice in Oklahoma. There appears to be little interaction between grazing system and weaning treatment. However, both affected the overall performance of cows especially during the winter months. Early weaning would resulted in a significant savings of about 20% in terms of DMI through a production year. However, direct application of DM savings in the current trial does not equate into an 20% increase in stocking rate. The biggest concern with this type of system is the management of the light weight calf. High mortality and morbidity was observed in this study, and would be economically detrimental for the application of such a system. Cow performance can be modified and still retain adequate rebreeding rates. Other factors such as current stocking rate, current herd management, herbage mass, herbage quality should be considered prior to altering current stocking density.

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Table 1. The effects of grazing system on performance of fall-calving cows in Trial 1.

Item	CONT[a]	ROTATE	SE[b]	P-value
Initial weight, kg	585	577	4.3	.62
Initial BCS[c]	6.7	6.5	.39	.21
Precalving weight, kg	616	611	3.6	.12
Precalving BCS	6.6	6.6	.14	.93
Calf birth weight, kg	38	37	3.4	.88
Weight at early weaning, kg	554	556	6.4	.81
BCS at early weaning				
Year 1	5.8	5.9	.07	.10
Year 2	6.0	5.7	.07	.01
Calf weight at early weaning[d],kg	105	112	4.5	.42
End of breeding weight, kg	488	480	6.8	.41
End of breeding BCS	5.2	5.1	.13	.14
Late winter weight, kg	438	421	4.6	.05
BCS at late winter weight	5.2	4.8	.11	.06
Weight 205 day weaning, kg	515	503	9.6	.41
BCS at 205 day weaning	5.6	5.4	.13	.41
Pregnancy rate, %	90	88	5.1	.91

[a] CONT = continuos grazed ROTATE = rotational grazed
[b] SE=standard error average of the least square means in a row
[c] Scale 1 = emaciated 9 = obese
[d] Weights adjusted for calving date and age of dam

Table 2. The effects of weaning treatment on performance o fall-calving cow in Trial 1.

Item	EW[a]	NW	SE[b]	P-value
Initial weight,kg	580	583	8.6	.83
Initial BCS[c]	6.5	6.6		.23
Precalving weight,kg				
Year 1	612	612	5.9	.98
Year 2	646	586	5.0	.01
Precalving BCS				
Year 1	6.6	6.6	.25	.88
Year 2	7.1	5.9	.21	.01
Calf birth weight, kg	37.5	38.9	3.4	.84
Weight at early weaning,kg	568	543	6.0	.05
BCS at early weaning				
Year1	5.7	6.2	.07	.01
Year 2	6.1	5.5	.06	.01
Calf weight at early weaning[d] , kg	111	106	4.5	.32
End of breeding weight, kg	489	479	6.2	.38
End of breeding BCS	5.37	5.10	.10	.32
Late winter weight, kg	439	461	5.7	.05
BCS at late winter weight, kg	4.4	5.0	.09	.03
Weight 205 day weaning, kg	533	485	6.7	.04
BCS at 205 day weaning	6.1	5.3	.13	.01
Pregnancy rate, %	88	92	4.1	.84

[a] EW = early weaning NW = normal weaning

[b] SE=standard error average of the least square means in a row

[c] Scale 1 = emaciated 9 = obese

[d] Weights adjusted for calving date and age of dam

Table 3. The effects of weaning treatment on BCS and weight changes in fall calving cows in Trial 2.

Intake Period	EW[1,2] (n=9)	NW (n=9)	P-value
Precalving (8/10/1994)			
weight, kg.	633	642	.46
BSC[3], units	7.3	7.3	.74
Pre-early weaning (11/11/94)			
weight, kg.	518	550	.001
BSC, units	5.5	6.1	.03
Lactation 130 days (1/11/95)			
weight, kg.	474	525	.004
BSC, units	4.5	5.2	.04
Lactation 190 days (4/7/95)			
weight, kg.	478	496	.10
BSC, units	4.7	5.0	.27
Lactation 240 days (6/23/95)			
weight, kg.	578	565	.23
BSC, units	6.2	5.8	.06
Pregnancy Rate, %	100	88	.74

[1] EW=early wean NW= normal wean

[2] SE weights=12.8 kg, SE BCS=.10 units

[3] Scale 1=emaciated 9=obese

Table 4. Chemical composition of native grass hay fed inTrial two.

Item[a]	Native grass hay
Dry matter	93.3
Ash % DM	6.7
CP % DM[b]	4.8
NDF	72.6
ADF	43.6
IVOMD	44.5

[a]Chemical analysis
[b]CP=Kjeldahl x 6.25

Table 5. The effects of weaning treatment on DM intake of native hay by fall calving cows in Trial 2.

