REPRODUCTIVE PERFORMANCE OF BEEF COWS WITH DIVERGENT GENETIC MERIT FOR MILK PRODUCTION

By

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CHAPTER I

INTRODUCTION

Understanding the association between milking ability and reproductive performance of cows is of considerable interest for beef cow-calf production. The relationship between milk production of cows and assorted performance traits of calves have been demonstrated in several studies (Cole and Johansson 1933; Cook et al 1942; Gifford, 1953; Montsma, 1960; Totusek et al., 1965, 1973). It is apparent that performance of the calf is greatly affected by the milk production of the dam (Neville, 1962; Melton et al., 1967; Rutledge et al., 1971; Reynolds et al., 1978; Boggs et al., 1980). Therefore, milking ability of the cow has a significant role in cow-calf production. Certainly, the weaning weight of the calf is the one of the basic factors that affects earnings of the beef cow producers.

Reproduction of livestock is the dominant determinant of economic efficiency (Rege et al., 1993). However, reproduction consists of many individual components including calving date, calving interval, calving percentage and age at first calving that are used to measure reproductive efficiency (Bourdon and

Brinks, 1983; Meacham and Notter, 1987; Morris and Cullen, 1988; Meyer, 1990; Lopez and Brinks, 1990; Macgregor, 1995).

Selection of heifers for maternal ability can be performed by using Expected Progeny Differences (EPD). The use of the Milk EPD has been adopted by beef breed associations to estimate the genetic differences in milking ability of beef cattle (Benyshek et al., 1988). These Milk EPDs have been published by numerous beef breed associations. The Milk EPD is a predictor of the weaning weight differences for calves from daughters of bulls. It is not just a tool that can be used to predict weight of milk production. Thus, Milk EPDs may also have an effect on reproductive performance if there is a relationship between milking ability and reproductive performance. Many studies show that the prediction of maternal ability of cows has been successfully with the use of milk EPD (Mallinckrodt et al., 1990, 1993; Diaz et al., 1992; Marston et al., 1992; Marshall and Long, 1993; Buchanan, 1993,1996a, b).

Several researchers have stated that the reproductive performance of cows at certain points of production depends upon body energy reserves (Wiltbank et al., 1964; Selk et al., 1988, Spitzer et al., 1995). Inefficient body energy levels can be destructive to reproductive performance in primiparous cows (Carroll and Hoerlein, 1966) because of the extra nutritional requirement for gaining weight with first lactation can cause decreased reproductive performance of cows. Therefore, management of cows to a specific body energy level is necessary to receive favorable reproductive efficiency.

Buchanan et al. (1996a, b) reported that cows sired by High Milk EPD bulls had lower body condition score which may cause reduced reproductive efficient of cows for next generation. Thus, research was needed to investigate performance of cows from Hereford and Angus breeds with different genetic merit for milk production. The objective of the present study was to determine the effect of genetic differences in milk production of beef cows on the length of the period from calving to onset of luteal activity and to evaluate differences in calving interval, calving date and calving percentage.

CHAPTER II

LITERATURE REVIEW

General Characteristics of Breeds

Hereford and Angus breeds are maintained widely in the USA both as straightbred and crossbred. Hereford and Angus have some similar characteristics that make them reasonable choices in the commercial beef industry. In general, the Hereford breed is known for its vigor and foraging ability and it tends to keep reproductive performance and body condition under severe conditions. On the other hand, the Angus breed presents the advantages in carcass quality and maternal ability especially during the preweaning period (Briggs et al., 1969; Bundy et al., 1982). In one study, Baker et al. (1984) compared Hereford, Jersey, Angus, Holstein, and Brahman. They stated that the Angus and Hereford have higher rank in terms of marbling score, conformation score and final grade than the other purebreds and crossbreds except the Jersey.

Hereford

The Hereford is a breed that was developed from Herefordshire which lies between Severn river and Wales in England. The first Herefords were imported into the U.S. in 1817 by Henry Clay of Kentucky. However, the first breeding herd of Herefords was established by William H. Sotham and Erastrus Corning of New York in 1840. Then, the Hereford breed was developed rapidly in the U.S (Briggs et al., 1969).

The color pattern of the Hereford breed is easily differentiated from other breeds with the white face and red-colored body. Their color pattern has turned into a very valuable trade-mark. The white color also has been seen on some part of the body such as breast, flank, tail switch, underline and below the hock and knees on both fore and hind legs. The red color varies from a really dark red to a very light-yellowish color pattern (Bundy et al., 1982).

When breeders started to cross Hereford with Angus, they saw that crossbred calves have a white underline with a block body and white face. The cause is that red is recessive to black color and the white markings are dominant.

The general body form of Hereford should be large and smooth. In addition, they should be well-developed in the back, hind round and loin areas. Hereford bulls should have masculine appearance and be heavly muscled and strong in their bone structures (Bundy et al. 1982). In another study, the Hereford breed was exceeded by the Angus breed in terms of breed maternal effect for preweaning average daily gain and 200-day weight (Gregory et al., 1978b).

The Polled Hereford breed was originated from the horned Hereford breed. A few calves were born which did not have horns due to a mutation among the horned Herefords. Waren Gammon provided much of the effort to establish polled Hereford herds in Iowa around 1900. In recent years, the Polled Hereford and Hereford breed associations have recombined.

Angus

The Angus was originated in Northern Scotland and first imported into the U.S. by George Grant of Kansas, in 1873. The importation of Angus to the U.S. was more popular during late 19th century. Then, while establishment of Angus herds was increasing, the importation of this breed from outside of the country decreased gradually.

The color pattern of the Angus breed is completely black. Generally, the Angus is polled. The general body form of Angus should be medium with a smooth body, well-developed muscling, and adequate length of body side. The mature Angus bulls should show masculinity and ruggedness and have heavy muscle without coarseness. On the other hand, the female Angus should be more feminine and be clean-cut in her facial features. They also should carry their smoothness uniformly. The Angus breed is known for marbling and maternal ability.

Even if Angus calves are born very small, the weights of calves at weaning are similar to the most of the other breeds (Gay,1916; Briggs et al., 1969; Bundy et al., 1982). A study involving a Brown Swiss, Hereford, Red Poll and Angus was done by Gregory et al. (1978b) and they found that the Angus breed excelled, with the Hereford, in terms of preweaning average daily gain and 200-day weight of calf.

Maternal Effect on Reproductive Performance of Beef Cows

One of the main goals of beef producers is to increase reproductive performance since this affects economic efficiency of commercial beef production. Maternal influence in reproductive performance is a critical factor to improve efficiency of beef production. Several investigators have studied maternal effects in beef cows (Dickerson, 1947; Kempthorne, 1955; Willham, 1963). Many environmental factors influence reproductive efficiency of cow such as age of dam, age of bull, season and year (Davis, 1951; Bishop et al., 1954; Philips et al., 1943; Warnick, 1955). The maternal effect of the dam is defined by environmental as well as genetic sources (Koch, 1972). In one study, Willham (1972) reported that maternal influence could be considered to be a value of a cow that affects part of the phenotypic value of her calves. Thus, the maternal effect of the dam joins with her offspring's own genetic value.

Reproductive performance of cattle may be influenced by several different sources. Genetic variance explains variation in reproductive efficiency of cows, but estimates of repeatability and heritability were low (Philips, 1939). The correlation between direct and maternal effects might be negative (Willham, 1972). High yielding cows tend to have decreased reproductive efficiency due to the negative effect of milk yield (Ray et al., 1992). According to Koch (1972) there is a high correlation between total milk yield of cows and weight gain of calves from parturition to weaning in cow-calf production systems. Brahman cows have lower reproductive efficiency than Bos Taurus purebred cows (Turner, 1980). Koger et al. (1967) observed that Brahman offspring also have lower survival rate.

Several researchers have investigated maternal effects on reproductive efficiency of beef cows in terms of calving interval. In one study, Dunn and Kaltenbach (1980) found that younger dams often showed more than a 365-day interval between two consecutive calvings and longer anestrus period after parturition. Werth et al. (1996) studied crossbred Hereford, Angus, and Shorthorn to evaluate calving intervals of young cows. They emphasized that if the mating period was begun too soon after parturition, younger cows might have less than 365-day calving interval. Khan and Khan (1983) studied Red Sindhi cattle and concluded that calving interval affects greatly milking ability of cows. Calving interval was more variable than calving date phenotypically (Bourdon and Brinks, 1983). They also found that calving interval was more likely to be a biased measure of reproduction than calving date.

There is genetic variation for first calving date in Simmental (Meacham and Notter, 1987). They also stated that the heritability of first calving date and second calving date (0.17±0.04, 0.07±0.06, respectively) was slightly higher than that of calving interval (0.04±0.05). Milk production of cows that gave birth in the spring was decreased during the subsequent calving period due to the effect of calving date (Crosse, 1986). However, when calving date was retarded from January to March, the decrease in milking ability was prevented (Gleeson, 1988). Bourdon and Brinks (1983) studied straightbred Hereford, Angus and Red Angus to correlate calving interval with calving date in beef cows. They pointed out that calving date would have a higher heritability than calving interval. Moreover, they reported that cows with long gestations were less efficient than cows with shorter gestation length because each one day of lengthened gestation caused an increased calving interval of 1.17 day. Paloma et al. (1992) studied Aberdeen Angus and reported that first calving date was a very effective predictor of lifetime reproductive performance of cows. Calving date appears to be a more adequate reproductive measurement than calving interval to improve reproductive efficiency since calving date is more heritable (Bourdon and Brinks, 1983; Meacham and Notter, 1987; Lopez de Torre and Brinks, 1990; Macgregor, 1995).

Some studies have showed that estimation of maternal heritability was low for gestation length (Philipsson, 1976; Gaillard and Chavaz, 1982).Cows with earlier calving would have greater length of interval from parturition to later mating period (Azzam and Nielsen, 1987). They also found that maternal effects substantially influenced gestation length. Lindley et al. (1958) studied straightbred Herefords and reported that repeatability estimates varied from 0.03 to 0.15 and most of the heritability estimates were very close to zero. Newman et. al. (1993) studied cows out of Red Angus dams and Charolais and Tarentaise sires and estimated breed maternal effect between diverse dams. They observed that dams sired by the Tarentaise breed showed lower conception ratio and calving percentage than dams sired by Charolais. They also stated that gestation length, conception rate, and calving difficulty score were influenced substantially by cow's age. In addition, younger age dams had lower gestation length and lower conception rate than mature cows. Brahman crossbred cows showed highest reproductive performance among many types of crossbred cows due to non-additive influences on conception rate (Olson et al., 1990). They also stated that maternal non-additive genetic effects influenced survival rate. Milk yield level of cows affected not only first service conception ratio but also interval from calving to first estrus after parturition (Witbank et. al., 1964; Corah et. al., 1975; Richard et. al., 1986).

Maternal Effect on Reproductive Performance of Dairy Cattle

Although a few studies have been conducted to evaluate the relationship between maternal ability and reproductive performance of beef cows, numerous studies were done in dairy cattle with regard to milk production and reproduction. Increase in milk production was related with an increase in open days, days to first mating and number of mating per pregnancy (Laben et al., 1982). But, they observed that days open was lower for dairy herds that have highest level of milk production. They further reported that although the relationship between milk production and reproductive performance was negative, adequate reproductive management and feeding methods might affect this relationship in positive way. In one study, Dhaliwal et al. (1995) reported that there was an advantage in fertility of high producing dams.

McGowan et al. (1996) studied Holstein Friesian dairy cows to investigate the relationship between reproductive efficiency and body condition scores. They stated that there was an important positive relationship between reproductive efficiency and body condition scores. They also reported that there was a significant positive relationship between milk production and days to first estrus of dairy heifers. From the same study, McGowan et al. (1996) stated that the relationship between level of milk production and calving interval in cows was positive. Low yielding cows had greater reproductive efficiency than cows achieving peak yields for interval from parturition to first service (Dhaliwal et al., 1995). Another study was done by Hamudikuwanda and Erb (1987) and they emphasized that there was a small negative relationship between milk production level and calving interval of dairy cows. However, they also reported that previous calving interval of cows was more important than milk output in affecting reproductive performance of dams. If interval between two consecutive calving periods was about 360 days, milk yield of European dairy cow was at its greatest level (Bar-Anan and Soller, 1979).

An antagonist relationship between milk production and pregnancy rate has been found for dairy cows (Francos and Rattner, 1975; Spalding et. al., 1975; Ferguson, 1990). Dhaliwal et al. (1995) studied reproductive performance of cows with high and low milk outputs. They reported that high producing cows were substantially higher with regard to interval from parturition to conception and interval from first service to conception. In addition, pregnancy rate was higher in cows with low average yield. Cows with higher than 38 kg milk per day had less chance to be pregnant in one or two matings than cows with less than 38 kg yield (Lean et al., 1989). When low-producing dams in the herd were bred early, maximum efficiency of reproduction could be obtained (Bar-Anan and

Soller, 1979). Bar-Anan et al. (1985) also found that cows with high average yield has lower pregnancy rates than cows with low yield. In dairy cattle, among several studies reporting a negative relationship between milk production and calving rate, the degree of this relationship varied widely (McGowan et al., 1996).

