MILK EXPECTED PROGENY DIFFERENCES AND ITS EFFECT ON MILK PRODUCTION AND CALF PERFORMANCE IN FIRST CALF HEIFERS FROM ANGUS AND POLLED HEREFORD SIRES

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NOMENCLATURE

adg	average daily gain
AMP	Average Milk Production
bcs	body condition score
ccfs	calf conformation score
ccs	calf condition score
cm	centimeters
d	days
EPD	Expected Progeny Difference
h	hours
HMA	High Milk Angus
HMH	High Milk Polled Hereford
kg	kilograms
LMA	Low Milk Angus
LMH	Low Milk Polled Hereford
mo	month
ww	age adjusted weaning weight

CHAPTER I

INTRODUCTION

Calf weaning weight is an important trait in beef production and is greatly determined by cow maternal ability. It is generally assumed that maternal ability is largely a function of the milking ability of the cow. Thus milking ability of the cow herd plays a vital role in cow-calf production since weaning weight of the calf greatly influences net income. Calculation and use of expected progeny differences for maternal milk have heightened interest in selection for milk production. Beef cattle breed associations have adopted the use of the Milk Expected Progeny Differences (EPD) to predict the difference in weaning weight of calves from daughters of different bulls. The Milk EPD is an estimate of the milking ability of a bull's daughters compared to the average of the daughters of other bulls. This Milk EPD is measured for pounds of calf, not pounds of milk. The EPD is a valuable tool that allows us to include an evaluation of genetic merit as a selection tool to aid in predicting performance. Current selection trends have placed increasing emphasis on milk EPDs in the selection of replacement females and recent research is proving milk EPDs to be an accurate predictor of cow performance (Mallinckrodt et al., 1990, 1993; Marshall and Long, 1993; Marston et al., 1992; Buchanan, 1993). However much of this research has dealt solely with cows and little attention has been given to determining what toll this selection pressure may take on first calf heifers.

Replacement heifers play a vital role in the beef industry. As these first calf heifers are selected and enter production, many factors must enter into consideration. Selection, management, and performance all determine the ability of the heifers to function profitably in our competitive cow-calf industry. Development of an effective selection program for first calf heifers would allow for consideration of individual performance, milking potential, age at puberty, and reproductive efficiency.

With recent research indicating that Milk EPD's will accurately predict average differences in weaning weight, a concern arises that, with this increased performance, a toll on body condition may result. Thus, is increased milk production taxing reproductive efficiency?

The purpose of this study was to evaluate the accuracy of the Milk EPD on first calf heifers and how selection for milk production affects the relationships between the level of milk production, calf performance, dam's body condition, and the performance of the postpartum, lactating beef cow.

CHAPTER II

REVIEW OF LITERATURE

Selection for Replacement Females

Heifers, as replacement females, may be selected for several traits at different stages of their productive life. The objective is to identify heifers that will conceive early in the breeding season, calve easily, rebreed, produce milk consistent with the most economical feed supply, wean a heavy calf, and make a desirable genetic contribution to the calf's postweaning growth and carcass merit. Ultimately, selection and management of replacement heifers involve decisions that affect future productivity of the entire cowherd. To calve at 24 mo of age, heifers must achieve puberty and concieve by 15 mo of age (Lesmeister et al., 1973). Programs to develop breeding heifers have focused, therefore, on the physiological processes that influence puberty.

Age at Puberty

Age at puberty is most important as a production trait when heifers are bred to calve as 2-yr-olds and in systems that impose restricted breeding periods (Ferrell, 1982). The number of heifers that become pregnant during the breeding season and within a defined time period is correlated with the number that exhibit estrus early in the breeding season (Short and Bellows, 1971). In an attempt to decrease age at puberty, supplementation programs to increase weight gain have been implemented. Bellows et al. (1965), Arije and Wiltbank (1971), and Lemenager et al. (1980) reported that increasing winter weight gains of spring-born heifers reduced pubertal age and therefore age at breeding. Age at puberty in heifers was significantly decreased by feeding monensin (Mosely et al., 1977, 1982) or concentrates (Dufour 1975, McCartor, et al., 1979) which decrease the acetate:proprionate ratio in the rumen.

Several studies indicate that feeding high levels of concentrates can reduce subsequent milk production by increased deposition of udder fat (Swanson, 1960; Gardner et al., 1977; Little and Kay, 1977; Sejrsen, 1978). However, Marston, Lusby, and Wettemann (1995) found that limit-feeding a high concentrate diet for approximately 60 d before breeding does not affect subsequent milk-producing ability.