Period	EW[1,2]	NW	P-value
Precalving (8/10/1994)			
DM intake, kg	7.7	7.8	.89
Intake, % BW	1.2	1.2	.84
Pre-early weaning (11/11/94)			
DM intake, kg	8.5	11.3	.0001
Intake, % BW	1.6	1.9	.07
Lactation 130 days (1/11/95)			
DM intake, kg	7.4	11.0	.0001
Intake, % BW	1.5	1.9	.06
Lactation 190 days (4/7/95)			
DM intake, kg	8.1	11.2	.002
Intake, % BW	1.6	2.0	.05
Lactation 240 days (6/23/95)			
DM intake, kg	7.7	10.3	.002
Intake, % BW	1.3	1.6	.09

[1] EW=early wean NW= normal wean

2 SE intake = 1.1 kg, SE % body weight = .12 %

Table 6. Effects of weaning treatment on body weight changes in fall born calves in trial 2.

Item	Early Weaned	Normal Wean	P-value
Birth weight, lb.	40	40	.87
Weight at EW, lb.	97	98	.67
Weaning Weight, (6/23/95)	226	227	.84

Figure 1. Accumulative effects of early weaning on cow body weight and BCS in fall-calving cows.

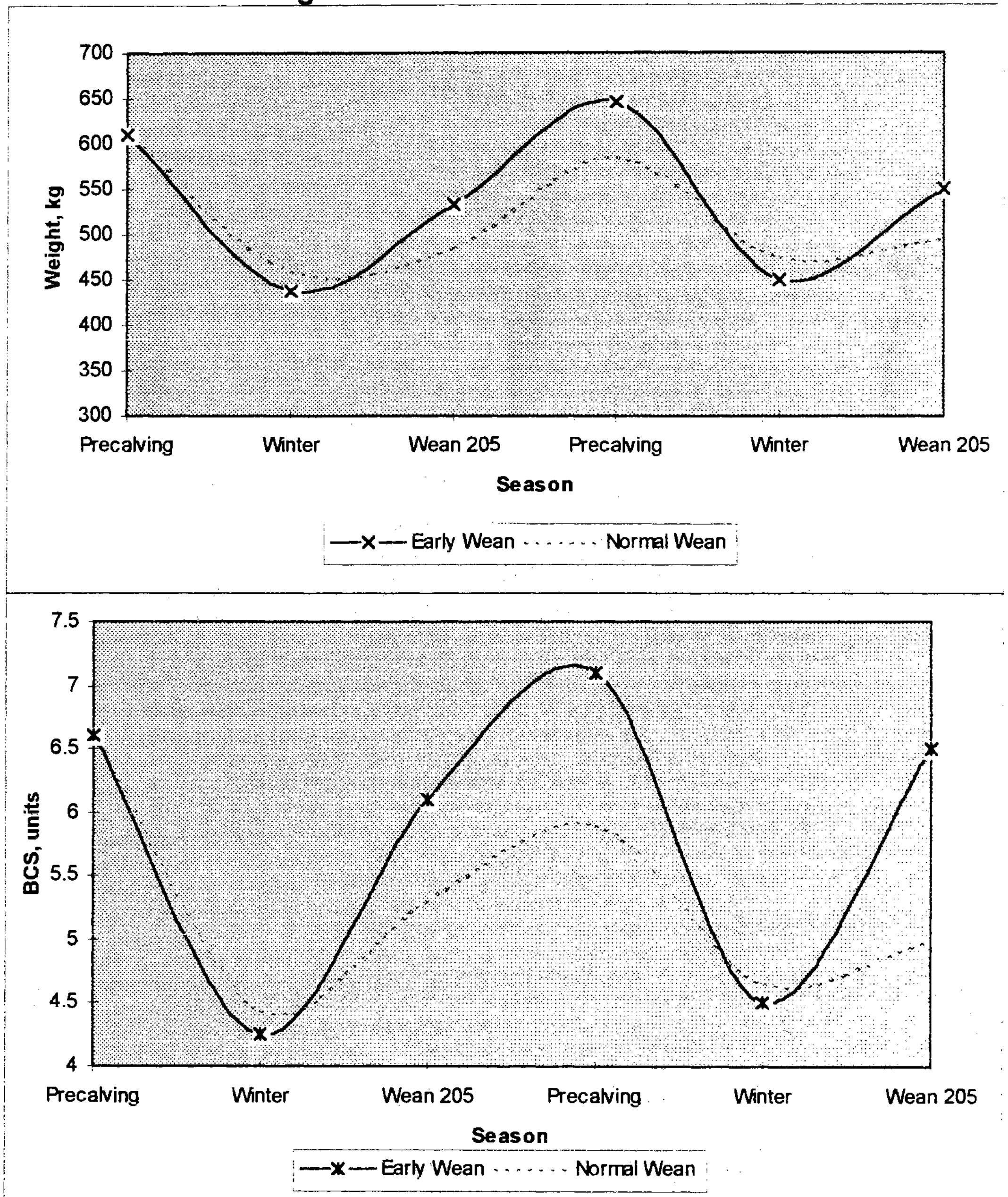
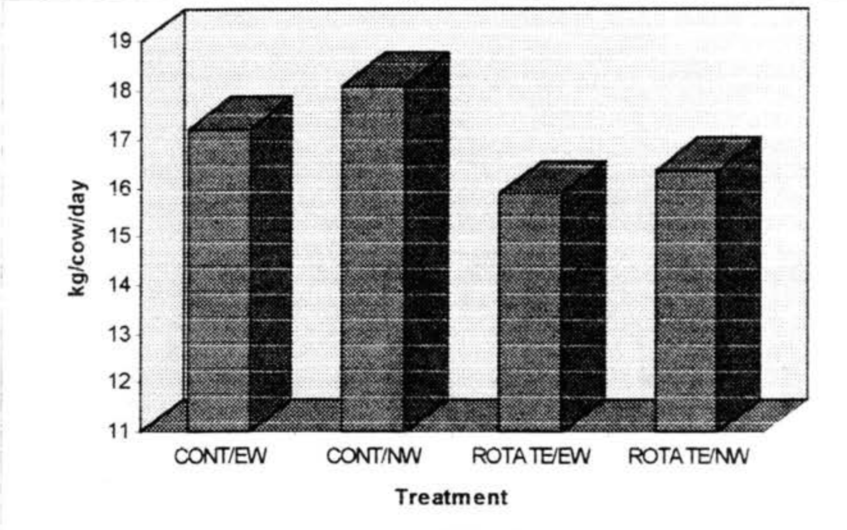
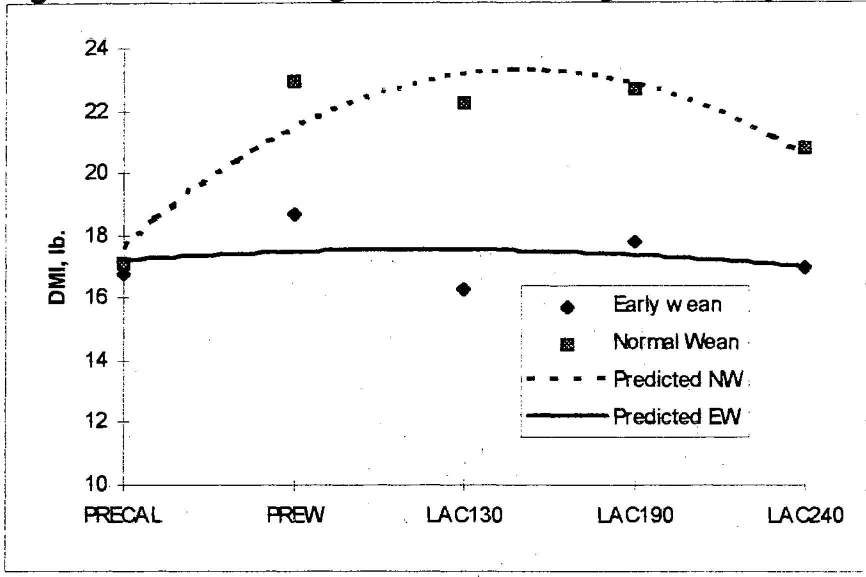


Figure 2. Dry matter disappearance per cow following 164 d winter grazing period



Grazing treatment (P=.07)

Figure 3. The effects of weaning treatment and supplemental protein on forage DMI of fall calving cows consuming native hay in Trial 2.