Breed Effects on Reproductive Performance of Beef Cows

The impact of breed is another critical factor for reproductive efficiency of cows. Many investigators have been interested in reproductive performance of beef cows from diverse breeds (Laster et al., 1976; Gregory et al., 1979a; Cundiff et al., 1986). Differences among straightbreds or crossbreeds appear with regard to reproductive efficiency (Davis et al., 1983; Jenkins et al., 1991; Jenkins and Ferrell, 1991). Montano-Bermudez and Nielsen (1990b) observed lower reproductive performance among high milking mature cows. Nelson et al. (1985) studied Angus, Simmental and Hereford cattle and stated that breed was an important source of variation in milk production of beef cows. Jenkins and Ferrell (1992) studied nine diverse breeds (Braunvieh, Gelbvieh, Limousin, Angus, Simmental, Hereford, Pinzgaver, Red Poll and Charolais). One of their observations was that Herefords had lower milk yield than others among the breed groups. Clutter and Nielsen (1987) studied Red Poll, Shorthorn and Hereford, which differed widely in genetic capacity for milk yield. They reported that as cows grew older, dissimilarity of milk yield level among three breeds increased. In addition, they stated that milk production level was critical to determine 205-day weight in beef production system. They also reported that cows with high milk yield had more advantage in weaning weight than others and this advantage was carried on during postweaning feedlot performance. Cundiff et al. (1996) organized research by using several different breeds. They used purebred and crossbred cows to investigate the effects of bioeconomic traits on both quality and quantity of production. They observed that crossbred cows with Holstein and Jersey breeding had the highest milk yield among twenty seven purebred and straightbred types. Furthermore, they reported that interaction between age of dam and sire breed was important for calving without assistance.

Several researchers have investigated breed effects of both beef and dairy cattle for calving interval. Hanzen et al. (1994) studied beef and dairy breeds to investigate reproductive rate in overall efficiency of production. They reported that calving intervals were strikingly different among breed groups. Mean calving interval was lowest in dairy breeds, intermediate in milked beef and highest in suckled beef (393, 401 and 435 days, respectively). Moreover, service number per pregnancy was higher in beef breeds than dairy cattle. Furthermore, primiparous cows in dairy herds had shorter interval from calving to first estrus than those in beef herds. McElhenney and Long (1986) studied with Hereford, Holstein, Brahman, Angus, Jersey dams and their crosses and Red Poll and Charolais sires that represented medium and large mature size, respectively. They reported that differences among breeds of dam were important for calving interval. Purebred beef breeds such as Hereford and Angus showed shorter calving interval than purebred dairy breeds. However, there were not significant differences among crossbred cows in terms of calving interval. Therefore, breed differences were important in comparisons of breed types. Newman and Deland (1991) conducted study with seven different breeds. They stated that calving interval was smallest with Friesian and greatest with Shorthorn cross cows among seven different breeds.

Calving percentage was not influenced by breed effects (Newman and Deland, 1991). However, parity and the interaction between breed effects and parity were important sources of variation in calving percentage. Freetly and Cundiff (1998) conducted research using seven different sire breeds (Brahman, Hereford, Belgian Blue, Tuli, Angus, Piedmontese, and Boran) and three different dam breeds (Angus, Marc III (composed by four diverse breeds), and Hereford). They treated with them with two levels of nutrition: low (12.6 Mcal ME/day) and high (15.8 Mcal ME/day). They reported that even if there was no dissimilarity between high and low nutrition treated group of cows, a difference between crossbred heifers with diverse breeds of sires existed. Moreover, they stated that there was little difference in calving ratio among sire breeds. Montano et al. (1987) studied Shorthorn-cross, Red Poll-cross and Hereford-cross cows that had high, intermediate and low milking ability, respectively. They emphasized that the three breed groups showed basically similar calving date and conception rate. Calving percentage was 89%, 86% and 85% in low, intermediate and high producing cows. Thus, high yielding cows displayed the lowest calving percentage. Newman and Deland (1991) stated that Shorthorn and European cross cows tended to have lower calving percentage than others did. Zebu cross heifers had medium calving percentage. Moreover, dairy cross cows showed higher calving percentage than other breeds in this study. Cundiff et al (1996) reported that calving percentage was lowest in Galloway and highest in Sahiwal and Longhorn. (87% and 95%, respectively). However, original Hereford-Angus cross dams displayed 91% of calving percentage in this study. Calving rate was higher in Angus than in Hereford and Shorthorn breeds (Burris and Priode, 1958). Comerford et al. (1987) studied Limousin, Brahman, Simmental and Polled Hereford. They pointed out that calving percentage was highest in Limousin among four different beef breeds because Limousin produced heavy calves with higher survival ratios.

The relationship between conception rate and genetic capacity of a cow for milk production was antagonistic (Montano-Bermudez and Nielsen, 1990a). Gregory et al. (1992) studied nine breeds (Hereford, Pinzgauer, Charolais, Limouisin, Red Poll, Angus, Braunvieh, Simmental and Gelbvieh) and reported that there was dissimilarity in conception rate among breeds. They found that Limousin had the lowest (74.8%). In contrast, Red Poll breed had highest conception rate with 86.6%. Cundiff et al. (1996) observed lowest and highest conceptions rates in Charolais and Sahiwal, respectively among 27 different breeds.

Brown Swiss had higher breed maternal and average additive effects on milk yield and growth performance than Hereford, Red Poll and Angus (Gregory et al., 1978a). Interval from parturition to conception (Legates and Myers, 1988), service numbers per pregnancy (Rothschild et. al., 1979; Bertrand et al., 1985) did not significantly differ among different genetic groups. On the other hand, conception rate (Olson et al., 1985), and the length of gestation (Rothschild et al., 1979) were affected by different genetic groups. The average length of gestation was 281, 284 and 286 days for Angus, Shorthorn and Hereford, respectively (Burris and Blunn, 1952).

Milk Expected Progeny Differences

Prediction of genetic merit has been determined for beef cattle by using The Best Linear Unbiased Prediction Techniques (BLUP) (Henderson, 1973). The predictions of genetic merit are expressed as Expected Progeny Differences. Milk Expected Progeny Difference is a concept that is used to predict genetic merit for maternal ability of beef cows within breed. We need to predict genetic merit for maternal ability of beef cows. Because milk yield of beef cows is a major element that affects weight gain of calves from birth to weaning (Neville, 1962; Boggs et al., 1980; Beal et al., 1990). Milk production of a dam explains approximately 66% of the variation in calf weaning weight (Neville, 1962; Rutledge et al., 1971). In another study, about 40-46% of the gaining weight of calf explained by variation due to maternal effect from birth to weaning has been reported by Koch (1972).

Beef Cattle Breed Associations report EPD's for many traits related with maternal and growth ability. The Milk Expected Progeny Differences is a prediction of maternal ability for daughters of bulls in comparison with daughters of the other bulls (American Hereford Association, 1998; American Angus Association, 1998). If breeders can use Milk EPD accurately to estimate the probable weaning weight differences due to milk yield, the EPDs provide a chance for producers to rank bulls in terms of genetic merit for maternal ability. Performance of cows has been improved by the using National Sire Evaluation (NSE) (Benyshek, 1986). Some previous researchers demonstrated that Milk EPD may be used to predict performance of dam accurately (Mallinckrodt et al., 1990; Marston et al., 1992; Buchanan et al., 1993).

In addition to sire Milk EPD, total maternal EPD is very useful in predicting maternal ability of beef cows. The total maternal EPD is the combination of weaning growth passed through daughters of bulls to daughters' offspring and maternal ability passed to daughters of bulls (Northcutt and Buchanan, 1993). Therefore, the total maternal EPD is an instrument to estimate the performance of calves from daughters of bulls. Mallinckrodt et al. (1990) studied Polled Hereford and Simmental and they found that the difference in weaning weight of calves was the same or higher than expected weaning weight by using Milk EPD and total maternal EPD values. Producers ought to determine the appropriate milk level for their herds and select bulls according to that Milk EPD level (Buchanan et al., 1992).

Marshall and Long (1993) investigated the association of sire Milk EPD and total maternal weaning weight EPD with milking ability of crossbred daughters and to weaning weight of the daughters calves. Their results showed that a 1-kg change in sire total maternal EPD for weaning weight was associated with a 1.18 kg alteration on weight of daughters calves. They stated that the difference in sire Milk EPD was positively related to differences among milk production of daughters and thus, subsequent calf weaning weight. The regression of calf weaning weight on total maternal EPD for milk was 0.95 and 1.02 kg, respectively (Notter and Cundiff, 1991; Nunez-Dominguez et al., 1993). These values are fairly close to the expected value of 1.00. Marshall and Long (1993) also reported that a 1-kg difference in sire Milk EPD was associated with a 1% change in cumulative milk production of daughters. Diaz et al. (1992) made a similar conclusion from research using Polled Hereford bulls' crossbred daughters.

Marston et al. (1992) examined the association of Milk EPD with actual milk yield and with weaning weight of calf. They found that a 1-kg change in EPD for milk output was associated with a 3.74 and 4.85-kg difference in weaning weight for purebred Simmental and Angus, respectively. These regression values lead breeders to conclude that maternal Milk EPD can be an underestimate of genetic merit. While 205-day weight can be predicted by using total milk production, total milk yield and weaning weight of calf can be estimated more accurately by using Milk EPD scores (Marston et al., 1990). Buchanan et al. (1997) preliminarily reported that there was no remarkable decline in reproductive efficiency of dam.

As a result, numerous studies have shown that per unit change in sire milk EPD corresponded to a change in actual milk yield of dam. Moreover, total maternal and Milk EPDs are conceivably good predictors of cow performance and 205-day weight of calves. (Mallinckrodt et al., 1990, 1992; Diaz et al., 1992, Masrton et al., 1992; Buchanan et al., 1997).

Body Condition Effect on Reproduction

Reproductive performance greatly influences biological efficiency of the cow herd and ultimately net income of the beef cow producer in a cow-calf operation. Therefore, producers should develop programs to improve reproductive performance of their cows. Paputungan (1997) investigated the elements that influence reproductive performance of Indonesian native cows. He reported that size of body is the major factor that affects reproductive efficiency. Hence, it is important to supply nutritional requirements to meet the needs of Indonesian native cows and thus, subsequent adequate body condition and live weight of cows. Grainger et al. (1982) stated that there is a positive correlation between body fat at the time of calving and later milk production of mature cows. Reproductive efficiency of beef cows depends upon the total energy status at certain stage of reproduction (Wiltbank et al., 1962; Donaltson et al., 1967; Crouton and Stolid, 1976; Dunn and Kaltenbach, 1980; Dziuk and Bellows, 1983). The energy reserves of cows at parturition highly affect the reproductive performance (Wiltbank et al., 1964; Whitman et al., 1975; Richards et al., 1986; Spitzer et al., 1995). Specifically, reproductive efficiency is affected by the energy status of the cow in both prepartum and postpartum periods (Wiltbank et al., 1962,1965; Corah et al., 1974; Dunn and Kaltenbach, 1980; Dziuk and Bellows, 1983).

Beef cows should store energy during time of adequate nutrition to meet nutrient requirements, especially in the winter since environmental constraints can limit the performance of the suckled beef cows. Dietary nutrient level of cows affects interval to first estrus (Dunn and Kaltenbach, 1980), conception rates (Wiltbank et al., 1964; Bellows and Short, 1978) and number of calves (Jenkins and Ferrell, 1989). All of these factors are important profit determinants in cow-calf production. Lactating beef cows had intervals from 46 to 168 days after parturition to estrus (Dunn and Kaltenbach, 1980). Selk et al. (1988) investigated associations among body condition, nutrition level before parturition and reproductive efficiency. They reported that nutritional management of cows before and after parturition influenced body condition and conception ratio of beef cows. Conception rate is greatly influenced by body condition of cows at the beginning of the breeding season and at the time of parturition. Interval from calving to first estrus and conception ratio of beef cows are affected by nutrition consumption in both prepartum (Whitman et al., 1975) and postpartum (Wiltbank et al. 1962) and are also influenced by body condition (Richards et al., 1986). Supplying a high level of energy intake can decrease the time of anestrus after parturition (Dziuk and Bellows, 1983). Reduction in energy consumption of beef cows lengthens the calving interval and the interval from calving to first estrus (Joubert, 1954; Wiltbank et al., 1964; Bellows and Short, 1978). Restricted nutrition during the late prepartum period causes a low body condition score at calving and increased the postpartum interval to the first estrus cycle. It also caused a decline in the ratio of cows that display early estrus in the breeding season in beef cattle (Lowman et al., 1979, 1982; Dziuk and Bellows, 1983) and in dairy cows (Reid, 1960; Gardner et al., 1969).

The body condition scoring system is a subjective tool that can be used to evaluate cows' body fat levels. Many different body condition-scoring systems have emerged for beef cows. Herdsmen use visual and tactile determination to assess the amount of body fat carried by cows. One of the scoring systems is a six-point system which ranges from 0= emaciated and no fatty tissue to 5= very fat and no noteworthy bone structure over the skin propounded by Lowman et al. (1976). In addition, Wagner (1985) defined a 9-point scoring system for cattle. According to this system, body condition score appears as follows;

1= severely emaciated and physically weak

2= emaciated but not weakened

3= very thin with no fat

4= thin and easily visible ribs

5= good overall appearance or moderate

6= good smooth appearance

7= fleshy appearance and considerable fat

8= obese or very fleshy and over-conditioned

9= very obese and extremely wasty.

Many researchers have used the 9-point system (Cantrell et al., 1982, Warner and Spitzer, 1982; Wettemann et al., 1982; Dunn et al., 1983 ; Wagner, 1985; Richards et al., 1986; Wagner et al., 1988).