Research may also suggest that selection for milk production may decrease age at puberty in beef heifers. Breeds selected for milk production as well as size reach age at first estrus sooner than breeds of similar size and growth potential that were not selected for milk production (Cundiff, 1986). Laster et al. (1979) recorded a mean within-breed correlation of -.88 between age at puberty and subsequent milk production of cows. Breeds selected for milk production as well as size reach puberty earlier than do breeds of similar size and retail product growth potential that were not selected for milk production (Cundiff, 1986). The negative relationship between milk production and age at puberty may be as great as the positive relationship between mature size and age at puberty. Heifers that do reach estrus at an earlier age and, thus, conceive and calve earlier, immediately indicate their greater reproductive efficiency and lifetime potential (Lesmeister et al., 1973). But with increased selection for milk production, will these heifers tax their own body reserves, decreasing body condition scores, and result in later rebreeding dates decreasing lifetime efficiency? Boggs (1980) indicated that the cow will attempt to maintain her potential for milk production at the expense of body reserves, thus inhibiting rebreeding performance.

Increasing genetic potential for milk production may also be an underlying causal factor of increased maintenance requirements between breeds in nonlactating, mature cows (Ferrell and Jenkins, 1984; Taylor et al., 1986). Cows that produced more milk tended to lose more weight (or to gain less weight) than lower-producing cows, resulting in lowered body condition scores. Despite this relationship, neither the degree of weight change nor the amount of milk produced was related to timing of the first ovulation postcalving (Beal et al., 1990).

Milk Expected Progeny Differences

Milk production in beef cattle is generally considered to be the major component of maternal effects on calf growth until weaning. Although there are numerous studies examining heritabilities of milk production in dairy cattle, both for complete lactation and individual test-day records, there are few estimates for beef cattle (Meyer et al. 1994). Yet, genetic predictors such as Sire Milk EPD and Total Maternal EPD are very useful in estimating maternal ability of beef cows. Benyshek (1986) reported that the use of the national sire evaluation (NSE) procedures in purebred beef cattle herds has been cited as a positive force for increasing performance within those herds. Expected Progeny Differences (EPD) for milk are an estimate of the milking ability of a bull's daughters compared to the average of the daughters of other bulls. Breeders who use sire milk and total maternal EPD values as selection tools should expect such selection to be effective, on average, but should also expect that a substantial proportion of individuals or small groups may not rank as predicted (D.M. Marshall, 1993). Buchanan et al. (1993) examined the effectiveness of Milk

EPD for predicting calf weaning weight differences and evaluated correlated changes in other traits associated with the cow and calf. He concluded that daughters of high milk EPD bulls will have heavier calves at weaning than daughters of low milk EPD bulls. Mallinckrodt et al. (1993) indicated that differences in calf weaning weights were either similar to or greater than differences predicted by maternal milk and total maternal expected progeny differences from national cattle evaluations. Producers that make bull selections based upon milk EPD should be able to use the values to rank bulls with some confidence. However, Buchanan et al. (1993) concluded by suggesting that an increase in calf weaning weight is not without cost in the cow's ability to maintain herself in terms of body condition score and thus subsequent reproduction.

Milking Ability

Milking ability of beef cows is one of the principal factors influencing weaning weights of calves of similar breed composition (Neville, 1962; Boggs et al., 1980). Beal et al. (1990) concluded that milk yield of the dam is the greatest single factor influencing preweaning gain in calves of similar breeding. Calf performance is greatly influenced by the milk production of the dam. Koch (1972) reported that variation due to maternal effects account for 40-46% of the gain from birth to weaning. Neville (1962) and Rutledge et al. (1971) reported that milk production accounted for about 66% of the variation in calf weaning weight. Boggs (1980) reported that each kg of milk per day added 7.20 kg of 205-d adjusted weaning weight and .34 kg/day of ADG. Clutter and Nielson (1987) reported the importance of milk intake in determining 205-d weight in a typical beef production setting. They concluded that a significant portion of the weight advantage at weaning resulting from a higher level of milk intake was maintained through a postweaning feedlot period and was reflected in final weights as well as carcass weights. The factors that affect observed differences in calf weaning weights include calf genotype for growth and a cow's milking ability. The increased availability of EPD values for milk and maternal value has given producers another tool for within breed selection. A bull's total maternal weaning weight EPD refers to expected weaning weight differences in its daughters' offspring due to the cumulative effects of genes that it passes on to its daughters for maternal effect on weaning weight (presumably due primarily to milk production) and the genes passed on to its grand progeny for preweaning growth. A bull's milk EPD refers to expected weaning weight differences in its daughters' offspring due only to differences in daughter maternal effect on weaning weight, separate and apart from differences in grandprogeny preweaning growth genotype (Marshall and Long, 1993).