Chapter V

Running Head: Early weaned calves grazing winter wheat

Performance of early weaned fall born calves grazing wheat pasture[1]

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Abstract

These trials were conducted to evaluate live weight gain of early weaned fall-born calves grazing winter wheat. Calves from fall-calving cows were early weaned on December 10, 1993 (year one n=55) and November 29, 1994 (year two n= 44) and placed in a drylot for approximately 15 days. During the 15-d receiving period, calves received native hay and were supplemented daily with .91kg of a 40% CP supplement. During year three 43 fall-born calves where weaned November 29, 1995 and received in a drylot for 30 d on a concentrate diet and then moved to winter wheat. The basal drylot diet consisted mainly of corn, cotton seed hulls and soybean meal and wasformulated to provide 16% CP, 1.87 Mcals of Nem/kg, and 1.14 Mcals of NEg/kg on a DM basis. Following

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each receiving period calves were moved approximately 29 km to the Wheat Pasture Research Unit in Marshall, OK. Average daily gain for year one was .93 kg.d (134d) and .80 kg/d (138d) for year two. Regression analysis revealed a quadratic (P < .01) increase in ADG during years one and two as calf age increased. As body weight of calf increased there was a linear (P<.01) increase in expected ADG in year one. However, during year two a quadratic response (P<.01) was observed. Calf performance in both years appeared depressed during the initial period on wheat (.64 kg/d year one and .15 kg/d year two). Calves weighing less than 145 kg or younger than 160 d did not gain above .91kg /day which would be common for this weight of calf if suckling the dam. During year three calves where fed in drylot to a weight 140.5 kg and a age of 120 d. Similar growth patterns where realized with depressed weight gain during the initial period on wheat (.43 kg/d). Average daily gain for the 102 day grazing trial was .89 kg/d. Predicted weight and age needed to attain a rate of gain of .91 kg/d for year three would be 186.4 kg and 155 days of age. Initial weight gain in light weight stocker calves is not related to body weight. Initial gain is also limited by age in some respects as predicted age for calves to gain above .91 kg was similar with cattle at different initial body weights. Acceptable weight gains in light weight stocker calves grazing winter wheat can be realized following an adaptation period.

(Key Words: Early Weaning, Stocker Calves, Wheat Pasture.)

Introduction

Lower calf prices pressure the cow-calf segment of the industry to decrease annual cow cost. The practice of early weaning is an option that may decrease feed (Peterson et al., 1987) and land requirements needed per unit of calf weaned. The largest problem this practice faces is management of the early weaned calf. Early weaning of fall-born calves in Oklahoma allows producers the option of utilizing wheat as a forage based growing program for light weight calves. To date there is little research concerning utilization of high quality forage such as wheat pasture by very young, light weight calves. The objective of these trials was to quantify performance of young light weight calves grazing wheat pasture.

Materials and Methods.

Years one and two. Calves from 55 (year one) and 44 (year two) multiparious fall calving cows were early weaned on December 10, 1993 and November 27, 1994. At the time of weaning during year one all calves were vaccinated with either Ultrabac 7 (5 cc s.c. Boehringer Inglheim) or Alpha-7 (2 cc s.c. Boehringer Inglheim) and during year one calves received Ultrabac 7 (5 cc s.c. Boehringer Inglheim). One calf died in year one two days following early weaning, however this calf was being treated for respiratory illness prior to weaning. Calves were supplemented daily with .91 kg of a 41% crude protein pellet (pelleted cottonseed) and allowed free access to native hay for 20 days in year one and 10 days in year two. Following the receiving period during both years calves were vaccinated with BoviSheild 4 + L5 (2 cc i.m. SmithKline Beecham) and TSV-2 (2 c.c. intranasal, SmithKline Beecham). After vaccination all calves were transported 29 km to the Wheat Pasture Research Unit near Marshall, OK. Calves grazed winter wheat from December 12, 1993 to May 11 in year one, and from December 9, 1994 to May 10 1995 in year two. Calves had free access to wheat pasture, water, trace mineral salt, and a round bale of grass hay during the grazing period. Calves were monitored daily for sickness and treated with Micotil (Elanco, Animal Health) if rectal temperature was above 40°C. During year one, one calf died of polioencephlomacia and all calves during that year received a thiamin, (B1 HCL) injection on February 22, 1994. All calves were weighed on and off trial following a 15 h shrink. However, intermittent weights were taken full at approximately 0900.

Year 3. Forty-three fall born calves where early weaned on November 29, 1995 and moved to drylot. Initially calves were vaccinated with BoviSheild 4 + L5 (2 cc i.m. SmithKline Beecham) and TSV-2 (2 c.c. intranasal, SmithKline Beecham). On December 5, 1995 all calves received were mass medicated with an injection of Micotil (Elanco, Animal health) due to numerous acute respiratory problems (25% morbidity).