Predictions of body fatness of cows with the body condition scoring system may be helpful in determining the energy level of beef cows prior to or during the time of parturition. Body condition score may be used as a management instrument to determine the body energy reserves in dairy cows (Hady et al., 1994). Body condition score explained more than 90% of the variation in body fat reserves (Wright and Russel, 1984). Dunn et al. (1983) investigated body condition score using 55 mature beef cows and reported that body condition scores were highly related with carcass fatness and with total carcass energy (r: 0.86 and r: 0.77, respectively). Makarechian and Arthur (1990) investigated the body condition effects at the time of mating and calving on reproductive efficiency of two breed groups. Cows with body condition less than 3.0 (on a 6- point scale) had a lower conception ratio, a lower number of calves and longer calving interval than cows that had 3.0 condition score at calving.

In general, the evaluation of cow body fat using a condition scoring system is organized at three different times which are at breeding, at calving and at weaning. Body condition at breeding has an effect on reproductive efficiency of cows (Nicoll and Nicoll, 1987). Cows with good body condition score at the time of calving showed higher estrus than cows that had thin body condition ($P<.05$) (Whitman et al., 1975). Osboro and Wright (1992) also reported that body condition level of beef cows is critical at calving. However, some studies displayed that alteration in percentage of body fat reserves is very important after calving (Warnick et al., 1981; Rutter and Randel, 1984; Hancock et al., 1985). Early estrus and conception rate were affected by body condition at calving (Richards et al., 1986). The interval from the time of calving to first estrus in Brangus cows was influenced by dietary nutrient consumption after parturition (Rutter and Randel, 1984). They noted that heifers and mature cows had 5.8 and

7.3 mean condition scores, respectively according to 1= very thin to 9= very fat. They also stated that cows that maintained body condition had about a 30-day shorter interval to estrus after parturition than cows that had lost body condition. Body condition scores of cow at the time of birth greatly influenced the interval to estrus after calving and conception rate of multiparous cows (Richards et al., 1986; Selk et al., 1988).

The weight changes either pre or post partum may influence cows with good body condition at the time of calving (Corah, 1975). Another study conducted by Dunn and Kaltenbach (1980) showed that if cows were getting to lean due to losing live weight prepartum, gaining weight postpartum might cause a decrease in the interval from calving to first estrus. Cows that have body condition lower than four had a longer interval after parturition (Richards et al., 1986). Cows that had a high milk production level lose more weight and thus, had inadequate condition score (Beal et al., 1990). Buchanan et al. (1993) reported that Polled Hereford and Angus cows that were sired by low Milk EPD bulls had 5.4 and 5.7 condition scores, respectively. In contrast, the same breed cows that were sired by High Milk EPD bulls had low body condition scores (Polled Hereford, 5.0; Angus, 5.2). Wettemann et al. (1982) studied Herefords to investigate the association between percent weight changes and condition score changes during a five month period and reported that body condition score ranged from 3.8 through 6.5 before calving and average body condition score was 5.1 (on 9-point scale). Thus, alteration of condition scores may be used for determining reproductive efficiency of beef cows. In another study, Buchanan et al. (1996a) examined the effectiveness of the Milk EPD to predict performance of calves and to evaluate the effect on body condition and weight of cow and reported that cows that were sired by low Milk EPD bulls have a higher body condition score at the time of weaning than cows sired by high Milk EPD bulls. If cows can maintain body weight prepartum, they have a higher pregnancy rate. On the other hand, if cows lose weight at the time of mid to late pregnancy, their pregnancy ratios declined (Garmendia et al., 1984). The management of cows that were in poor body condition at parturition is important to get adequate body condition before mating time and thus, subsequent increased reproductive efficiency and preweaning gain of calves (Houghton et al., 1990).

Spitzer et al. (1995) investigated the effect of body condition score at parturition on reproductive efficiency and birth weights of calves from the primiparous cows. They noted that cows with higher body condition score had heavier calves at parturition. If energy requirements of cows can not be supplied by feed, cows start to use body fat reserves, which ultimately causes inadequate body condition. In other words, cows try first to maintain their potential for milk output and may not maintain adequate body condition due to not enough nutrition. Hence, this may prevent rebreeding efficiency of cows during breeding season (Boggs et al. 1980).

CHAPTER III

MATERIALS AND METHODS

Source of Data

All cows and calves in this study were from the beef research range at North Lake Carl Blackwell, located west of Stillwater, Oklahoma. From 1989 through1992, Hereford and Angus bulls with wide variation in Milk EPD were used to artificially inseminate cows that were crossbred. The base cows were categorized within 3 groups which were Hereford-Angus, ¼ Brahman – ¼ Angus – ½ Hereford, and ¼ Brahman – ½ Angus – ¼ Hereford.

There were four different groups in terms of breed and Milk EPD level. These were High Milk EPD Hereford (10), Low Milk EPD Hereford (8), High Milk EPD Angus (13), and Low Milk EPD Angus (13). Thus a total of 44 bulls were used for the four groups. Average Milk EPDs for the four different groups is in Table 1. The average Milk EPDs were 7.40 and -3.92 kg for high and low Hereford and 8.73 and -6.11 kg for high and low Angus, respectively. This resulted in a difference of 11.32 and 14.84 kg for Hereford and Angus bulls groups, respectively. In addition to Milk EPD, average weaning weights EPD and

TABLE 1. AVERAGE MILK, BIRTH WEIGHT, AND WEANING WEIGHT EXPECTED PROGENY DIFFERENCES (EPD) AND RANGE FOR MILK EPD (kg) FOR HIGH VS LOW MILK EPD ANGUS AND HEREFORD BULLS

Breed	Level	N	Milk EPD Mean	Milk EPD Range From	Milk EPD Range To	BW EPD Mean	WW EPD Mean
Angus	High	13	8.73	3.63	12.71	1.12	9.60
Angus	Low	13	-6.11	-13.62	-2.27	2.15	13.48
Hereford	High	10	7.40	0.91	13.17	1.28	13.21
Hereford	Low	8	-3.92	-6.81	-0.45	2.42	12.94

Sire EPD values were obtained from American Angus and Hereford Breed Associations, 1998.

average birth weights EPD are in Table 1. Average birth weight EPDs from those four groups displayed a difference of 1.03 and 1.14 kg for Angus and Hereford sire groups, respectively. Finally, average weaning weight EPDs showed a difference of 3.88 and 0.26 kg for Angus and Hereford sire groups, respectively. The published accuracy for Milk EPD level of all bulls ranged from .49 to .99. Heifers used in this study were born from 1989 through 1993 at the research range. During the 5 year period, over 300 heifers calves were born as daughters of high and low Milk EPD bulls. Spring-calving heifers were mated to calve in February through April. All heifers were kept as possible replacements except for fewer than five of the unusually small heifers in any calving period. Fall-calving heifers were bred to calve in September, October, and November. First calf heifers were mated to Salers bulls (n=21) to calve at about 24 month. For subsequent calving, cows were artificially mated to sires (not more than three each breeding season) of several different breeds for a period of approximately 55 days followed by a 20 day clean up period. If females were not able to conceive during a total mating period of 75 days, they were moved to the opposite breeding season. However, if cows failed to conceive in two consecutive breeding seasons, or if they had a severe physical problem, they were culled from the herd.

Measurements

Male calves were castrated within 24 hours of birth. Calves were weaned at an average of 205 days of age in the spring and 240 days of age in the fall.

Condition scores were determined according to a 9-point system which was 1=very thin to 9=very fat at first and 7th months of lactation (Wagner, 1985). Calving interval, calving date, and calving percentage were calculated. Calving interval was calculated as the number of days from first calf to the second calf, regardless of calving season. In addition, calving date was calculated as the number of days following the beginning of the calving season. The date of first breeding and the date of first calving for each season from 1989 through 1997 are given in Table 2. Calving percentage was calculated as the proportion of cows that calved in one year that also had a calf in the same season of the next year.

Management of the Cow Herd

Cows that were used in this study were maintained on Bermuda grass pastures and native range at Lake Carl Blackwell Research Range. 40 cows were maintained in each pasture. Approximately 1 to 5 pound of 41% CP range cubes were used for fall calving cows. Approximately 1 to 6 pound of 41%CP cubes were used for supplementation from October through May, in addition to Bermuda Hay and prairie grass. Range cubes (41% CP) were also provided through the breeding season (March-June) for spring-calving cows.

TABLE 2. THE DATE OF FIRST BREEDING AND THE DATE OF FIRST CALVING FOR EACH SEASON FROM 1989 THROUGH 1997

Year	Season	Breeding Date	Calving Date
1989	Spring	May 8	February 22
1989	Fall	December 4	September 2
1990	Spring	April 26	February 11
1990	Fall	November 26	September 9
1991	Spring	April 27	January 28
1991	Fall	December 3	August 26
1992	Spring	April 28	January 25
1992	Fall	December 1	September 4
1993	Spring	April 30	January 28
1993	Fall	November 30	August 30
1994	Spring	May 3	February 7
1994	Fall	November 28	September 4
1995	Spring	May 1	February 1
1995	Fall	November 28	August 31
1996	Spring	May 6	February 11
1996	Fall	December 3	September 2
1997	Spring	May 5	February 16
1997	Fall	December 3	September 9

Laboratory Analysis

Postpartum luteal activity was determined for all cows that calved in 1997 to assess the effect of genetic differentiation in milk output on reproductive efficiency. Approximately 10-ml-blood samples were collected from each cow weekly beginning 40 days after parturition. At the time of collection, an anticoagulant (EDTA) was added to blood samples. Samples were put in ice to cool them to 4°C. All samples were centrifuged for 15 minutes to separate plasma and blood cells. Plasma was stored at -20°C until progesterone was quantified by radioimmunoassay (Vizcarra et al,. 1997). When concentration of progesterone was greater than 1 ng/ml in two consecutive weekly samples, collection of blood samples was stopped from cows.

Statistical Analysis

Measurements of reproductive performance (calving interval, calving date, calving percentage, body condition score of dams and onset of luteal activity) were analyzed by least squares analyses of variance. The model included the effect of breed and Milk EPD level of cow, sire of cow within breed and milk level, year, age of dam, sex of calf, season of birth, and all two-factor interactions. Three orthogonal contrasts were obtained for mean comparisons (breed, milk level, and breed*milk level interaction). Two additional contrasts were evaluated if the interaction between breed and milk level was significant ($P<.05$). These examined High vs Low Milk EPD in each breed separately.

The general linear model used to analyze reproductive traits as follows:

$$Y_{ijklmnp} = \mu + A_i + B_{j(i)} + C_k + D_l + F_m + G_n + AC_{ik} + AD_{il} + AF_{im} + AG_{in} + CD_{kl}$$

$$+ CF_{km} + CG_{kn} + DF_{lm} + DG_{ln} + FG_{mn} + E_{ijklmnp}$$

Where $Y_{ijklmnp}$ = observed value for interested trait calculated on the p^{th} dam, of the n^{th} sex of calf, of the m^{th} season of birth, of the l^{th} age of dam, of the k^{th} year, of the j^{th} sire nested within i^{th} breed Milk EPD group.

μ = Overall mean

A_i = Effect of the i^{th} breed Milk EPD group

$B_{j(i)}$ = Random effect of the j^{th} sire nested within i^{th} breed Milk EPD group

C_k = Effect of the k^{th} year

D_l = Effect of the l^{th} age of dam

F_m = Effect of the m^{th} season of birth

G_n = Effect of the n^{th} sex of calf

AC_{ik} = Effect of interaction of the i^{th} breed Milk EPD group with k^{th} year

AD_{il} = Effect of interaction of the i^{th} breed Milk EPD group with l^{th} age of dam

AF_{im} = Effect of interaction of the i^{th} breed Milk EPD group with m^{th} season of birth

AG_{in} = Effect of interaction of the i^{th} breed Milk EPD group with n^{th} sex of calf

CD_{kl} = Effect of interaction of the k^{th} year with l^{th} age of dam

CF_{km} = Effect of interaction of the k^{th} year with m^{th} season of birth

CG_{kn} = Effect of interaction of the k^{th} year with n^{th} sex of calf

DF_{lm} = Effect of interaction of the l^{th} age of dam with m^{th} season of birth.

DG_{ln} = Effect of interaction of the l^{th} age of dam with n^{th} sex of calf.

FG_{mn} = Effect of interaction of the m^{th} season of birth with n^{th} sex of calf

$E_{ijklmnp}$= Random error effects, E's assumed NID $(0, \theta^2)$

The actual model was reduced by removing two-factor interactions with P>.30.

CHAPTER IV

RESULTS AND DISCUSSION

The results for reproductive traits of beef cows will be presented and discussed under five categories which are calving interval, calving date, calving percentage, body condition score, and days to first luteal activity.

Calving Interval

Average lifetime calving interval of all cows (AVECI); individual yearly calving intervals of all cows (FINDCI) and cows that follow 12 -month interval (RINDCI) were analyzed. The analyses of variance for AVECI, FINDCI, and RINDCI of beef cows are presented in Table 3. AVECI was influenced by dam group and sire nested within dam group ($P<.05$). McElhenney and Long (1986) reported that cow breed type and parity had an effect on calving interval ($P<.01$). In addition, both AVECI and FINDCI were significantly influenced by year ($P<.0001$). Also, season influenced both FINDCI ($P<.001$) and RINDCI ($p<.01$). Bourdon and Brinks (1983), Haile-Mariam et al. (1993), Macgregor (1995), and Carvalheira et al. (1995) reported similar findings that year-season had a significant effect on calving interval ($P<.01$). However, Khan and Khan (1983) stated that season was not a significant effect on calving interval. There was a dam group by year interaction for AVECI (P<.01). There was no significant interaction between breed and year-season of calving in calving interval (Carvalheira et al., 1995). Papuntugan (1997) also reported that breed, age, and interaction between breed and age were not significant source of variation on reproductive efficiency. Moreover, both FINDCI and RINDCI were significantly influenced by cow age nested within year by season interaction (P<.0001). Bourdon and Brinks (1983) reported similar results that age of dam had significant effect on calving interval (P<.01). In general, age of dam, age of bull, year and season of calving (Philips et al., 1943; Warnick, 1955) affected reproductive performance of cows. Dhaliwal et al. (1996) reported that high yielding cows had consistently lower reproductive performance than low yielding cows for all intervals of calving to first service.