Marshall and Long (1993), found that a 1-kg change in sire total maternal weaning weight EPD corresponded to a change of 1.18 kg for daughter's calf weaning weight. This regression value is very close to the theoretical expectation of one. Thus, differences among daughters in milk yield and resulting calf weaning weights were positively related to differences in sire milk EPD. Their value for pooled regression of daughter milk yield on sire milk EPD was approximately 1% of the overall mean milk yield. This indicates that a 1-kg change in sire milk EPD corresponded to a difference of approximately 1%, on average, in cumulative daughter milk yield. Diaz et al. (1992) also reported a value near 1% from a study using crossbred daughters of Polled Hereford bulls. Marston et al. (1992) regressed cumulative 205-d milk production on the cow's own milk EPD and reported values of 42.1 and 69.3 kg for Angus and Simmental, respectively. Mallinckrodt et al. (1990) reported that actual calf weaning-weight differences were similar to or greater than expected, based on milk and total maternal EPD values of dams and maternal grandsires in a study of Simmental and Polled Hereford cows.

Thus, this research suggests that estimates of milk and total maternal expected progeny difference values, on average, are positively related to actual daughter milk production and resulting daughter's offspring weaning weight. However, the size of such relationships can be relatively modest in terms of intended selection response, but they are reasonably consistent with theoretical expectations.

Effect of Milk Production Changes on Body Condition

As we begin to see the effect of selection for milking ability, we also recognize environmental constraints that can restrict the performance of the lactating beef cow. Research has well documented that dietary energy levels in both the prepartum and postpartum periods influence subsequent reproductive performance in cattle (Wiltbank et al., 1962, 1964, 1965; Dunn et al., 1969; Wiltbank, 1970; Corah et al., 1974; Dunn and Kaltenbach, 1980; Dziuk and Bellows, 1983). Robison et al. (1978) reported that age of cow significantly affected milk yield, with increased production from 2 to 5 years of age, little difference between 5 to 8 years, and a decline in cows older than 8 years of age. This indicates that due to a greater energy requirement in the first half of a cow's productive life, it is advantageous to get replacement females producing more efficiently earlier in age, to capitalize on her productive years. Regardless of age or cow size, selection for increased milking ability increases nutritional requirements. For cows varying in milk production, megacalories required for one year increased as peak milk yield increased (NRC, 1996). If required energy is unavailable to meet the needs of lactating beef cows, body condition, a measure of fat reserves (1=emaciated; 5=moderate; 9=extremely fat), will decrease. Richards et al. (1986) reported that cows with body condition scores of ≤4 had longer postpartum intervals. Boggs et al. (1980) indicated that when level of nutrition is inadequate, the cow will attempt to maintain her potential for milk production at the expense of body reserves, thus inhibiting rebreeding performance. Current (NRC 1984) feeding standards for beef cattle imply that, for cows producing milk, all cows would be expected to respond similarly to increased energy allowance. Following the NRC recommendations for energy allowance for all breeds may or may not result in availability of excess energy for conversion to maternal weight gains when the standards are applied uniformly across all breeds and breed crosses (Ferrell and Jenkins, 1992).

Generally, in the commercial setting, cow body condition scores are assesed at breeding, calving, and weaning. Recommendations for adequate cow conditions at these three times varies as do the results on reproductive performance. Osboro and Wright (1992) indicated that body condition at calving had a greater effect on reproductive performance than body condition at other times(although only slightly greater than body condition at the start of mating) and than changes in live weight or body condition after calving. This contrasts with some previous reports in which it has been suggested that body condition at mating(Nicoll and Nicoll, 1987) or change in body condition after calving(Warnick et al., 1981; Rutter and Randel, 1984; Hancock, et al., 1985) are more important. Yet some reports indicate no effect of changes in live weight and body condition on reproductive performance(Whiteman et al., 1975; Dunn and Kaltenbach, 1980)

Means of Measurement

Actual milk production of beef cows has been extensively measured under experimental conditions. Techniques to measure milk production have included weigh-suckle-weigh (Rutledge et al., 1971; Totusek et al., 1973; Beal et al., 1990), hand milking (Totusek et al., 1973), and machine milking (Gleddie and Berg, 1968; Beal et al., 1990). Totusek et al. (1973), reported that since his estimates of milk production were accurately obtained under the trial conditions, it is suggested that the calf-weight-change method is a more precise estimator of actual milk yield (milk intake by calf) than is hand-milking. This is likely a result of a greater release of oxytocin caused by the calf nursing stimulus.