The basal diet (Table 1) was formulated to provide 16% CP, 1.87 Mcals of NEm/kg, and 1.14 Mcals of NEg/kg on a DM basis. Calves were maintained within a drylot pen, sorted by weight and had access to water at all times. Bunks were managed so adlibitum intake was met within a 24-hr period and very little feed remained in the bunks the following morning. All pens were fed at approximately 0730 daily (60% of daily feed) and again at 1400 (40% of daily feed). Calves were on full feed within eight days following weaning. No feed refusals were noted and the ration appeared to be very palatable. Calves where transported to the Wheat Pasture Research Unit on January 12, 1996 and remained on wheat pasture through April 24, 1996.

Statistical Analysis. Data were originally sorted by animals that received medication during the receiving period, prior to wheat and analyzed as a completely randomized block. There was no effect of medication status on receiving or subsequent gain on wheat pasture. Therefore, data were analyzed a completely randomized design utilizing GLM of SAS (1985) with sex considered the main effect to generate least square means. Least square means within a year are the average weight gains for both steer and heifer calves. Regression analysis (SAS, 1985) was utilized to evaluate the effects of initial age and weight on expected daily gains of calves on wheat. Individual response curves were calculated by year.

Results and Discussion

Calf Gains. Calves weighed 98 kg in year one and 97 kg in year two at the time of early weaning (Table 2). During the receiving period calves gained .57 kg/day during year one and .28 kg/d year two. Lower gains during the receiving period during year two may be attributed to the fact that 13% (n=6 head) were treated for respiratory disease. Calves weighed 107 kg in year one at 100 days of age, and 99 kg year two at 105 days of age when they were moved to wheat pasture. Initial weight gains on wheat for year one and year two were lower than those realized later in the grazing season. Overall ADG while the calves grazed wheat pasture where .87 kg/d for year one and .81 kg/d for year two. During year three, calves weighted 97 kg at the time of early weaning. Calf gains during the 30-day receiving period average 1.18 kg/d. Initial weight of calves going on to wheat averaged 141 kg with an initial age of 120 days. Similar to years one and two, gains during the first days were reduced during the initial grazing period (.61 kg/d first 28 days). Total average daily gain for the 102 day trial was .85 kg.

Health. During year one there was 10% morbidity in the calves with one loss to polioenceplomacia. During year two, morbidity reached 30% with a mortality of 10% while calves were on wheat. As mentioned earlier some calves were sick prior to the transport to wheat pasture, and this may have attributed to the increased sickness and mortality in year two. Most of the illness during year two was respiratory with the exception of one bloat-related death. During year three one calf died shortly following weaning from pneumonia and a morbidity rate of 25% was realized in the remaining calves during the trial. Most illness and death of the calves for all years was realized in the first 30 days following early weaning.

Regression Analysis. Regression analysis by years revealed a quadratic ($P<.01$) increase in average daily gain (ADG) when ADG was regressed against age (Figure 1; Table 3). Additionally, as body weight increased there was a linear ($P< .01$) increase in ADG in year one and a quadratic ($P<.01$) increase in

ADG during year two (Figure 2; Table 3). Age and weight are highly correlated variables and both explain a portion of the variation in ADG of these light weight calves. Age, weight, and sex were utilized in stepwise regression and did not improve the prediction equation. During the initial periods for both years ADG was below .91 kg/day this rate of gain would be unacceptable considering calves gain at least .91 kg/day while suckling their dams and receiving a 12% CP creep feed.

The observation that age and weight limits initial gains on wheat may lead to different strategies during the receiving period. The equations for years one and two allow one to predict the average weight at which calves would be expected to gain greater than .91 kg/day. Calves during year one needed to be 160 days of age or 135 kg to attain a rate of gain of .91 kg/day. During year two calves would need to be 165 d or 140 kg to attain a rate of gain of .91 kg/d. Initial age and weights for both years one and two were less than the average 140 and 165 days of age needed to gain .91 kg/day.

Other management techniques such as short term conditioning with a concentrate diet during the receiving period may increase initial weight and age of calves prior to the grazing period (Purvis and Lusby, 1996). During year three calves where placed in a drylot and fed concentrate for 30 d. Initial weight going on wheat was 141 kg with an average age of 120 days. There was a quadratic ($P<.01$) effect of age on ADG in the calves for year three (Figure 3; Table 3). Additionally, there was a significant linear effect of weight on ADG (Figure 4; Table 3). Predicted weight, from year 3, would have to be 186.4 kg for a calf to gain above .91 kg/d. However, age of animal was similar to the previously predicted values at 155 days of age to gain .91 kg/d. Therefore, weight per se does not seem to be as good a predictor of daily gain as does age. It is interesting to note that even though initial body weights where different between trials (one and two vs three), the age at which an animal would gain .91 kg/d was similar for all three data sets. The period of depressed gains during the initial periods may be age related, metabolically linked or simply an environment/diet change adaptation.

