EFFECTS OF MILK LEVEL, CALF TYPE AND TWIN REARING ON COW AND CALF PERFORMANCE

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CHAPTER 1

INTRODUCTION

Economic conditions in recent years have resulted in a renewed awareness of the critical need for maximum dilution of fixed operating costs associated with the cow-calf enterprise. Thus, increased calf weaning weight continues to be the principal goal in most commercial cow-calf enterprises.

Producers have access to a variety of management techniques which may result in increased productivity by the cow-calf unit. Among these are: creep feeding, pasture fertilization, improved supplementation, implanting calves, weaning calves at an older age and using heavier milking cows. Other mechanisms for intensification such as controlled twinning and embryo transplants are currently being investigated.

The key to the success of management regimes designed to intensify production is the efficiency with which increased performance is realized. Maximum profit or minimum loss is the realistic goal of all enterprises.

The objectives of the experiments reported in this manuscript were: (1) to determine the influence of varying levels of winter supplementation on milk yield, pre-weaning calf performance and reproductive efficiency of Hereford, Herford x Holstein and Holstein cows under range and drylot conditions; (2) compare the feedlot performance and carcass traits of calves with 0, 25 and 50% Holstein breeding;

(3) determine the effects of two widely differing milk levels on the performance of calves of two biological types; and (4) determine the effects of twin rearing upon supplemental feed requirements, milk production and reproductive performance of Hereford x Holstein females.

CHAPTER 2

REVIEW OF LITERATURE

This review will survey the literature relating to: (1) the effects of milk production in beef herds upon calf performance and efficiency of production; (2) the effects of nutritional regime on milk production and efficiency among cows; (3) the effects of level of milk consumption on feed efficiency and forage intake of suckling calves; and (4) the effect of twin rearing on performance of cows and sheep.

Influences of Milk Production Level Among Cows on Calf Performance

Milk consumption by calves is known to have a marked effect on preweaning calf growth. Several workers (Knapp and Black, 1941; Gifford, 1953; Drewry et al., 1959; Velasco, 1962; and Totusek and Arnett, 1965) have reported correlations ranging from .40 to .88 between level of milk consumption and weight gain among calves. Gifford (1949), Brumby et al., (1963), Gleddie and Berg (1968), Neville (1962) and Velasco (1962) found that the correlation between milk consumption and weight gain decreased as lactation progressed. Other workers (Gifford, 1952, Drewry et al., 1959; and Totusek and Arnett, 1965) reported increasing correlations between estimated daily milk consumption and calf weight gain as lactation progressed.

Schwulst et al. (1966) reported non-significant correlations between average daily gain and milk consumption of .36, .23 and .23 during the second, third and fifth weeks, respectively, after birth.

Klett et al. (1965) reported significant ($P < .01$) correlations ranging from .67 to .81 between milk intake and calf weight at various stages of lactation in an Angus herd. However, non-significant correlations were observed in a Hereford herd suggesting that Angus cows provided a greater proportion of the total nutrient needs of their calves in the form of milk. Milk consumption had little, if any, association with calf weight as indicated by non-significant correlations. Melton et al. (1967) reported correlations between total calf gain and percent butterfat, solids-not-fat and total solids of milk that were near zero.

Christian et al. (1965) reported a correlation of .40 between calf weaning weight and total butterfat yield from 0 to 60 days suggesting that this concentrated source of energy was important when rumen development was limited. In this study, estimates of dam's milk production appeared to be independent of calf birth weight suggesting that milk production was not affected by capacity of the calf.

Cundiff and Gregory (1968) reported data indicating that milk butterfat content had a greater effect on weaning weight and preweaning gain than total milk volume during the first 60 days of lactation. Similar observations were reported by Burris and Bangus (1955) and Owens (1953) for sheep.

Kress and Anderson (1974) reported milk production data on Hereford cows which produced an average of 870 kg of milk during a 205 day lactation. Estimated daily milk production was 6.1 kg on day 35 of lactation and declined to 2.2 kg on day 185 of lactation. In a similar study, Carpenter et al. (1973) reported that Hereford cows produced 4.9 kg of milk per day compared to 6.0 kg of milk for Charolais cows. Mature cow size was not significantly associated milk yield within breed; however, cows of small mature size tended to produce more milk than larger cows.