Increasing accuracy of the weigh-suckle-weigh method involves averaging two one day weigh-suckle-weigh measurements (Rutledge et al., 1971) or by uniformly nursing cows before weigh-suckle-weigh procedure (Boggs et al., 1980). This method of intensifying the procedure by averaging measurements or removing and replacing calves at a set interval before the weigh-suckle-weigh isolation period could improve reliability of weigh-suckle-weigh measurements (Beal et al., 1989).

Beal et al. (1989), also suggested that the precision of the machine milking procedure, the consistency of milk production as estimated by machine milking in successive lactations and the strong relationship of estimated milk production and calf gain raised the possibility that milk production measured by machine milking might be a better indicator than weaning records of their previous calves of differences among cows in expected calf weaning weights. To evaluate this possibility, Beal compared the within age and breed group correlation estimates of milk production in the current lactation and adjusted calf weaning weights in a previous or subsequent year with the within group correlation of adjusted weaning weights in adjacent years. Comparable simple correlations, without age or breed adjustments, were .43 ($P<.07$) and .47 ($P<.01$) for the two relationships, respectively. The similarity of both the within group and simple correlations suggests that recording machine milking estimates of milk production would be comparable, but no better than, the use of previous calf weaning weights in predicting the weaning weights of subsequent calves raised by individual beef cows.

CHAPTER III

MATERIALS AND METHODS

Angus and Polled Hereford Bulls with large differences in Milk Expected Progeny Difference (Milk EPD) were mated to cows(n=209) that were inseminated to calve from 1989-1991(spring and fall calving). These cows were Hereford-Angus, 1/4 Brahman-1/4 Angus-1/2 Hereford, and 1/4 Brahman-1/2 Angus-1/4 Hereford. The replacement heifers that represent the cows analyzed in this data set are a result of three of fours years of heifers produced for a long term study to evaluate Milk EPD.

Thirty-six bulls were chosen to form each of the four groups (High Milk EPD Angus n=9, High Milk EPD Polled Hereford n=9, Low Milk EPD Angus n=9, Low Milk EPD Polled Hereford n=9). Average Milk EPDs from the four groups (Table 1) showed a difference of 26.5 and 31.3 lb for Polled Hereford and Angus sire groups, respectively. Daughters(n=195) of High and Low Milk EPD bulls had their first calves as 2-yr-olds in the spring and fall of 1991(n=75), 1992(n=76), and 1993 (n=44). Heifers from the four milk groups were randomly mated (artificial insemination) to Angus(n=2), Gelbvieh(n=1), Polled Hereford(n=2), and Saler(n=21) bulls at least

TABLE 1. AVERAGE MILK, BIRTH WEIGHT, AND WEANING WEIGHT EXPECTED PROGENY DIFFERENCES (EPD) OF POLLED HEREFORD AND ANGUS SIRES OF FIRST CALF HEIFERS.

			Average EPDs		
Breed	n	Milk EPD Level	Milk	BW	WW
Angus	9	High	+18.3	2.5	18.6
Angus	9	Low	-13.0	4.5	25.0
P.Hereford	9	High	+16.8	2.6	22.3
P.Hereford	9	Low	-9.7	5.6	26.3

twice and then placed in single sire breeding pastures with crossbred bulls for a total breeding period of 75 d. Spring-calving heifers were bred to calve in February, March, and April and fall-calving heifers were bred to calve in September, October, and November.

Condition scores and weights were obtained for the heifers prior to breeding, at each monthly milk-weigh, and at the time their calves were weaned (Table 2). Calving difficulty scores were assigned by the herdsman using a scale of 1 to 6 (1= no difficulty, 2= little difficulty, 3= moderate difficulty, 4= major difficulty, 5= caesarean section, and 6= abnormal presentation). Cows receiving a score of 1 or 2 were assigned a value of 0 whereas a score of 3 or more was considered a difficult birth which required assistance and was assigned a value of 1 for analysis. Birth weights were obtained and male calves were castrated within 24 h of birth. Calves remained with their dams on pasture and were not creep fed. Spring-born and fall-born calves were weaned at an average of 205 and 240 d, respectively. Fall-born calves were weaned at an older age as this is a common practice of Oklahoma producers. Calf weight, hip height, condition score, and conformation score were determined at weaning. Calf condition scores (1= very thin to 9= very fat with 5= average) and conformation scores, a measure of muscling, (12= slightly less than average muscling, 13= average muscling, and 14= slightly above average muscling) were determined by averaging scores