Implications

Overall, calves gained .84 kg/day while grazing wheat pasture. Less than optimal weight gains were realized during the first grazing periods during all years. During year three animals where heavier and older than for years one and two, yet initial weight gains on wheat pasture were still depressed. Special management during the receiving period may be needed to increase weight prior to placement of early weaned claves on wheat pasture.

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Table 1. Composition of diets for year 3 (%dry matter basis.)

item	Ration(%)
Cottonseed hulls	14.7
Alfalfa pellets	14.9
Corn (rolled)	49.2
Soybean Meal (47%)	14.6
Cane Molasses	4.7
Limestone 38%	.09
Dical	.05
Vitamin E (50%)	.002
Vitamin A	.0015
Deccox (grams/ton)[a]	20.4

[1] Decoquinate

Table 2. Live weight gains of early weaned, light weight calves grazed on wheat

Item	Year 1 93-94	SE	Year 2 94-95	SE	Year 3 95-96	SE
Initial age	76	.06	80	10	80	7.0
Weight at early weaning, kg	98	4.5	97	5.9	97	3.8
Receiving period ADG, kg	.57	.04	.28	.04	1.18	.05
Weight at the end of receiving, kg	107	2.3	99	2.7	141	4.1
Wheat pasture ADG, kg						
ADG1 (year one, 12/2793-1/3/94) (year two, 12/9/94/1-12/95) (year three,1/12/96-1/23/96	.65	.04	.34	.03	.25	.07
ADG 2 (year one 1/3/94- 2/9/94) (year two 1/12/95-2/2/95) (year three 1/24/96-1/30/96	.67	.03	1.13	.06	.61	.08
ADG 3 (year one 2/9/94-3/3/94) (year two 2/2/95 - 2/28/95) (year three 1/31/96-2/6/96)	.86	.05	.94	.01	.74	.12
ADG 4 (year one 3/3/94 - 3/22/94) (year two 2/28/95 - 3/30/95) (year three 2/7/96-2/13/96)	.97	.04	.82	.03	.84	.14
ADG5 (year one 3/24/94- 4/20/94) (year two 3/30/95 - 4/28/95) (year three 2/14/96-3/5/96)	1.2	.05	1.13	.03	.89	.06
Grazeout, ADG 6 (year one 4/20/94 - 5/11/94) (year two 4/28/95 - 5/10/95) (year three 3/6/96-4/24/96)	.66	.04	.66	.03	1.08	.05
Total ADG grazing wheat	.87	.03	.81	.05	.85	.05
Total ADG. (weaning to May)	.93	.01	.85	.03	.88	.03
Total Gain	123	2.7	126	3.2	123	4.2
Morbidity, %	10		30		25	
Mortality, %	3		10		3	

Table 3. Regression equations to predict ADG in light weight stocker calves grazing wheat pasture.

Item	Equation	r^2
Year one		
age	ADG = 1.94 + (-.016 *age) + (.0001*age^2)	.46
weight	ADG = .96 + (.00014 * weight) + (.00009 * weight^2)	.35
Year two		
age	ADG =.89 x (-.003*age) + (.00006* age^2)	.43
weight	ADG = .21 + (.0053*weight)	.33
Year three		
age	ADG = -3.5 + (.057 *age) + (.00014 *age^2)	.36
weight	ADG = .18 + (.0011 *weight) + (x .000008 *weight^2)	.32

Figure 1. The effects of age on expected average daily gain of light weight stocker calves year 1 and 2.

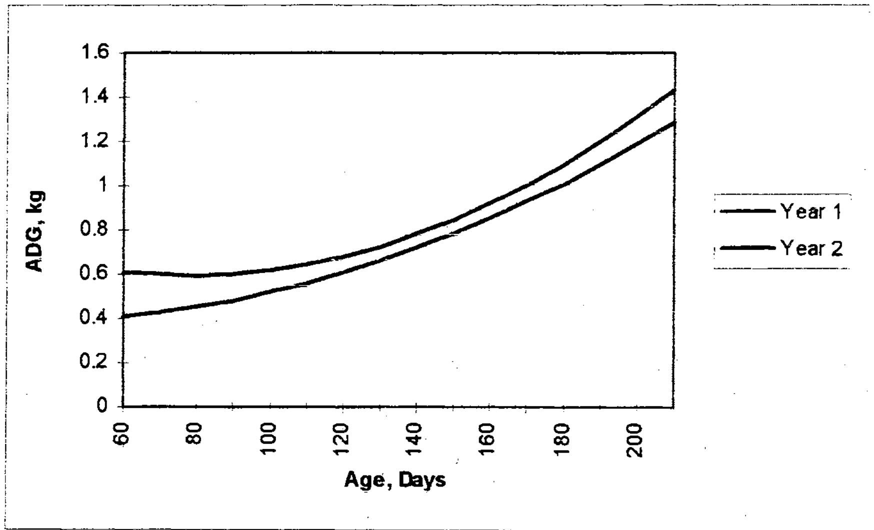


Figure 2. The effects of live bodyweight on expected ADG in light weight stocker calves year 1 and 2.