The least squares means, standard errors, and mean comparisons for AVECI, FINDCI, and RINDCI are in Table 4. Calving interval is the number of days from the birth of a calf in one year to the birth of the next calf, regardless of the season. There is a significant difference between breed groups for AVECI (P<.05). Cows sired by High Milk EPD bulls had longer intervals than cows sired by Low Milk EPD bulls. High Milk EPD cows sired by Hereford bulls (466.7 days) tended to have greater calving interval than Low Milk EPD cows sired by Hereford bulls (424.5 days) (P<.06). Differences between High and Low Milk EPD cows sired by Hereford and Angus were not statistically significant. The least squares means of AVECI and FINDCI showed that High Milk EPD cows sired by Hereford bulls had longer (about 42 and 20 days, respectively) calving interval than Low Milk EPD cows sired by Hereford bulls. This suggests some loss in reproductive performance of cows. In contrast, the least squares means of RINDCI indicated that the difference between High and Low Milk EPD cows sired by Hereford and Angus bulls were very small. Therefore, this suggests that there is no real loss in reproductive performance of beef cows from greater milk production. This was close to findings reported by Gregory et al. (1979), Reynolds et al. (1980), Khan and Khan (1983), and Kress et al. (1984).

There was a dam group by year of first calf interaction for AVECI (Table 5). High and Low Milk EPD cows sired by Angus and Hereford bulls did not differ for those entering the herd in 1991 through 1995 except the fact that High Milk EPD cows sired by Hereford were the longest (644.1 days) and statistically differed ($P<.01$) in average calving interval than Low Milk EPD cows sired by Hereford (475.6 days) in 1995. But the evidence should be viewed skeptically since the number of observation is so small for two groups in 1995 (n=3). Younger cows often displayed calving intervals more than 365-day (Dunn and Kaltenbach, 1980). The difference between breed and level was not statistically significant. Both FINDCI and RINDCI are shown for both spring and fall calving seasons in Table 6. Differences among dam groups were not statistically important except the fact that cows sired by High Milk EPD Hereford bulls in the spring had longer calving intervals (460.1 days) and were significantly different ($P<. 05$) than sired by Low Milk EPD Hereford bulls (417.9 days) for FINDCI. Both least squares means of FINDCI and of RINDCI illustrated that High

Milk EPD cows sired by Angus bulls had the lowest calving interval (387.41 and 365.95 days, respectively) for the fall calving season. These results were close to findings reported by Macgregor (1995). However, differences among dam breed groups were not statistically significant for RINDCI. The results indicate that there is no substantial difference among four dam groups based on calving interval and point out that it is consistent that High Milk EPD cows had slightly longer calving intervals than Low Milk EPD cows in spring but the reverse was true in fall.

Calving Date

Calving dates of all cows that were used in study (FCD) and of cows that followed a 12-month interval (RCD) were analyzed. The analyses of variance for both FCD and RCD are shown in Table 7. Year was a significant source of variation for FCD and RCD (P<.001). There was not a significant dam group and year by sex of calf interaction effects for either FCD or RCD. Although sire nested within dam group (P<.01), cow age, and dam group by year interaction (P<.05) were significant sources of variation for FCD, those sources did not affect RCD. On the other hand, RCD was significantly influenced by season, sex of calf (P<.01), and dam group by cow age interaction (P<.05). Newman et al. (1993) reported that sex effect were critical for calving day (P<.01). Moreover, year and year by season interaction highly affected both FCD (P<.0001) and RCD (P<.01 and P<.0001, respectively). Bourdon and Brinks (1983), Rege and Famula (1993), and Macgregor (1995) stated that year-season was a significant source of variation for calving date (P<.01). Lopez de Torre and Brinks (1989) and Macgregor (1995) reported that age of dam had no significant effect on calving date. However, Bourdon and Brinks (1983), Morris (1984), Azzam and Nielsen (1987), and Buddenberg et al. (1990) were in agreement with the results that age of dam affected calving date.

Least squares means, standard errors, and mean comparisons for both FCD and RCD are in Table 8. Calving dates are presented as days following the beginning of the calving season. There is a significant interaction between breed groups and milk level (P<.05) for RCD. Both FCD and RCD showed that High Milk EPD cows sired by Angus bulls had longer calving dates (32.2 and 35.8 days, respectively) than Low Milk EPD cows sired by Angus bulls (27.9 and 30.0 days, respectively). The reverse was true for cows sired by Hereford bulls. However, none of the differences were found statistically significant.

FCD was affected (P<. 05) by a dam group by year interaction (Table 9). Differences between High and Low Milk EPD cows sired by Hereford and Angus bulls were not statistically significant except the fact that High Milk EPD cows sired by Angus bulls in 1995 were the longest (39.7 days) and significantly differed (P<. 05) in calving dates from Low Milk EPD cows sired by Angus bulls.

In contrast, RCD was influenced (P<. 05) by dam group by cow age interaction (Table 10). 2-year-old cows calved significantly earlier than older cows and the difference in calving date among 3 year old and older cows were small (Rege and Famula, 1993). There was no uniform direction between cows sired by High and Low Milk EPD Angus and Hereford bulls at 3 through 8 years age. Low Milk EPD cows sired by Angus and Hereford bulls had later (about 9.0 and 10.6 days, respectively) calving dates than High Milk EPD cows sired by Angus and Hereford bulls. In addition, the differences Low and High Milk EPD cows sired by Angus and Hereford bulls were statistically significant (P<. 05). These results may suggest that there is some alteration on reproductive performance.

Calving Percentage

Calving percentage of all cows that were 2 years old (FCP1), of all cows that were between 3 through 8 years old (FCP2) and of cows that follow 12 months interval (RCP) were analyzed. The analyses of variance for FCP1 and FCP2 of beef cows are presented in Table 11. There were no significant differences in dam group, sire nested within dam group, year, season, and dam group by year interaction effects when looking at FCP1. Olson et al. (1990), Gregory et al. (1992), Newman et al. (1993) (P<.01) and Comerford et al. (1987) (P<.05) reported different findings that year had significant effect on calving rate. In addition, dam group, sire nested within dam group, sex of calf effects were also not statistically significant for FCP2. On the other hand, FCP2 was significantly influenced by year, cow age nested within year, and season by a sex of calf interaction (P<. 05). But, this is not completely in agreement with the results reported by Newman et al. (1993). They reported that, although year was critical for all traits, age of dam was not a significant source of variation for calving rate. Also, FCP2 was affected by season (P<. 01), cow age nested within year by season (P<. 001) and year by season interactions (P<. 0001). In contrast, the analyses of variance for calving percentage of cows that follow 12 months interval (RCP) were shown in Table 12. Although dam group, sex of calf and dam group by season interaction effects were not significant sources of variation in RCP, there was a significant sire nested within dam group (P<. 05), year, cow age, cow age by season, season by sex of calf (P<.01) and season (P<.0001) effects on RCP.

The least squares means, standard errors, and mean comparisons for FCP1, FCP2 and RCP are shown in Table 13. Calving percentage is the proportion of cows that calved in one year that had a calf in the same season of next year. There is a significant difference between breed groups for FCP2 (P<.05). However, Newman and Deland (1991) stated that breed was not a significant source of variation for calving percentage. Two-year-old cows sired by High Milk EPD bulls had a higher calving percentage for both Angus and Hereford sired cows for FCP1 (72 and 72 %, respectively). Gregory et al. (1992) reported that there was a difference in calving rate between Angus and Hereford. Burris and Priode (1958) stated that calving rate was higher in Angus than in Hereford and Shorthorn. All High Milk EPD cows, that were between 3 through 8 years old, sired by Angus bulls showed slightly higher calving percentage for both FCP2 and RCP (79 and 86%, respectively). However, there was no real difference between Low and High Milk EPD cows sired by Hereford bulls for FCP2 as well as RCP. Newman et al. (1993) reported that older cows expressed higher pregnancy rate than younger cows (P<.01). Bar-Anan et al. (1985) found that cows with high yield had lower pregnancy rate than cows with low yield. The difference between cow breed groups was not statistically significant.

Body Condition Score

Body condition score of all cows at 1st (BCS1) and 7th (BCS7) months of lactation period were analyzed. The analyses of variance for BCS1 and BCS7 are presented in Table 14. Sire nested within dam group, year, age of dam, season, and year by season affects ($P < .0001$) both BCS1 and BCS7. Sowell et al. (1992) reported similar findings that year was a significant effect on cow body condition at breeding ($P < .001$) but, these results are not completely in agreement with the results of Marston et al (1992). They stated that age group was not significant source of variation for body condition score. Olson et al. (1985) reported that year, sex of calf, type of sire, and type of dam affected body condition score ($P < .001$). Even if dam group ($P < .01$) and dam group by season ($P < .0001$) was a source of variation for BCS7, those effects did not influence BCS1. On the other hand, while cow age by season interaction ($P < .01$) affected on BCS1, this interaction did not affect BCS7. Moreover, sex of calf was not a significant source of variation in BCS1 nor BCS7.

In addition to BCS1 and BCS7, difference between body condition score of cows at 7th and at 1st months of lactation (BCSD) was also analyzed and the sources of variation for BCSD are given in Table 15. Sires nested within dam group, sex of calf, and cow age nested within year by sex of calf interaction were not significant for BCSD. However, dam group, dam group by season ($P < .05$), cow age nested within year (P<.01), year, season, and cow age nested within year by season interaction (P<.0001) affected BCSD.

The least squares means, standard errors, and mean comparisons for BCS1, BCS7, and BCSD are displayed in Table 16. Milk level is critical for BCS (p<.05), BCS7 (P<.001), and BCSD (P<.01). Even though there is no significant interaction between breed group and milk level, milk level within the Hereford breed (P<.01) and milk level within the Angus breed (P<.05) were statistically significant for BCS7. Cows sired by High Milk EPD bulls had a lower body condition score for BCS1, BCS7 and BCSD. The difference between High and Low Milk EPD cows sired by Hereford and Angus bulls was not significant for BCS1. However, there is a significant (P<.01) difference between cows sired by Low Milk EPD Angus (5.33) and High Milk EPD Angus bulls (5.07) for BCS7. This is also true for Hereford sired cows (P<.05). Low Milk EPD cows sired by Angus and Low Milk EPD cows sired by Hereford bulls had higher body condition scores (5.33 and 5.35, respectively). Richards et al. (1986) stated that cow with low body condition score (≤ 4) showed longer postpartum intervals. Macarechian and Arthur (1990) stated that cows with lower condition than 3.0 (on a 6-point scale) had a lower calving rate and shorter calving interval at calving. In contrast, condition score differences between cows at 7^{th} and at 1^{st} months of lactation showed that, although cows sired by Low Milk EPD bulls had not lost any condition score during 7^{th} month of period, cows sired by High Milk EPD Angus and Hereford bulls had lost some condition scores (-.16 and -.08, respectively). The difference was not significant for Hereford sired cows, but the difference between High and Low Milk EPD cows sired by Angus bulls (-.16 and -.04, respectively) was statistically significant (P<.05). In general, the results suggested that cows that were sired by Low Milk EPD bulls had higher condition score at the time of weaning than cows sired by High Milk EPD bulls.

Dam group by season of birth interaction affected both BCS7 and BCSD (Table17). Cows sired by High Milk EPD bulls tended to have lower condition scores than cows sired by Low Milk EPD bulls for both BCS7 and BCSD. The difference between High and Low Milk EPD cows sired by Hereford bulls were not significant during the spring season for both BCS7 and BCSD. This also was true for Angus sired cows in the fall. However, Low Milk EPD cows sired by Angus bulls in the spring were higher in condition (5.64) and significantly differed (P<.05) in condition score than High Milk EPD cows sired by Angus bulls while Low Milk EPD cows sired by Hereford bulls at fall had significantly higher (5.12) body condition score (P<.0001). In addition, the difference between High and Low Milk EPD cows sired by Hereford bulls were also statistically significant (P<.05) in the fall (4.78 and 5.12, respectively). BCSD showed significant difference (P<.0001) between cows sired by High and Low Milk EPD Angus bulls at spring season (.19 and .34, respectively). Also, High and Low Milk EPD cows sired by Hereford bulls at fall season were different (P<.0001) than each other (-0.56 and -0.42, respectively). The results showed that cows sired by Angus bulls did not lose condition score during lactation if calving in the spring, even High and Low Milk EPD cows sired by Angus bulls gained a little more condition score at that time (.19 and .34, respectively). In contrast, High and Low Milk EPD cows sired by Hereford bulls in the fall season lost some condition score (-0.56 and -0.42, respectively) even though they increased in condition score in the spring and ultimately, there was some loss in reproductive performance. These results showed that cows that calved in the spring season have an advantage to fall calving cows. The reason for this advantage is probably due to feeding advantages during the spring and summer. Moreover, the results in the fall season give an idea that there is an expense in condition score, which may affect reproductive efficiency of cows. However, Lindley et al. (1958) reported that the reproductive performance was higher in summer and fall than in winter and spring generally.