TABLE 2. SYSTEM OF BODY CONDITION SCORING (BCS) FOR BEEF CATTLE

BCS	Description
1	EMACIATED - Cow is extremely on emaciated with no palpable fat detectable over spinous processes transverse processes, hip bones or ribsTail-head and ribs project quite prominently.
2	POOR - Cow still appears somewhat emaciated but tail-head and ribs are less prominent. Individual spinous processes are still rather sharp to the touch but some tissue cover exists along the spine.
3	THIN - Ribs are still individuallly identifiable but not quite as sharp to the touch. There is obvious palpable fat along spine and over tail-head with some tissue cover over dorsal portion of ribs.
4	BORDERLINE - Individual ribs are no longer visually obvious. The spinous processes can be identified individually palpation but feel rounded rather than sharp. Some fat cover over ribs, transverse processes and hip bones.
5	MODERATE - Cow has generally good overall appearance. Upon palpation, fat cover over ribs feels spongy and areas on either side of tail-head now have palpable fat cover.
6	HIGH MODERATE - Firm pressure now needs to be applied to feel spinous processes. A high degree of fat is palpable over ribs and around tail-head.
7	GOOD - Cow appears fleshy and obviously carries considerable fat. Very spongy fat cover over ribs and around tail-head. In fact ``rounds'' or ``pones'' beginning to be obvious. Some fat around vulva and in crotch.
8	FAT - Cow very fleshy and over-conditioned. Spinous processes almost impossible to palpate. Cow has large fat deposits over ribs, around tail-head and below vulva. ``Rounds'' or ``pones'' are obvious.
9	EXTREMELY FAT - Cow obviously extremely wasty and patchy and looks blocky. Tail-head and hips buried in fatty tissue and ``rounds'' or ``pones'' of fat are protruding. Bone structure no longer visible and barely palpable. Animal's mobility may even be impaired by large fatty deposits.

Adapted from Richards et al. (1986).

assigned by at least two evaluators. Calf weaning weights and hip heights were adjusted to 205 days of age for spring and fall-born calves.

Monthly estimates of 24 h milk production were obtained using weigh-suckle-weigh procedures on all cows during the first year of lactation (both spring and fall). Only those cows successfully weaning a calf were included in this analysis. Cow-calf pairs were maintained in separate pastures determined by calf sex. Both groups of cows and calves were gathered from pastures and placed by groups in holding pens the afternoon prior to measurement. Calves were seperated from cows around 1800 h. The following morning at 545 h calves were placed with dams and allowed to nurse. Groups were then randomly seperated into smaller pens (approximatley 25 cows per pen). This allowed for a staggering of groups so that all groups could be properly observed. Calves were seperated from dams as soon as the calves had finished nursing (15 to 30 min). This procedure was repeated at 1145 h with the exception that calves were weighed prior to and after nursing. The difference between these two weights was considered to be the amount of milk produced by the dam in 6 h. Less than 2% of the differences were negative. These negative differences were set to zero for the analysis. The 1145 h procedure was repeated at 1745 h. Estimates obtained at 1145 h and 1745 h milkings were summed and doubled to estimate 24 h milk production.

Spring-calving (April through September) and Fall Calving (November through May) cows were evaluated for six months. Six month average 24 h milk production was computed for both spring and fall groups using estimates for the first six months of lactation.

Cows were maintained on native range and Bermuda grass pastures at Lake Carl Blackwell Research Range, located west of Stillwater, Oklahoma. Each pasture maintained approximately forty cows. Bermuda hay and approximately 4 to 6 pounds of 41% CP range cubes per day were provided for supplementation from October through May. Range cubes (41% CP) were also provided through the breeding season (March-June) for spring-calving cows.

Data were analyzed using least squares analysis of variance using the General Linear Models procedure of SAS (1986) to determine the effects of cow group (CG), season of calving, year, sex of calf, and all two factor interactions on 24 h milk production, age adjusted weaning weight, calf birth weight, calving difficulty score, calf conformation score, calf condition score, age adjusted hip height, dam's condition score, dam's weight, calf weight, percent that rebred within one breeding season, and days to rebreed among cows that rebred within one season. Sire of dam nested within CG was included in all models and was used to test CG. Calving date was also included as a covariate. Groups were compared by least significant difference to detect differences ($P < .05$).

CHAPTER IV

RESULTS AND DISCUSSION

There were significant differences between two-year-old daughters sired by High or Low Milk EPD Angus and Polled Hereford bulls for age adjusted weaning weight (ww), calf condition score (ccs), calf conformation score (ccfs), cow body condition score (bcs) at weaning, monthly calf weights, and monthly cow milk production estimates. Significance levels for effects included in the preliminary model on monthly measurements of 24-hour milk production and average 24 h milk production (AMP) are presented in table 1. There were no significant differences between the High or Low Milk EPD groups for calving difficulty score, calf birth weight, adjusted calf hip height, percent of cows to rebreed within one season, monthly body condition scores, and monthly dam weights or dam weight at weaning.