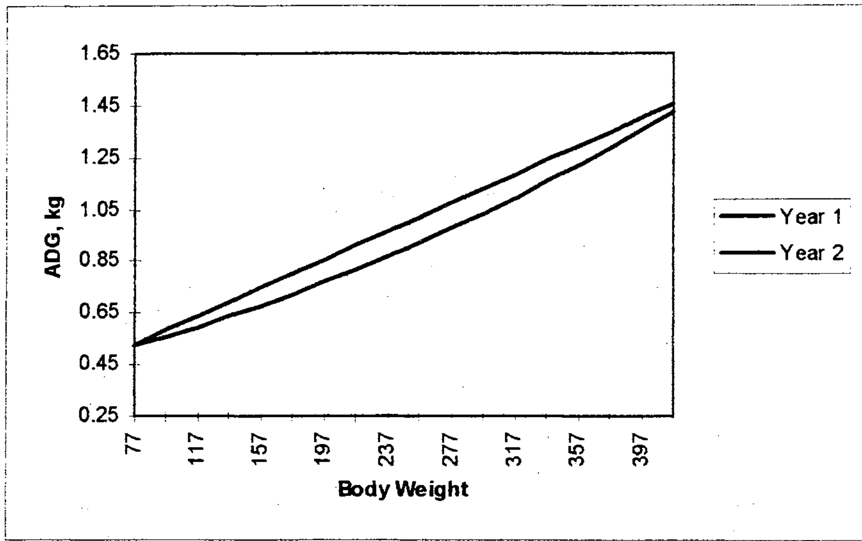


Figure 3. The effects of age on expected average daily gain in light weight stocker calves year 3.

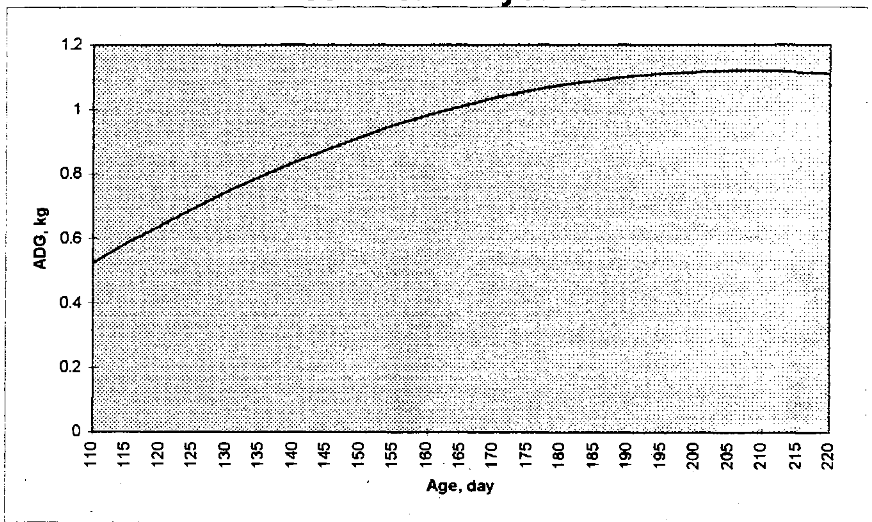
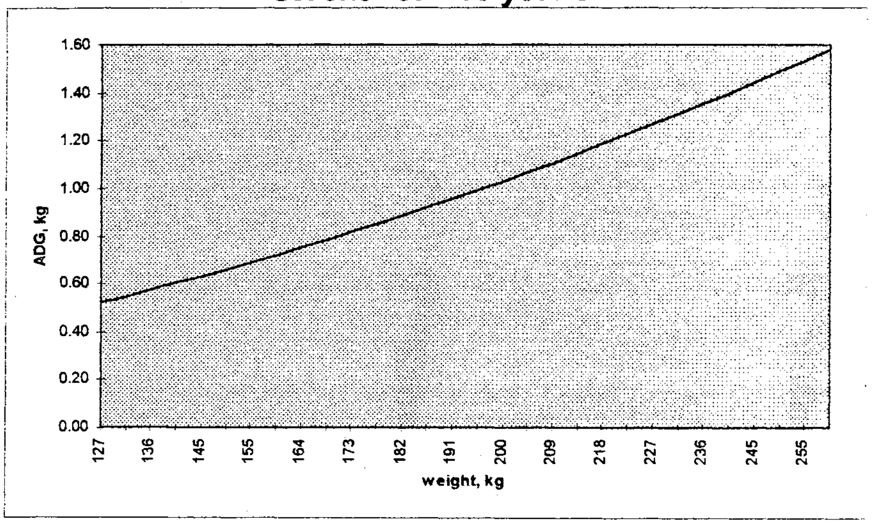