Days to First Luteal Activity

Date of luteal activity of all cows (FDOLA) and of cows that follow 12 months interval (RDOLA) were analyzed and the analyses of variance for FDOLA and RDOLA are shown in Table 18. Dam group, sire nested within dam group, and sex of calf effects did not influence both FDOLA and RDOLA. Season of birth had a significant effect ($P<.0001$) for FDOLA as well as RDOLA. Furthermore, while cow age was a significant source of variation for FDOLA ($P<.05$), RDOLA was not affected by cow age.

The least squares means, standard errors, and mean comparisons for both FDOLA and RDOLA are presented in Table 19. Days to first luteal activity is the difference between calving date and first date that the concentration of progesterone level at cows' blood is greater than 1 ng/ml in two consecutive weekly samples. High Milk EPD cows sired by Hereford bulls showed longer dates of luteal activity than Low Milk EPD cows sired by Hereford bulls for both FDOLA and RDOLA (57.6 and 60.5 days, respectively). However, the reverse was true for cows sired by Angus bulls for FDOLA. In contrast, RDOLA showed almost similar dates of luteal activity between High and Low Milk EPD cows sired by Angus bulls (54.8 and 54.3 days, respectively). However, neither difference among four cow groups was statistically significant.

TABLE 3. ANALYSES OF VARIANCE FOR AVERAGE LIFETIME CALVING INTERVAL (AVECI), INDIVIDUAL YEARLY CALVING INTERVAL OF ALL COWS (FINDCI), AND INDIVIDUAL YEARLY CALVING INTERVAL OF COWS THAT FOLLOW 12 MONTHS INTERVAL (RINDCI)

	AVECI		FINDCI		RINDCI	
Source of Variation	df	p-value	df	p-value	df	p-value
Dam Group	3	0.0321	3	0.4689	3	0.8096
Sire(Dam Group)	37	0.0407	34	0.0869	34	0.3544
Year	4	0.0001	5	0.0001	4	0.0877
Cow Age(Year)	-	-	12	0.0170	9	0.1466
Season	-	-	1	0.0005	1	0.0043
Sex of Calf	-	-	1	0.3668	1	0.8427
Dam Group*Year	12	0.0084	-	-	-	-
DamGroup*Season	-	-	3	0.0105	3	0.0513
Cow Age(Year)*Season	-	-	17	0.0001	13	0.0001
Season *Sex of Calf	-	-	-	-	1	0.1922
RESIDUAL	209	MS 4728.52	881	MS 10352.98	581	MS 8556.62

Calving interval is the number of days from first calf to the second calf, regardless of calving season.
AVECI . Total calving intervals of each cows / total number of calvings
Dam groups : High Milk EPD Angus (HMA), Low Milk EPD Angus (LMA), High Milk EPD Hereford (HMH), and Low Milk EPD
MS · Mean Squares
Year for AVECI: Year of the first calf

Table 5. LEAST SQUARES MEANS AND STANDARD ERRORS FOR AVERAGE LIFETIME CALVING INTERVAL (AVECI) BY INTERACTION: DAM GROUP VS YEAR

Source of Variation Interaction: Dam Group*Year of Birth			AVECI		
BREED	LEVEL	YEAR OF BIRTH	n	LSMeans	SE
Angus	High	1991	17	409.6	27.8
Angus	Low	1991	17	420.6	30.7
Hereford	High	1991	13	454.3	42.7
Hereford	Low	1991	22	438.7	27.9
Angus	High	1992	19	394.1	24.3
Angus	Low	1992	19	398.9	22.2
Hereford	High	1992	12	333.4	39.9
Hereford	Low	1992	19	417.3	21.1
Angus	High	1993	16	405.5	31.2
Angus	Low	1993	11	414.2	24.9
Hereford	High	1993	7	495.8	39.9
Hereford	Low	1993	15	422.1	26.4
Angus	High	1994	14	413.5	21.9
Angus	Low	1994	17	413.3	20.5
Hereford	High	1994	9	406.1	27.4
Hereford	Low	1994	10	368.6	25.4
Angus	High	1995	12	442.8	25.6
Angus	Low	1995	11	407.0	29.8
Hereford	High	1995	3	644.1 [a]	44.2
Hereford	Low	1995	3	475.6 [b]	42.4

[a, b] Means within different Milk EPD group with the same type of breed and year of calving with different superscripts differ ($p<.01$).
AVECI : Total calving intervals of each cows / total number of calvings
Year of birth: Year of the first calf

TABLE 6. LEAST SQUARES MEANS AND STANDARD ERRORS FOR INDIVIDUAL YEARLY CALVING INTERVAL OF ALL COWS (FINDCI), AND INDIVIDUAL YEARLY CALVING INTERVAL OF COWS THAT FOLLOW 12 MONTHS INTERVAL (RINDCI) BY INTERACTION : DAM GROUP VS SEASON

Source of Variation Interaction: Dam Group*Season			FINDCI			RINDCI		
BREED	LEVEL	SEASON	n	LSMeans	SE	n	LSMeans	SE
Angus	High	Spring	111	449.6	12.0	60	437.6	16.0
Angus	Low	Spring	140	424.4	10.7	84	406.4	13.6
Hereford	High	Spring	67	460.1[a]	14.9	30	412.3	22.3
Hereford	Low	Spring	120	417.9[b]	12.0	72	394.9	15.2
Angus	High	Fall	146	387.4	11.3	113	365.9	13.4
Angus	Low	Fall	133	408.4	12.0	106	386.1	14.1
Hereford	High	Fall	91	413.1	12.9	70	379.5	15.7
Hereford	Low	Fall	150	415.4	10.9	116	384.2	13.1

[a,b] means within different Milk EPD group, same breed and season with different superscripts differ ($p < .05$).

Calving interval is the number of days from first calf to the second calf, regardless of calving season.

TABLE 7. ANALYSES OF VARIANCE FOR INDIVIDUAL CALVING DATE OF ALL COWS (FCD), AND INDIVIDUAL CALVING DATE OF COWS THAT FOLLOW 12 MONTHS INTERVAL (RCD)

	FCD			RCD		
Source of Variation	df	p-value		df	p-value	
Dam Group	3	0.6878		3	0.1917	
Sire (Dam Group)	37	0.0037		37	0.1042	
Year	6	0.0001		5	0.0030	
Cow Age	6	0.0238		5	0.6855	
Season	1	0.1366		1	0.0026	
Sex of Calf	1	0.0916		1	0.0021	
Dam Group*Year	18	0.0482		15	0.0607	
Dam Group*Cow Age	18	0.1465		15	0.0147	
Year*Season	6	0.0001		5	0.0001	
Year*Sex of Calf	6	0.1279		5	0.1763	
Cow Age*Season	6	0.2166		-	-	
Season*Sex of Calf	-	-		1	0.1128	
RESIDUAL	1165	MS	271.07	814	MS	263.67

Calving date is the number of days following the beginning of the calving season.
MS : Mean Squares
Sex of calf: Previous sex of calf

TABLE 8. LEAST SQUARES MEANS, STANDARD ERRORS AND MEAN COMPARISONS FOR INDIVIDUAL CALVING DATE OF ALL COWS (FCD), AND INDIVIDUAL CALVING DATE OF COWS THAT FOLLOW 12 MONTHS INTERVAL (RCD)

		FCD			RCD		
Breed	Level	n	LSMeans	SE	n	LSMeans	SE
Angus	High	350	32.2	3.2	253	35.8	3.3
Angus	Low	374	27.9	3.2	269	30.0	3.4
Hereford	High	207	26.9	3.4	141	25.7	3.7
Hereford	Low	343	29.5	2.6	245	33.4	2.7
Mean Comparison		df	p-value		df	p-value	
Breed		1	0.5161		1	0.3032	
Milk		1	0.8111		1	0.7712	
Breed*Milk		1	0.2584		1	0.0444	
Milk(Hereford)		1	0.3548		1	0.2237	
Milk(Angus)		1	0.5037		1	0.0941	

Calving date is the number of days following the beginning of the calving season.

TABLE 9. LEAST SQUARES MEANS AND STANDARD ERRORS FOR INDIVIDUAL CALVING DATE OF ALL COWS (FCD) BY INTERACTION: DAM GROUP VS YEAR

Source of Variation Interaction: Dam Group*Year			FCD		
Breed	Level	Year	n	LSMeans	SE
Angus	High	1991	18	33.0	6.8
Angus	Low	1991	18	21.4	7.5
Hereford	High	1991	14	32.1	8.7
Hereford	Low	1991	24	21.9	6.8
Angus	High	1992	35	32.1	5.0
Angus	Low	1992	41	30.3	5.4
Hereford	High	1992	26	24.2	6.3
Hereford	Low	1992	42	38.5	4.9
Angus	High	1993	46	32.5	3.9
Angus	Low	1993	41	32.2	4.3
Hereford	High	1993	27	28.4	4.8
Hereford	Low	1993	49	33.0	3.7
Angus	High	1994	54	36.9	3.4
Angus	Low	1994	57	32.8	3.2
Hereford	High	1994	34	33.0	3.8
Hereford	Low	1994	56	35.4	3.0
Angus	High	1995	64	39.7[a]	2.6
Angus	Low	1995	70	30.6[b]	2.4
Hereford	High	1995	31	25.0	3.4
Hereford	Low	1995	60	26.9	2.5
Angus	High	1996	68	27.7	2.4
Angus	Low	1996	72	25.8	2.2
Hereford	High	1996	37	23.6	3.3
Hereford	Low	1996	56	26.3	2.7
Angus	High	1997	65	23.5	2.5
Angus	Low	1997	75	22.7	2.5
Hereford	High	1997	38	22.4	3.8
Hereford	Low	1997	56	24.7	3.3

[a,b] Means within different Milk EPD group, the same breed and year with different superscripts differ ($p < .05$)

Calving date is the number of days following the beginning of the calving season.

TABLE 10. LEAST SQUARES MEANS AND STANDARD ERRORS FOR INDIVIDUAL CALVING DATE OF COWS THAT FOLLOW 12 MONTHS INTERVAL (RCD) BY INTERACTION : DAM GROUP VS AGE OF DAM

Source of Variation Interaction: Dam Group*Age of Dam			RCD		
Breed	Level	Age of Dam	n	LS Means	SE
Angus	High	3	59	32.9	2.4
Angus	Low	3	51	27.6	2.7
Hereford	High	3	30	24.9	4.4
Hereford	Low	3	51	29.2	3.2
Angus	High	4	57	26.8[a]	2.6
Angus	Low	4	63	35.7[b]	2.4
Hereford	High	4	29	28.0	3.5
Hereford	Low	4	51	29.6	2.6
Angus	High	5	52	30.8	3.3
Angus	Low	5	52	31.2	3.3
Hereford	High	5	31	25.6[a]	4.1
Hereford	Low	5	51	36.2[b]	2.9
Angus	High	6	45	37.9	4.0
Angus	Low	6	51	29.3	4.2
Hereford	High	6	23	31.6	5.0
Hereford	Low	6	44	34.9	3.7
Angus	High	7	27	37.9	5.2
Angus	Low	7	36	27.0	5.4
Hereford	High	7	19	22.4	6.6
Hereford	Low	7	31	37.9	5.3
Angus	High	8	13	48.8	7.5
Angus	Low	8	16	29.3	7.6
Hereford	High	8	9	21.5	9.7
Hereford	Low	8	17	32.3	7.4

[a,b] Means within different Milk EPD group, the same breed and age of dam with different superscripts differ ($p < .05$).

Calving date is the number of days following the beginning of the calving season.

TABLE 11. ANALYSES OF VARIANCE FOR CALVING PERCENTAGE OF COWS THAT WERE TWO YEARS OLD (FCP1), AND CALVING PERCENTAGE OF COWS THAT WERE THREE THROUGH EIGHT YEARS OLD (FCP2)

	FCP1		FCP2	
Source of Variation	df	p-value	df	p-value
Dam Group	3	0.2815	3	0.1993
Sire(Dam Group)	34	0.9809	37	0.3438
Year	3	0.9422	5	0.0196
Cow Age(Year)	-	-	11	0.0374
Season	1	0.6947	1	0.0057
Sex of Calf	-	-	2	0.9002
Dam Group*Year	9	0.3566	-	-
Dam Group*Season	-	-	3	0.0719
Year*Season	-	-	5	0.0001
Cow Age(Year)*Season	-	-	11	0.0002
Season*Sex of Calf	-	-	2	0.0159
RESIDUAL	275	MS 0.23	1264	MS 0.15

Calving percentage is the proportion of cows that calved in one year that also had calf in the same season of the next year.
MS : Mean Squares
Sex of calf: Previous sex of calf

TABLE 12. ANALYSES OF VARIANCE FOR CALVING PERCENTAGE OF COWS THAT FOLLOW 12 MONTHS INTERVAL (RCP)

	RCP		
Source of Variation	df	p-value	
Dam Group	3	0.2642	
Sire(Dam Group)	37	0.0431	
Year	5	0.0018	
Cow Age	5	0.0037	
Season	1	0.0001	
Sex of Calf	1	0.8919	
Dam Group*Season	3	0.1804	
Year*Season	5	0.0001	
Cow Age*Season	5	0.0016	
Season*Sex of Calf	1	0.0048	
RESIDUAL	990	Mean Squares	0.15

Calving percentage is the proportion of cows that calved in one year that also had calf in the same season of the next year.
Sex of calf: Previous sex of calf

TABLE 13. LEAST SQUARES MEANS, STANDARD ERRORS, AND MEAN COMPARISONS FOR COWS THAT WERE TWO YEARS OLD (FCP1), CALVING PERCENTAGE OF COWS THAT WERE THREE THROUGH EIGHT YEARS OLD (FCP2), AND CALVING PERCENTAGE OF COWS THAT FOLLOW 12 MONTHS INTERVAL (RCP)

		FCP1			FCP2			RCP		
Breed	Level	n	LS Means	SE	n	LS Means	SE	n	LS Means	SE
Angus	High	83	0.72	0.05	358	0.79	0.04	285	0.86	0.06
Angus	Low	87	0.61	0.04	387	0.78	0.03	304	0.84	0.05
Hereford	High	56	0.72	0.05	228	0.71	0.03	171	0.75	0.05
Hereford	Low	100	0.68	0.06	372	0.74	0.03	297	0.81	0.04
Mean Comparison		df	p-value		df	p-value		df	p-value	
Breed		1	0.4635		1	0.0435		1	0.0700	
Milk		1	0.1443		1	0.5999		1	0.5793	
Breed*Milk		1	0.5363		1	0.4735		1	0.2962	
Milk(Hereford)		1	0.1033		1	0.8935		1	0.7250	
Milk(Angus)		1	0.5779		1	0.3699		1	0.2614	

Calving percentage is the proportion of cows that calved in one year that also had calf in the same season of the next year.