Two-year-old cows sired by High Milk EPD Angus and Polled Hereford bulls had significantly higher ($P<.05$) 24 h milk production estimates than did two-year old cows sired by Low Milk EPD Angus and Polled Hereford bulls. Least squares means and standard errors for monthly measurements of 24 h milk production and Average Milk Production (AMP) are presented in table 2 by cow breed group.

There were significant differences between the cow breed groups in the first, second, and fourth months. The groups sired by Angus were significantly different in those three months, but the Polled Hereford sired groups were not significantly different in any of the six months even though the High Milk EPD Polled Hereford (HMH) sired groups tended to have higher 24 h milk production estimates than the Low Milk EPD Polled Hereford (LMH) sired groups. In the first month of lactation High Milk Angus (HMA) produced more milk ($P<.05$) than did Low Milk Angus (LMA), 6.4 and 4.9 kg, respectively. For the second month of lactation, HMA produced more milk ($P<.05$) than did LMA, 4.9 and 3.6 kg, respectively. Likewise, the fourth month of lactation showed similar findings as the HMA produced more milk ($P<.1$) than did LMA, 5.2 and 3.8 kg, respectively. There were no significant differences in months three, five, and six for the Angus sired groups, even though HMA tended to have higher milk production estimates than did the LMA. For Average Milk Production (AMP), over the first six months of lactation, HMA produced more ($P<.05$) milk than did LMA, 4.9 and 3.7 kg respectively. Although the six monthly lactation estimates indicated no significant difference between the Polled Hereford sired milk groups, HMH produced more milk, for AMP, ($P<.1$) than did LMH, 4.8 and 4.1 kg respectively (Figure 1). The average milk production is within the range reported by other authors for different breeds and similar breed crosses (Gleddie and Berg, 1968; Rutledge et al., 1971; Totusek et al., 1973; Notter et al., 1978; Gaskins et al., 1980). Diaz et al. (1992) reported smaller differences between Polled Hereford females sired by High and Low Milk EPD sires, but he also had less difference in Milk EPD means between the groups.

Season of calving had no significant effect on 24 h milk production and Average Milk Production (AMP). Yet, spring calving cows tended to have higher 24 h milk production estimates than did fall calving cows. Year was not a significant source of variation except in month four where estimated 24 h milk production for calves born in 1991 was 2.2 kg higher than calves born in 1992. There was a significant source of variation due to a year by season interaction in the first and fourth months of lactation ($P<.05$).

Sex of calf was a significant source of variation ($P<.05$) in the first month of lactation as well as Average Milk Production (AMP). (It should be noted that sex was confounded with pasture during lactation.) Cows raising heifer calves produced 1.0 kg more ($P<.05$) milk in the first month of lactation than cows raising steer calves. Six month average 24 h milk production differed ($P<.05$) for the two sexes as cows raising heifers produced 4.7 kg compared with 4.1 kg for those raising steer calves. Rutledge et al. (1971) reported similar findings that heifer calves actually received more milk than male calves. Jeffrey et al. (1971) found that sex of calf had variable effect on milk yield; in the first year of their study male calves received more milk, while in the second year heifer calves had higher milk intake. Gleddie and Berg (1968) and Marshall et al. (1976) indicated that sex effects on milk yield estimates are negligible.

Significant differences (P<.05) were found for 205-day adjusted calf weaning weights (ww) for the calves among the four different milk groups (Table 3). The difference was not significant (P>.10) between the high and low milk Angus groups even though the HMA tended to have heavier adjusted calf weaning weights than the LMA, 229.39 and 218.88 kg respectively. HMH did have a significantly higher ww (P<.05) than did the LMH, 231.66 and 217.96 kg respectively. Boggs (1980) reported that cow milk production had the greatest influence on calf performance. Boggs stated that each kg of milk per day added 7.20 kg of 205-day adjusted weaning weight and .34 kg/day of ADG. This difference in cww between the four groups can be then attributed to milk production of their dams as Neville (1962) and Rutledge et al. (1971) reported that milk production accounts for about 66% of the variance in weaning weight. There was no significant year or sex effect on ww, but season and year by season were a significant source of variation on ww. Spring born calves were 38.03 kg heavier (P<.05) than fall born calves.