Figure 4. The effects of live bodyweight on expected ADG in light weight stocker calves year 3.



Chapter VI

Summary and Conclusions

Summary of early weaning and grazing systems on spring and fall-calving cows

H.T.Purvis II

Competition for the consumer dollar by other industries makes it necessary for cattlemen to evaluate new and different management techniques to lower production cost. The two largest expenses in the cow-calf segment of the industry is the land to maintain AUY and additional supplement or harvested forages. In theory early weaning should drastically reduce the amount of forage and purchased supplement need to maintain the cow through a production year. However, to date the accumulative effects of early weaning on cow productivity has not been documented.

To evaluate the effects of early weaning on spring-calving cow productivity a large scale three year study was implemented. Body weight and condition score fluctuated drastically in the early weaned nutritionally-restricted cattle. Nutrient restricted cattle where well below a minimum condition score of 5 at the time of calving during all three years. However, following early weaning these cows gained more weight and body condition compared to the normal managed herd. This may be the result of compensatory gain coupled with cessation of the lactation. The ability to build body stores over the summer and early fall allowed these cows to go into the subsequent calving season with more body condition than the normal managed herd.

Dry matter intake was determined on a subset of the production cows during the second production year. Total dry matter intake was lower for early weaned cows compared with normal weaned. Savings in dry matter intake due to early weaning ranged from 5 to 15%. It would appear that some increase in stocking rate could occur over time if animals were continually early weaned. This would be beneficial due to the fact early weaned calves weighted less than normal weaned during all years of the study.

Reproductive performance in terms of pregnancy rates were not affected by weaning treatment. This agrees with other reports that thin cows will return to estrus following calf removal. Additionally, BCS at the time of calving affected days to luteal activity even when the calf was removed. Therefore it would appear the return to luteal activity following early weaning is dependent on BCS at the time of calving.

Our results should allow cattlemen to evaluate early weaning as an option for there operation. When dealing with thin cows or first calf heifers early weaning may be a viable management decision. Additionally, in times of short forage supply one may see performance benefits in terms of increased weight and BCS when cows early weaned. To implement this management scheme on a long term basis a producer would have to; increase stocking rate to offset lower calf performance, retain ownership of calves through the stocker phase, or find an alternative growing programs that would assure better gains than realized on native range.

In a second experiment 82 fall-calving cows where used to compared the effects of weaning treatment and grazing systems on cow productivity. There was no interaction between grazing and weaning treatments for any variable measured. Cattle on rotational grazing (RG) lost more weight and BCS through the winter compared to continuous (CONT). However, following summer grazing there was no difference in BCS or weight prior to calving the following year. Grazing system did not affect reproductive rates or weight gains of calves. There has been numerous reports that rotational grazing limits cow performance. This however may be a function of environment, forage quality, and primarily stocking rate. There did not appear to be any major reduction at the current stocking rate, with the exception of winter loss. Fall-calving herds are generally in their first trimester of pregnancy during this period and weight loss is not as detrimental to productivity as compared to loss in the last third of pregnancy.

Early weaned, nutritionally restricted (EW) cows had drastic weight and BCS changes over the winter months compared to normal managed, normal weaned cows (NW). However, following the winter dormancy EW cows gained more weight and BCS than NW. Similar to the spring calving herd early weaning allowed cows to compensate for winter losses and have more body reserves going into the subsequent calving season. Cows that where EW had higher precalving weights and BCS following the first year. Even with drastic weight loss over the winter months pregnancy rates where similar between treatments.

Dry matter intake savings of 20% was realized due to early weaning. This may allow for some increase of stocking density and lower land area required to maintain the cow. Increased carrying capacity with similar weight gains in EW and NW calves would allow an operator to increase production per acre.

Vita

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Thesis: EFFECT OF EARLY WEANING AND GRAZING SYSTEMS ON PRODUCTIVITY OF SPRING AND FALL CALVING COWS

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