TABLE 14. ANALYSES OF VARIANCE FOR BODY CONDITION SCORE OF COWS AT 1ST MONTH OF LACTATION (BCS1), AND BODY CONDITION SCORE OF COWS AT 7TH MONTH OF LACTATION (BCS7)

	BCS1		BCS7	
Source of Variation	df	p-value	df	p-value
Dam Group	3	0.1352	3	0.0076
Sire(Dam Group)	37	0.0001	37	0.0001
Year	6	0.0001	6	0.0001
Cow Age	6	0.0001	6	0.0001
Season	1	0.0001	1	0.0001
Sex of Calf	1	0.1640	1	0.0834
Dam Group*Season	3	0.1175	3	0.0001
Year*Season	6	0.0001	6	0.0001
Year*Sex of Calf	-	-	6	0.0611
Cow Age*Season	6	0.0017	6	0.2241
Season*Sex of Calf	-	-	1	0.1582
RESIDUAL	1027	MS 0.25	1192	MS 0.24

MS Mean Squares

TABLE 15. ANALYSES OF VARIANCE FOR BODY CONDITION SCORE DIFFERENCE BETWEEN BODY CONDITION SCORE OF COWS AT 7^{TH} MONTH OF LACTATION, AND BODY CONDITION SCORE OF COWS AT 1^{ST} MONTH OF LACTATION (BCSD)

	BCSD		
Source of Variation	df	p-value	
Dam Group	3	0.0256	
Sire(Dam Group)	37	0.1709	
Year	6	0.0001	
Cow Age(Year)	18	0.0051	
Season	1	0.0001	
Sex of Calf	1	0.8884	
Dam Group* Season	3	0.0487	
Cow Age(Year)* Season	24	0.0001	
Cow Age(Year)* Sex of Calf	24	0.1772	
RESIDUAL	969	Mean Squares	0.20

TABLE 16. LEAST SQUARES MEANS, STANDARD ERRORS, AND MEAN COMPARISONS FOR BODY CONDITION SCORE OF COWS AT 1^{ST} MONTH OF LACTATION (BCS1), BODY CONDITION SCORE OF COWS AT 7^{TH} MONTH OF LACTATION (BCS7), AND BODY CONDITION SCORE DIFFERENCE BETWEEN BCS7 AND BCS1 (BCSD)

		BCS1			BCS7			BCSD		
Breed	Level	n	LSMeans	SE	n	LSMeans	SE	n	LSMeans	SE
Angus	High	301	5.21	0.1	350	5.07^{a}	0.1	300	-0.16^{c}	0.05
Angus	Low	327	5.36	0.1	375	5.33^{b}	0.1	325	-0.04^{d}	0.04
Hereford	High	185	5.19	0.1	204	5.12^{c}	0.1	182	-0.08	0.05
Hereford	Low	284	5.34	0.1	340	5.35^{d}	0.1	280	0.01	0.04
Mean Comparison		df	p-value		df	p-value		df	p-value	
Breed		1	0.7416		1	0.6324		1	0.1484	
Milk		1	0.0216		1	0.0008		1	0.0068	
Breed*Milk		1	0.9676		1	0.8009		1	0.6270	
Milk(Hereford)		1	0.0821		1	0.0071		1	0.0191	
Milk(Angus)		1	0.1140		1	0.0248		1	0.1140	

[a,b] Means within different milk level, same breed with different superscripts differ ($p<.01$).
[c,d] Means within different milk level, same breed with different superscripts differ ($p<.05$).

TABLE 17. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BODY CONDITION SCORE OF COWS AT 7TH MONTH OF LACTATION (BCS7), AND BODY CONDITION SCORE DIFFERENCE BETWEEN BCS7 AND BCS1 (BCSD) BY INTERACTION: DAM GROUP VS SEASON

Source of Variation Interaction: Dam Group*Season			BCS7			BCSD		
Breed	Level	Season	n	LS Means	SE	n	LS Means	SE
Angus	High	Spring	161	5.23[a]	0.06	141	0.19[c]	0.05
Angus	Low	Spring	203	5.64[b]	0.06	178	0.34[d]	0.04
Hereford	High	Spring	84	5.47	0.07	77	0.39	0.06
Hereford	Low	Spring	149	5.58	0.05	123	0.44	0.05
Angus	High	Fall	189	4.92	0.06	159	-0.52	0.06
Angus	Low	Fall	172	5.02	0.06	147	-0.41	0.05
Hereford	High	Fall	120	4.78[a]	0.06	105	-0.56[c]	0.05
Hereford	Low	Fall	191	5.12[b]	0.05	157	-0.42[d]	0.05

[a,b] Means within different milk level, same breed and season of birth with different superscripts differ ($p<.0001$).
[c,d] Means within different milk level, same breed and season of birth with different superscripts differ ($p<.05$).

TABLE 18. ANALYSES OF VARIANCE FOR DATE OF LUTEAL ACTIVITY OF ALL COWS (FDOLA) AND DATE OF LUTEAL ACTIVITY OF COWS THAT FOLLOW 12 MONTHS INTERVAL (RDOLA)

	FDOLA		RDOLA	
Source of Variation	df	p-value	df	p-value
Dam Group	3	0.9296	3	0.4776
Sire(Dam Group)	37	0.1178	37	0.2149
Cow Age	4	0.0187	4	0.3685
Season	1	0.0001	1	0.0001
Sex of Calf	1	0.3625	1	0.8602
Dam Group*Sex of Calf	3	0.1757	-	-
RESIDUAL	177	MS 206.73	135	MS 191.64

Date of luteal activity is the difference between birth date and first date that concentration of progesterone at cow's blood is greater than 1 ng/ml in two consecutive weekly sample.
MS : Mean Squares

TABLE 19. LEAST SQUARES MEANS, STANDARD ERRORS AND MEAN COMPARISONS FOR DATE OF LUTEAL ACTIVITY OF ALL COWS (FDOLA) AND DATE OF LUTEAL ACTIVITY OF COWS THAT FOLLOW 12 MONTHS INTERVAL (RDOLA)

		FDOLA			RDOLA		
Breed	Level	n	LSMeans	SE	n	LSMeans	SE
Angus	High	63	56.2	2.8	52	54.8	2.8
Angus	Low	75	57.5	2.1	61	54.3	2.2
Hereford	High	34	57.6	3.3	26	60.5	3.5
Hereford	Low	55	55.5	3.2	43	55.7	3.2
Mean Comparison		df	p-value		df	p-value	
Breed		1	0.9279		1	0.2405	
Milk		1	0.8797		1	0.3247	
Breed*Milk		1	0.5261		1	0.4354	
Milk(Hereford)		1	0.7076		1	0.8863	
Milk(Angus)		1	0.6069		1	0.2590	

Date of luteal activity is the difference between birth date and first date that concentration of progesterone at cow's blood is greater than 1 ng/ml in two consecutive weekly sample.

CHAPTER V

IMPLICATIONS

Reproductive performance greatly affects net income of the beef cow producers in the cow-calf industry. Selection programs should be designed such that consistent reproductive performance is maintained.

Milk EPD can be used to predict weaning performance in cow-calf operations accurately (Mallinckrodt et al., 1990; Marston et al., 1992; Gosz, 1995; Buchanan et al., 1997). This study was conducted to determine if changes in performance due to selection for Milk EPD had an effect on reproductive performance. The results indicated that there was not a large difference in reproductive performance resulting from difference in Milk EPD levels of the cows. This should allow beef producers to use Milk EPDs with less concern about potential negative effects on reproduction. However, It should be pointed out that this recommendation might not apply if the nutritional level is considerably lower than the conditions in this study.

The results also showed that cows that calved in the spring season have an advantage over fall calving cows. The reason for this advantage might be that there are better nutritional resources during times of high stress for spring calving cows.

Since some of traits are highly variable and the quantity of data is still relatively small, further research is necessary to more fully investigate lifetime reproductive efficiency of cows with differing genetic merit for milk production.

LITERATURE CITED

American Angus Association. Angus Sire Evaluation. Fall 1998. http://www.ccp.com/~angus/sireeval/.

American Hereford Association. 1998. Sire Selector. http://www.missouri.edu/~anscbeef/hereford/.

Azzam, S. M. and M. K. Nielsen. 1987. Genetic parameters for gestation length, birth date and first breeding date in beef cattle. J. Anim. Sci. 64:348.

Baker, J. F., C. R. Long and T. C. Cartwright. 1984. Characterization of cattle of a five bred diallel. V. Breed and heterosis effects on carcass merit. J. Anim. Sci. 59:922.

Bar-Anan, R. and M. Soller. 1979. The effects of days-open on milk yield and on breeding policy post partum. Anim. Prod. 29:109-119.

Bar-Anan, R., M. Ron, and G. R. Wiggans. 1985. Association among milk yield, yield persistency, conception and culling of Israeli Holstein cattle. J. Dairy Sci. 68:382-386.

Beal, W.E., D.R. Notter and R. M. Akers. 1990. Techniques for estimation of milk yield in beef cows and relationships of milk yield to calf weight gain and postpartum reproduction. J. Anim. Sci. 68:937.

Bellows, R. A. and R. E. Short. 1978. Effects of pre-calving feed level on birth weight, calving difficulty and subsequent fertility. J. Anim. Sci. 46:1522.

Benyshek, L. L., M. H. Johnson, D. E. Little, J. K. Bertrand and L. E. Kriese. 1988. Applications of an animal model in The United States beef cattle industry. J. Dairy Sci. 71 (Suppl.2):35.

Benyshek, L.L 1986. Sire evaluation-where we've come from. Proc. Beef Improvement fed. Symp. and Annual Meeting. pp 58-68.

Bertrand, J. A., Berger, P. J., Freeman, A. E. and Kelly D. J., 1985. Profitability in daughters of high versus average Holstein sires selected for milk yielk of daughters. J. Daity Sci., 68:2287-2294.

Bishop, M. W. H., R. C. Campbell, J. L. Hancock and A. Walton. 1954. Semen characteristics and fertility in the bull. J. Agr. Sci. 44:227.

Boggs, D. L., E. F. Smith, R. R. Schalles, B. E. Brent, L. R. Corah and R. J. Pruitt.1980. Effects of milk and forage intake on calf performance. J. Anim. Sci. 51:550.

Bourdon, R. M. and J. S. Brinks. 1983. Calving date versus calving interval as a reproductive measure in beef cattle. J. Anim. Sci. 57:1412.

Briggs, H. M. 1969. Modern breeds of Livestock. 3rd Edition. The Macmillian Company, New York, N.Y.

Buchanan, D.S., R. Gosz, E. Nesamvuni and L. Knori. 1996b. Reproduction performance for cows sired by high and low milk EPD Angus and Polled Hereford bulls – A preliminary report. Ok. Agr. Exp. Station. P-951:12.

Buchanan, D. S., G.K. Ziehe, and L. Knori. 1992. Performance of calves from heifers sired by High and Low Milk EPD sires: Preliminary Results. Ok. Agr. Exp. Station. MP-136:11.

Buchanan, D. S., R. Gosz, and L. Knori. 1997. Reproductive regularity for young cows sired by High and Low Milk EPD Angus and Polled Hereford bulls. Ok. Agr. Exp. Station. P-958:11.

Buchanan, D.S., G.K. Ziehe, and L. Knori. 1993. Calf performance, body weight and condition score for first calf heifers sired by high and low milk EPD sires. Ok. Agr. Exp. Station. P-933:5.

Buhanan, D.S., R. Gosz, E. Nesamvuni and L. Knori. 1996a. Calf performance and cow weight and condition for cows sired by high and low milk EPD Angus and Polled Hereford bulls. Ok. Agr. Exp. Station.P-951:1.

Bundy, C. E., R. V. Diggins, and V. W. Christensen. 1982. Livestock and poultry production. 5th Edition. Prentice-Hall, Inc., Englewood Cliffs, N. J; 07632.