Monthly calf weights (cww) were analyzed and there were significant differences (P<.05) between the four different milk groups for all six months (Figure 2). There were no significant differences in year or sex effects when looking at cww. HMA were significantly heavier (P<.05) than the LMA for one, two, three, four, five, and six month measurements, 7.81, 8.1, 10.31, 12.33, 13.81, and 15.07 kg respectively. HMH were significantly heavier (P<.05) than the LMH for one, two, three, four, five, and six month measurements, 6.22, 724, 8.07, 9.04, 10.29, and 11.24 kg respectively. Season by year interaction and season of calving were significant sources of variation for cww. Season of calving was significant (P<.05) for months one, three, four, five, and six, with spring calves being generally heavier except for month one where fall calving calves were heavier.

Calf conformation scores (ccfs) were found to be significantly different (P<.10) between the milk groups. HMA tended to have higher ccfs than LMA but this difference was not significant, 12.6 ± .1 and 12.3 ± .1 respectively. HMH tended to have significantly higher ccfs (P<.10) than LMH, 12.5 ± .1 and 12.2 ± .2 respectively. Year, year by season, and season were significant sources of variation for ccfs. Ccfs score least square means for spring- and fall-born calves were 12.6 ± .1 and 12.3 ± .1, respectively, thus indicating spring-born calves to be heavier (P<.05) muscled than fall-born calves at weaning.

Calf condition scores (ccs) were not significantly different for Polled Hereford groups, but HMA had significantly higher (P<.05) ccs than LMA, 5.4 ± .1 and 5.1

± .1 respectively. Year by season, year, season, and sex significantly affected ccs as male and spring-born calves were heavier conditioned ($P<.05$) than heifer or fall-born calves, 5.4, 5.4, 5.3, and 5.2 respectively. The overall mean age adjusted weaning hip height was 109.88 cm with no significant differences between the groups.

Popular thought is that heavier calf weights from daughters of High Milk EPD bulls are not likely obtained without some cost in the cow's ability to maintain size and condition. This cost is possibly increased in the case of two-year-old cows who have additional energy requirements in an attempt to reach a mature weight. No significant differences were found among the four cow groups for weight at each of the monthly measurements during weigh-suckle-weigh or at weaning. However, daughters of Low Milk EPD bulls tended to be somewhat heavier for both breeds at an increasing rate during lactation (Figure 3). Body condition scores for daughters of High Milk EPD sires tended to be lower than bcs for daughters of Low Milk EPD sires at an increasing rate through lactation but this difference was not significant until weaning (Figure 4). HMA had lower ($P<.05$) bcs than LMA at weaning, 4.96 and 5.23 respectively. HMH also tended to have lower bcs than LMH, but this difference was not significant. These results would indicate body fat reserves were influenced by level of milk as daughters sired by High Milk EPD sires utilized more of their energy reserves (fat deposits) than did daughters of

Low Milk EPD sires at weaning. This would also suggest that a possible decrease in bcs and or increase in milk production would perhaps result in lower reproductive efficiency of heavier milking cows. Boggs (1980) reported that milk production was negatively related to rebreeding date, as each additional kg of milk per day delayed rebreeding by 1.4 days. Even though a higher percentage of daughters from the Low Milk EPD groups bred back within one season, there were no significant differences between the HMA, LMA, HMH, or LMH for ability to rebreed within one season, 72.92%, 83.33%, 58.06%, 72.22% respectively. There were also no significant differences between the number of days it took those heifers to rebreed within one season. Days to rebreed least square means for HMA, LMA, HMH, and LMH, are 97.66, 98.09, 87.31, 102.22 days respectively with an overall mean of 95.38 days (Table 4). Selk et al. (1988) reported that body condition scores precalving and at the start of the breeding season, along with body weight changes between 2 and 4 months before parturition, are major factors that influence pregnancy rate of range beef cows. Richards et al. (1986) reported that cows with bcs of $\leq$ 4 had longer postpartum intervals.

These data suggest that as long as cows can adequately and efficiently regain adequate bcs (greater than 4.5) after weaning, milk production will not significantly decrease reproductive efficiency. That is not to say that milk production should be heavily selected for regardless of available feed resources. Further research is needed to determine the long term effects of reproductive efficiency between High and Low Milk EPD groups. Results of this study also indicate that 2-year-old calving cows are not significantly affected in their attempt to efficiently reach a mature weight by extreme selection for Milk EPD.

These results provide an initial verification that Milk EPD is an accurate predictor of daughter milk production between Polled Hereford and Angus sires, and that producers who make bull selections based on Milk EPD should be able to use the values to rank bulls with some confidence. The subsequent increase in calf weaning weight does not come without some cost in the cow's ability to maintain herself. Although bcs and reproductive performance did not significantly differ among the four milk groups, this cost of cow maintenance needs to be assessed and the long term effects need to be determined. These results also indicate that spring calving tends to be advantageous to fall calving as the High Milk groups weaned significantly heavier weight, heavier muscled calves with less cost to cow bcs at weaning under spring calving management than under fall calving management. This advantage is more than likely due to the obvious nutritional advantages during the spring season. Continued research is needed to determine what environmental, managerial, and economical constraints will limit selection for milk production.