Burris, M. J. and B. M. Priode. 1958. Effect of calving date on subsequent calving performance. J. Anim. Sci. 17:527.

Burris, M. J., and C. T. Blunn. 1952. Some factors affecting gestation length and birth weight of beef calves. J. Animal Sci. 11:34.

Cantrell, J. A., J. R. Kropp, S. L. Armbruster, K. S. Lusby, R. P. Wettemann, and R. L. Hintz. 1982. The influence of postpartum nutrition and weaning age of calves on cow body condition, estrus conception rate and calf performance of fall-calving beef cows. Okla. Agr. Exp. Sta. Res. Rep. MP-112.

Carroll, E. J., and A. B. Hoerlein. 1966. Reproductive performance of beef cattle under drought conditions. J. Am. Vet. Med. Assoc. 148:1030.

Clutter, A. C. and M. K. Nielsen. 1987. Effect of level of beef cow milk production on pre-and postweaning calf growth. J. Anim. Sci. 64:1313.

Cole, L. J. and I. Johansson. 1933. The yield and composition of milk from Aberdeen Angus cows. J. Dairy Sci. 16:565.

Comerford, J. W., J. K. Bertrand, L. L. Benyshek, and M. H. Johnson. 1987. Reproductive rates, birth weight, calving ease and 24-h calf survival in a four-breed diallel among Simmental, Limousin, Polled Hereford and Brahman beef cattle. J. Anim. Sci. 64:65-76.

Cook, A. C., W. H. Black, Bradford Knapp, Jr. and R. W. Philips. 1942. Relationship of milk production of milking Shorthorn dams to the carcass quality of their steer progeny. J. Animal Sci. 1:345.

Corah, L. R., T.G. Dunn, and C.C. Kaltenbach. 1975. Influence of prepartum nutrition on the reproductive performance of beef females and the performance of their progeny. J. Anim. Sci. 41:819.

Corah, L. R., A. P. Quealy, T. G. Dunn and C. C. Kaltenbach. 1974. Prepartum and postpartum levels of progesterone and estradiol in beef heifers fed two levels of energy. J. Anim. Sci. 39:380.

Crosse, S. 1986. The development and implementation of a computerised management information system for Irish dairy farmers. Ph. D. Thesis, National University of Ireland.

Croxton, D., and R. J. Stollard. 1976. Use of body condition scoring as a management aid in dairy and beef herds. Anim. Prod. 4:146.

Cundiff, L.V. 1986. The effect of future demand on production programs- biological versus product antagonisms. In: Beef Improvement Federation Proc. pp 110-127. Lexington, KY.

Cundiff, L. V., F. Szabo, K. E. Gregory, R. M. Koch, M. E. Dikeman, and J. D. Crouse. 1996. Breed comparisons in the germplasm evaluation program at March. Agricultural Research Service. U.S. Department of Agriculture.

Cundiff, L. V., K. E. Gregory, R. M. Koch, and G. E. Dickerson. 1986. Genetic diversity among cattle breeds and its use to increase beef production efficiency in a temperate environment. Proc. Third World Congr. Genet. Appl. Livest. Prod., IX:271-282.

David, M. E., J. J. Rutledge, L. V. Cundiff, and E. R. Hauser. 1983. Life cycle efficiency of beef production. I. Cow efficiency ratios for progeny weaned. J. Anim. Sci. 57:832.

Davis, H. P. 1951. Reproductive efficiency in a Holstein herd 1897-1950. J. Dairy Sci. 34:495.

Dhaliwal, G. S., R. D. Murray, H. Dobson. 1996. Effects of milk yield, and calving to first service interval, in determining herd fertility in dairy cows. Anim. Reprod. Sci. 41:109-117.

Diaz, C., D.R. Notter and W.E. Beal. 1992. Relationship between milk expected progency differences of Polled Hereford sires and actual milk production of their crossbred daughters. J. Anim. Sci. 70:396.

Dickerson, G. E. 1947. Composition of hos carcasses as influenced by heritable differences in rate and economy of gain. Iowa Agr. Exp. Sta. Res. Bull. 354-489.

Donaldson,L. E., J. B. Ritson, and D. B. Copeman. 1967. The reproductive efficiency of several North Queensland beef herds. Aust. Vet. J. 43:1.

Dunn, T.G., and C.C. Kaltenbach. 1980. Nutrition and postpartum interval of the ewe, sow, and cow. J. Anim. Sci. 51(Suppl. 1) :29.

Dunn, T. G., M. L. Riley, W. J. Murdock, and R. A. Field. 1983. Body condition score and carcass energy content in postpartum beef cows. J. Anim. Sci. (Suppl. 1):391(Abstr.).

Dziuk, P.J. and R. A. Bellows. 1983. Management of reproduction of beef cattle, sheep, and pigs. J. Anim. Sci. 57(Suppl. 2) :355.

Ensminger, M. E., M. W. Galgan and W. L. Slocum. 1955. Problems and practices of American cattlemen. Wash. Agr. Exp. Sta. Bul. 562:39.

Ferguson, J. D. 1990. Production and reproduction in dairy cows. In: Proceedings of Society of Ontario Veterinary Annual Conference, pp. 165-175.

Francos, G., and D. Rattner. 1975. On the relation between milk production and fertility in Kibbutz dairy cattle herds. J. Agric. Sci. 85:527-531.

Freetly, H.C.,L.V. Cundiff. 1998. Reproductive performance, calf growth, and milk production of first-calf heifers sired by seven breeds and raised on different levels of nutrition. J. Anim. Sci. 76:1513-1522.

Gaillard, C. and J. Chavaz. 1982. Genetic parameters for calving performance in simmental cattle. In: Proc. 2[nd] World Congress on Genetics Applied to Livestock Production. Madrid, Spain. VIII: 189.

Gardner, R. W. 1969. Interactions of energy levels offered to Holstein cows prepartum and postpartum. II. Reproductive performance. J. Dairy Sci. 52:1985.

Garmendia, J. C., R. P. Wettemann and K. S. Lusby. 1984. Effect of prepartum nutrition on plasma constituents and reproductive performance of range Beef cows. J. Anim. Sci. 59(Supply. 1.) 325. (Abstr.).

Gay, C. W. 1916. The breeds of Live-Stock. The Macmillian Company. New York, N.Y.

Gifford, W. 1953. Records of performance tests for beef cattle in breeding herds. Milk production of dams and growth of calves. Ark. Agr. Exp. Sta. Bul. 531.

Gleeson, P. 1988. Seasonality of milk supply-technical and economic considerations. Moorepark Dairy Farmers' Conference, pp. 28-31, Teagasc.

Gregory, K. E., D. B. Laster, L. V. Cundiff, G. M. Smith, and R. M. Koch. 1979. Characterization of biological types of cattle-cycle III: II. Growth rate and puberty traits in females. J. Anim. Sci. 49:461-471.

Gregory, K. E., J. D. Crouse, R. M. Koch, D. B. Laster, L. V. Cundiff, and G. M. Smith. 1978a. Heterosis and breed maternal and transmitted effects in beef cattle. IV. Carcass traits of steers. J. Anim. Sci. 47:1063.

Gregory, K. E., J. D. Crouse, R. M. Koch, D. B. Laster, L. V. Cundiff, and G. M. Smith. 1978e. Heterosis and breed maternal and transmitted effects in beef cattle. IV. Carcass traits of steers. 47:1063.

Gregory, K. E., L. V. Cundiff, and R. M. Koch. 1992. Breed effects and heterosis in advanced generations of composite populations for reproduction and maternal traits of beef cattle. J. Anim. Sci. 70:656-672.

Gregory, K. E., L. V. Cundiff, R. M. Koch, D. B. Laster, and G. M. Smith. 1978b. Heterosis and breed maternal and transmitted effects in beef cattle. I. Preweaning traits. J. Anim. Sci. 47:1031.

Hady, P. J., J. J. Domecq, and J. B. Kaneene. 1994. Frequency and precision of body condition scoring in dairy cattle. J. Dairy Sci. 77:1543-1547.

Haile-Mariam, M., K. Banjaw, T. Gebre-Meskel, and H. Ketema. 1993. Productivity of Boran cattle and their Friesian crosses at Abernossa Ranch, Rift Valley of Ethiopia. I. Reproductive Performance and Pre-Weaning Mortality. Trop. Anim. Hlth Prod. 25:239-248.

Hamudikuwanda, H., and H. N. Erb. 1987. Effects of sixty-day milk yield on post partum breeding performance in Holstein cows. J. Dairy Sci. 70:2355-2365.

Hancock, K.L., J.R. Kropp, K.S. Lusby, R.P. Wettemann, and D.S. Buchanan. 1985. The influence of postpartum nutrition and weaning age of calves on cow body condition, estrus, conception rate and calf performance of fall calving beef cows. J. Anim. Sci. 61(Suppl. 1) :432 (Abstr.).

Hanzen, Ch., Y. Laurent, and W. R. Ward. 1994. Comparison of reproductive performance in Belgian dairy and beef cattle. Theriogenology 41:1099-1114.

Henderson, C.R. 1973. Sire Evaluation and Genetic Trends. In Proc. The Jay L. Lush Symposium on Animal Breeding and Genetics. American Society of Animal Sciences. P. 10.

Houghton, P. L., R.P. Lemenager, L.A. Horstman, K.S. Hendrix, and G.E. Moss. 1990. Effects of body composition, pre-and postpartum energy level and early weaning on reproductive performance of beef cows and preweaning calf gain. J. Anim. Sci. 68:1438-1446.

Itulya, A. B. 1980. Most probable producing ability, fertility and related selection criteria for Hereford cows. Anim. Breed. Abstr. 49:817.

Jenkins, T. G. and C. L. Ferrell. 1989. Estimation of lactation traits of nine breeds of cattle fed at four levels of energy intake. J. Anim. Sci. 67(Suppl. 2):89 (Abstr.)

Jenkins, T. G., and C. L. Ferrell. 1991. Evaluation of conversion efficiency during three years of production involving nine breeds of cattle. J. Anim. Sci. 69(Suppl. 1):81 (Abstr.).

Jenkins, T. G., L. V. Cundiff, and C. L. Ferrell. 1991. Differences among breed crosses of cattle in the conversion of food energy to calf weight during the preweaning interval. J. Anim. Sci. 69:2762.

Johnson, M. B. 1930. Ranch organization and management in western North Dakota. N. D. Agr. Exp. Sta. Bul. 237:78 pp.

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

Kempthorne, O. 1955. The correlation between relatives in random mating populations. Cold Spring Harbor Symp. Quant. Biol. 22:60.

Khan, M. A. and A. W. Khan. 1983. Sex and season effect calving interval. Pakistan Agri. 41.

Koch, R.M. 1972. The role of maternal effects in animal breeding. VI. Maternal effects in beef cattle. J. Anim. Sci. 35: 1316.

Koger, M., J. S. Mitchell, R. W. Kidder, W. C. Burns, J. F . Hentges, Jr., and Warnick, A. C. 1967. Factors affecting survival in beef calves. J. Anim. Sci. 26:205 (Abstr.).

Laben, R. L., R. Shanks, P. J. Berger, and A. E. Freeman. 1982. Factors affecting milk yield and reproductive performance. J. Dairy. Sci. 65:1004-1015.

Laster, D. B., G. M. Smith, and K. E. Gregory. 1976. Characterization of biological types of cattle IV. Postweaning growth and puberty of Heifers. J. Anim. Sci. 43:63-70.

Laster, D.B., G.M. Smith, L.V. Cundiff, and K.E. Gregory. 1979. Characterization of biological types of cattle (cycle II). II. Postweaning growth and puberty of heifers. J. Anim. Sci. 48:500.

Lean, I. J., J. C. Galland, and J. L. Scott. 1989. Relationships between fertility, peak milk yields and lactational persistency in dairy cows. Theriogenology. 31:1093-1103.

Legates, J. E. and Myers, R. M. 1988. Measuring genetic change in a dairy herd using a control population. J. Dairy Sci. 71:1025-1033.

Lindley, C. E., G. T. Easley, J. A. Whatley, Jr. and D. Chambers. 1958. A study of the reproductive performance of a purebred Hereford herd. J. Anim. Sci. 17:336-342.

Lopez de Torre, G and J. S. Brinks. 1990. Some alternatives to calving date and interval as measures of fertility in beef cattle. J. Anim. Sci. 68:2650-2657.

Lowman, B. G. 1982. Review of research work into factors influencing fertility in beef cows. Meeting for JCO Cattle Committee. East of Scotland College of Agr. (Mimeo.).

Lowman, B. G., N. Scott, and S. Somerville. 1976. Condition scoring of cattle. Revised ed. bull. E. Scotl. Coll. Agric. No. 6.

Lowman, B. G., R. A. Edwards, S. H. Somerville and G. M. Jolly. 1979. The effect of plane of nutrition in early lactation on the performance of beef cows. Anim. Prod. 29:293.

Macgregor, R. G. 1995. Evaluation of calving date and calving interval as measures of reproductive efficiency in beef cows. J. S. Afr. vet. Ass. 66(4):235-238.

MacNeil, M. D. and S. Newman. 1994. Genetic analysis of calving date in Miles City Line 1 Hereford cattle. J. Anim. Sci. 72:3073-3079.

Makarechian, M., and P. F. Arthur. 1990. Effects of body condition and temporary calf removal on reproductive performance of range cows. Theriogenology. 34(3):435.

Mallinckrodt, C. H., B. L. Golden, and R. M. Bourdon. 1992. The impact of approximations of BLUP methodology on the reliability of expected progeny differences. Proc. West. Sect. Am. Soc. Anim. Sci. 43:135.

Mallinckrodt, C.H., R.M. Bourdon, B.L. Golden, R.R. Schalles, and K. G. Odde. 1993. Relationship of maternal milk expected progeny differences to actual milk yield and calf weaning weight. J. Anim. Sci. 71:355.

Mallinckrodt, C.H., R.M. Bourdon, R.R. Schalles, and K.G. Odde. 1990. Relationship of milk expected progeny differences to actual milk production and calf weaning weight. J. Anim. Sci. 68(Suppl. 1):245 (Abstr.).

Marshall, D. M. and B. A. Freking. 1988. Relationship of sire expected progeny differences to maternal performance of first-calf daughters in a commercial herd. SDSU Beef Report 8-19. pp 73-76.

Marshall, D.A., W.R. Parker, and C.A. Dinkel. 1976. Factors affecting efficiency to weaning in Angus, Charolais and reciprocal cross cows. J. Anim. Sci. 43:1176.

Marston, T. T., D. D. Simms, R. R. Schalles, K. K. Zoellner, and L. C. Martin. 1990. Relationship of milk expected progeny difference to total milk production and calf weaning weight in Angus and Simmental cows. J. Anim. Sci. 68 (Suppl. 1):488 (Abstr.).

Marston, T.T. ,D.D. Simms, R.R. Schalles, K.O. Zoellner, L.C. Martin and G.M. Fink. 1992. Relationship of milk production, milk expected progeny difference and calf weaning weight in Angus and Simmental cow-calf dairs. J. Anim. Sci. 70:3304.

McElhenney, W. H., C. R. Long, J. F. Baker, and T. C. Cartwright. 1986. Production characters of first generation cows of a five-breed diallel: Reproduction of mature cows and preweaning performance of calves by two third-breed sires. J. Anim. Sci. 63:59-67.

McGowan, M. R., R. F. Veerkamp, L. Anderson. 1996. Effects of genotype and feeding system on the reproductive performance of dairy cattle. Livestock Prod. Sci. 46:33-40.

Meacham, N. A. and D. R. Notter. 1987. Heritability estimates for calving date in Simmental cattle. J. Anim. Sci. 64:701-705.

Melton, A.A., J.K. Riggs, L.A. Nelson and T.C. Cartwright. 1967. Milk production, composition and calf gains of Angus, Charolais and Hereford cows. J. Anim. Sci. 26:804.

Meyer, K., K. Hammond, P. F. Parnell, M. J. Mackinnon, and S. Sivarajasingam. 1990. Estimates of heritability and repeatability for reproductive traits in Australian beef cattle. Livestock Production Science 25:15-30.

Montano, M., A. C. Clutter, and M. K. Nielsen. 1987. Effect of level of beef cow milk production on calf growth and cow reproduction. 3rd World Congress on Genetic Applied to Livestock Production. XI:113.

Montano-Bermudez, M., and M. K. Nielsen. 1990a. Reproductive performance and variation in body weight during annual cycles for crossbred beef cows with different genetic potential for milk. J. Anim. Sci. 68:2289.

Montano-Bermudez, M., and M. K. Nielsen. 1990b. Biological efficiency to weaning and to slaughter of crossbred beef cattle with different genetic potential for milk. J. Anim. Sci. 68:2297.

Montsma, G. 1960. Observations of milk yield and calf growth and conversion rate on three types of cattle in Ghana. Trop. Agr. (Trinidad) 37(4):293. Abstracted in Biological Abstracts 36:7820.

Morris, C. A. 1984. Calving dates and subsequent inter-calving intervals in New Zealand beef herds. Animal Production. 39:51-57.

Morris, C. A. and N. G. Cullen. 1988. Oestrous and reproductive performance of early- and late-calving beef cows. New Zealand J. of Agricultural Research 31:395-399.

Nelson, L. A., T. G. Martin, and C. J. Sandhage. 1985. Influence of breeding system and breed type of cow on milk yield and calf weaning weight. Indiana Beef Report-Dept. of Anim. Sci. Ag. Exp. Station/Coop Ext. Service. p15-17.

Neville, W. E. 1962. Influence of dam's milk production and other factors on 120 and 240 day weight of Hereford calves. J. Anim. Sci. 21:315.

Neville, W. E. Jr. 1962. Influence of dam's milk production and other factors in 120- and 240-day weight of Hereford calves. J. Anim. Sci. 21:315.

Newman, S. and M. P. Deland. 1991. Lifetime productivity of crossbred cows 2. age and weight at first oestrus, calf birth weight, assisted calvings, calving interval and reproduction rate. Australian J. Exp. Agr. 31:293-300.

Newmann, S., M. D. MacNeil, W. L. Reynolds, B. W. Knapp, and J. J. Urick. 1993. Fixed effects in the formation of a composite line of beef cattle. I. Experimental design and reproductive performance. J. Anim. Sci. 71:2026-2032.

Nicoll, A. M., and G. B. Nicoll. 1987. Pastures for beef cattle. In: A. M. Nicoll (Ed.) Feeding livestock on pasture. N. Z. Soc. Anim. Prod., Occ. Publ. No. 10.

Northcutt, S. L., and D. S. Buchanan. 1993. Expected progeny difference. Pat III, Maternal traits EPDs. OSU Extension Facts. OSU. No:3161:1-2.

Notter, D. R., and L. V. Cundiff. 1991. Across-breed expected progeny differences to adjust breed evaluations for sire sampling and genetic trend. J. Anim. Sci. 69:4776.

Nunez-Dominguez, R., L. D. Van Vleck, and L.V. Cundiff. 1993. Breed comparisons for growth traits adjusted for within-breed genetic trend using expected progeny differences. J. Anim. Sci. 71:1419-1428.

Olson, T. A., M. A. Elzo, M. Koger, W. T. Butts, Jr. and E. L. Adams. 1990. Direct and maternal genetic effects due to the introduction of Bos Taurus alleles into Brahman cattle in Florida: I. Reproduction and calf survival. J. Anim. Sci. 68:317-323.

Olson, T.A., A. van Dijd, M. Koger, D. D. Hargrove, and D. E. Franke. 1985. Additive and heterosis effects on preweaning traits, maternal ability and reproduction from crossing of the Angus and Brown Swiss breeds in Florida. J. Anim. Sci. 61(5):1121.

Osboro, K. and I.A., Wright. 1992. The effect of body condition, live weight, breed, age, calf performance, and calving date on reproductive performance of spring-calving beef cows. J. Anim. Sci. 70:1661.

Paloma Garcia, J. A., R. Alberio, M. C. Miquel, M. O. Grondona, J. Carrillo G. Schiersmann. 1992. Effect of calving date on lifetime productivity of cows in a winter-calving Aberdeen Angus herd. Anim. Prod. 55:177-184.

Paputungan, U. 1997. Variation in reproductive efficiency of Indonesian native cows. AJAS 10(2):240-244.

Philipsson, J. 1976. Studies on calving difficulty, stillbirth and associated factors in Swedish cattle breeds: III. Genetic parameters. Acta Agr. Scand. 26:211.

Phillips, R. W. 1939. Reproductive failures in Livestock. Yearbook of Agriculture. 476.

Phillips, R. W., B. Knapp, Jr. L. C. Heemstra, and O. N. Eaton. 1943. Seasonal variation in the semen of bulls. Am. J. Vet. Res. 4:115.

Ray, D. E., T. J. Halbach, and D. V. Armstrong. 1992. Season and lactation number effects on milk production and reproduction of dairy cattle in Arizona. J. Dairy Sci. 75:2976-2983.

Rege, J. E. O. and T. R. Famula. 1993. Factors affecting calving date and its relationship with production traits of Hereford dams. Anim. Prod. 57:385-395.

Reid, J. T. 1960. Effects of energy intake upon reproduction in farm animals. J. Dairy Sci. 43:103.

Reynolds, W.L., T.M. Derouen and R.A. Bellows. 1978. Relationships of milk yield of dam to early growth rate of straightbred and crossbred calves. J. Anim. Sci. 47:584.

Richards, M. W., J. C. Spitzer and M. B. Warner. 1986. Effect of varying levels of postpartum nutrition and body condition at calving on subsequent reproductive performance in beef cattle. J. Anim. Sci. 62:300-306.

Rothschild, M. F., Pearson, R. E. and Miller, R. H. 1979. Differences in reproduction performance of daughters of daughters of single and multiple-trait selected sires. J. Kairy Sci. 62: Suppl. 1, 166.

Rutledge, J.J., O.W. Robison, W.T. Ahlschwede and J.E. Legates. 1971. Milk yield and its influence on 205-day weight of beef calves. J. Anim. Sci. 33:563.

Rutter, L.M. and R.D. Randel. 1984. Postpartum nutrient intake and body condition: Effect of pituitary function and onset of estrus in beef cattle . J. Anim. Sci. 58:265.

Selk, G. E., R. P. Wettemann, K. S. Lusby, J. W. Oltjen, S. L. Mobley, R. J. Rasby, and J. C. Garmendia. 1988. Relationships among weight change, body condition and reproductive performance of range beef cows. J. Anim. Sci. 66:3153-3159.

Sowell, B. F., J. D. Wallace, E. E. Parker, and G. M. Southward. 1992. Protein supplementation and 48-hour calf removal effects on range cows. J. Range Manage. 45(2):123-128.

Spalding, R. W., R. W. Everett, and R. H. Foote. 1975. Fertility in New York artificially inseminated Holstein herds in dairy herd improvement. J. Dairy Sci. 58:718-723.

Spitzer, J. C., D. G. Morrison, R. P. Wettemann, and L. C. Faulkner. 1995. Reproductive responses and calf birth and weaning weights as affected by body condition at parturition and postpartum weight gain in Primiparous beef cows. J. Anim. Sci. 73:1251-1257.

Totusek, R., D.W. Arnett. 1965. Estimators of milk production in beef cows. J, Anim.Sci. 24:906.

Totusek, R., D.W. Arnett, G.L. Holland and J.V. Whiteman. 1973. Relation of estimation method, sampling interval and milk composition to milk yield of beef cows and calf gain. J. Anim.Sci. 37:153

Turner, J. W. 1980. Genetic and biological aspects of zebu adaptability. J. Anim. Sci. 50:1201.

Vizcarra, J.A., R.P. Wetttemann, K.S. Lusby, G. E. Selk and J. V. Yelich. 1995. Body condition score is a precise tool to evaluate beef cows. Ok. Agr. Exp. Station. P-943:201.

Wagner, J. J. 1985. Carcass composition in mature Hereford cows. Estimation and influence on metabolizable energy requirements for maintenance during winter. Ph. D. Thesis. Oklahoma State University, Stillwater, OK.

Wagner, J. J., K. S. Lubsy, J. W. Oltjen, J. Rakestraw, R. P. Wettemann, and L. E. Walters. 1988. Carcass composition in mature Hereford cows: Estimation and effect on daily metabolizable energy requirement during winter. J. Anim. Sci. 66:603.

Warner, M. B. and J. C. Spitzer. 1982. Effect of postpartum nutrition on the reproductive performance of beef cattle. South Carolina Agr. Exp. Sta. Res. Ser. 69:12.

Warnick A.C., D.D. Hargrove, F.M. Peacock, and H.L. Chapman. 1981. Effects of pre-wintering condition score and winter feed levels on pregnancy rate of Brahman cows and calf weaning weight. J. Anim. Sci. 53(Suppl. 1) :374 (Abstr.).

Warnick, A. C. 1955. Factors associated with the interval from parturition to first estrus in beef cattle. J. Anim. Sci. 14:1003.

Werth, L. A., S. M. Azzam, and J. E. Kinder. 1996. Calving intervals in beef cows at 2, 3, and 4, years of age when breeding is not restricted after calving. J. Anim. Sci. 74:593-596.

Wettemann, R. P., K. S. Lusby and E. J. Turman. 1982. Relationship between changes in prepartum body weight and condition and reproductive performance of range cows. Oklahoma Agr. Exp. Sta. Res. Rep. MP-112:12.

Whitman, R.W., E.E. Remmenga, and J.N. Wiltbank. 1975. Weight change, condition and beef-cow reproduction. J. Anim. Sci. 41:387 (Abstr.).

Willham, R. L. 1963. The covariance between relatives for characters composed of components contributed by related individuals. Biometrics. 19:18.

Willham, R. L. 1972. The role of maternal effects in animal breeding: III. Biometrical aspects of maternal effects in animals. J. Anim. Sci. 35(6):1288

Willham. 1972. Beef milk production for maximum efficiency. J. Anim. Sci. 34:864.

Wiltbank, J. N., J. Bond, E. J. Warwick, R. E., Davis, A. C. Cook, W. L. Reynolds, and M. W. Hazen. 1965. Influence of total feed and protein intake on reproductive performance in the beef female through second calving. USDA Tech. Bull. No. 1314, Washington, DC.

Wiltbank, J.N., W.W. Rowden, J.E. Ingalls, K.E. Gregory, and R.M. Koch. 1962. Effect of energy level on reproductive phenomena of mature Hereford cows. J. Anim. Sci. 21:219.

Wiltbank, J.N., W.W. Rowden, J.E. Ingalls and D.R. Zimmerman. 1964. Influence of post-partum energy level on reproductive performance of Hereford cows restricted in energy intake before calving. J. Anim. Sci. 23:1049.

Wright, I. A. and A. J. F. Russel. 1984a. Partition of fat, body composition and body condition score in mature cows. Anim. Prod. 38:23.

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