TABLE 1. SIGNIFICANCE LEVELS FOR MAIN EFFECTS INCLUDED IN THE PRELIMINARY MODEL ON MONTHLY MEASUREMENTS OF 24-HOUR MILK PRODUCTION AND AVERAGE 24-HOUR MILK PRODUCTION

		Month[b]						
Source	df	1	2	3	4	5	6	AMP[c]
Cow Group (CG)	3	*	*	NS	†	NS	NS	**
Sire of Dam/CG	32	NS	NS	NS	NS	NS	**	NS
Season of Calving	1	NS	NS	NS	NS	NS	**	NS
Year	2	NS	NS	NS	*	*	NS	NS
Sex of Calf	1	*	NS	NS	NS	NS	†	*
Calf Sire/Year	25	NS	NS	NS	NS	NS	NS	NS
Calf Age	1	***	***	***	†	*	**	**
Error MS		3.14	3.45	3.83	4.76	4.06	2.95	1.37
Error df		94	116	126	126	125	125	93

[a] ***=P<.001, **=P<.01, *=P<.05, †=P<.10, NS=P>.10.
[b] For spring-calving group, month 1=April and month 6=September, for fall-calving group, month 1=November and month 6=April.
[c] AMP=Average 24-h milk production for first 6 mo of lactation.

TABLE 2. LEAST SQUARES MEANS AND STANDARD ERRORS FOR MONTHLY MEASUREMENTS OF 24-HOUR AND SIX MONTH AVERAGE 24-HOUR MILK PRODUCTION BY COW GROUP

Month of Lactation[d]	Cow Group			
	LMH	HMH	LMA	HMA
First	$5.3\pm.4^{b}$	$6.1\pm.5^{a,b}$	$4.9\pm.4^{b}$	$6.4\pm.4^{a}$
Second	$4.5\pm.3^{b,c}$	$5.3\pm.4^{b}$	$3.6\pm.4^{c}$	$4.9\pm.3^{a,b}$
Third	$4.5\pm.4^{a}$	$4.4\pm.5^{a}$	$3.7\pm.5^{a}$	$4.9\pm.4^{a}$
Fourth	$4.3\pm.4^{a,b}$	$4.8\pm.5^{a,b}$	$3.8\pm.5^{b}$	$5.2\pm.4^{a}$
Fifth	$3.9\pm.3^{a}$	$4.2\pm.4^{a}$	$3.4\pm.4^{a}$	$4.3\pm.3^{a}$
Sixth	$3.4\pm.5^{a}$	$4.4\pm.6^{a}$	$3.8\pm.5^{a}$	$4.5\pm.4^{a}$
AMP	$4.2\pm.2^{b,c}$	$4.8\pm.3^{a,b}$	$3.7\pm.3^{c}$	$4.9\pm.2^{a}$

[a,b,c] Means in a row with different superscripts are significantly different ($P<.05$).

[d] Means reported by month and AMP are in kg/24h

TABLE 3. LEAST SQUARES MEANS AND STANDARD ERRORS FOR AGE ADJUSTED WEANING WEIGHT BY COW GROUP, SEASON OF BIRTH, AND SEX OF CALF

Comparison	Age Adjusted Weaning Weight, kg
Cow Group:	
LMH	217.9 ± 4.2^{b}
HMH	231.7 ± 5.2^{a}
LMA	$218.9 \pm 5.0^{a,b}$
HMA	229.4 ± 4.1^{a}
Season of Birth:	
Spring	243.5 ± 4.7^{a}
Fall	205.5 ± 4.1^{b}
Sex of Calf:	
Steer	221.2 ± 4.0^{a}
Heifer	227.8 ± 3.9^{a}

[a,b] Means in a column with different superscripts are significantly different (P<.05).

TABLE 4. LEAST SQUARES MEANS AND STANDARD ERRORS FOR DAYS TO REBREED FOR COWS WHO REBRED WITHIN ONE SEASON

Cow Group	n	Days to Rebreed	% Rebred
LMH	39	102.2 ± 5.4[a]	72.22%[a]
HMH	18	87.3 ± 9.9[a]	58.06%[a]
LMA	40	98.1 ± 5.9[a]	83.33%[a]
HMA	35	97.7 ± 5.2[a]	72.92%[a]
Total	132	95.38	72.93%

[a] Means in a column with different superscripts are significantly different (P<.05).

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