Milk production and composition among Hereford cows managed on range and in drylot was reported by das Neves et al. (1974). Range cows produced 4.8 kg of milk daily that contained 2.6, 11.0 and 8.4% butterfat, total solids and solids-not-fat, respectively. Drylot cows produced 4.5 kg of milk with 3.2, 11.4 and 8.2% butterfat, total solids and solids-not-fat, respectively. Milk production among range cows showed fluctuations which reflected forage availability.

Gregory et al. (1965) reported that Angus, Hereford and Shorthorn cows produced 4.1 and 3.2 kg of milk daily during two consecutive lactations while similar reciprocal cross cows produced 4.3 and 3.6 kg daily during the same period. Cundiff (1973) reported that reciprocal crossbred females of Angus, Hereford and Shorthorn breeds produced more milk and were more persistent than straightbred females. Similar results were reported by Schwulst et al. (1968).

The most rapid method of increasing milk production in beef herds is by infusion of genes for high milking ability from dairy breeds. Boston et al. (1972) reported that as two-year-olds, Angus x Holstein cows produced 5.7 kg of milk daily compared to 4.0 kg for Angus cows. As three-year-olds, Angus x Holstein cows produced 6.3 kg of milk daily compared to 5.2 kg for Angus cows.

McGinty and Frerichs (1971) reported estimates of milk yield from Brown Swiss x Hereford and Herford cows at three intervals during lactation. On days 85, 135 and 180 of lactation estimated milk yields of Brown Swiss x Hereford and Herford cows were 8.6, 6.0, 5.2 and 4.0, 4.1 and 3.3 kg, respectively.

Kropp et al. (1973) and Holloway et al. (1975) reported that Holstein cows produced more milk and weaned heavier calves than Hereford or Herford x Holstein cows managed on range or under drylot conditions. Holsteins produced about twice as much milk as Herefords and required about three times as much supplement to maintain a level of reproductive performance equivalent to that of Herefords. Hereford x Holstein cows were intermediate with regard to milk production and supplemental feed requirements.

A consideration of primary importance with regard to increased milk production in beef cow herds is the efficiency with which milk is converted to calf gain. Several researchers (Montsma, 1960; Wistrand and Riggs, 1966; Neville, 1962; Melton et al., 1967; and Kress, Hauser and Chapman, 1968) have reported efficiencies ranging from 4.0 to 23.5 kg of milk per kilogram of calf gain in beef cows. Brumby et al. (1963) reported that the milk required per kilogram of calf gain increased linearly from 9.1 kg at six weeks to 50 kg at 24 weeks of age when calves consumed an all milk diet. However, when calves were allowed access to pasture, Drewry, Brown and Honea (1959) reported that efficiency improved with age. Angus calves in this study required 12.5, 10.8 and 6.3 kg of milk per kilogram of gain during the first, third and sixth months of lactation.

As the level of milk consumption increases, the efficiency of conversion of milk to calf gain may decrease. Deutscher (1970) observed that the calves of Angus cows required 6.0 kg of milk per kilogram gain compared to 7.1 kg for calves of Angus x Holstein cows. Similar findings were reported by McGinty and Frerichs (1971).

Numerous workers have suggested that calf capacity may be a factor which limits the cow's milk production. In veiw of the fact that Hereford cows did not display a lactation curve similar to dairy breeds, Gifford (1953) concluded that the calf's capacity for milk limited the cow's production during early lactation.

Several workers have proposed that residual milk in the udder after nursing was evidence of a calf's limited ability to consume milk. Schwulst et al. (1966) reported residual milk equal to 15 and 11% of the total secretion following nursing during the second and third weeks of lactation, respectively. Among Holstein cows under beef management, Plum and Harris (1971) observed that 5.7, 3.2 and 1.3 kg of residual milk remained in the udder following nursing during the first, second and third months of lactation, respectively. Gleddie and Berg (1968) reported that machine milked beef cows produced 1.2 kg more milk daily than calves consumed during the first month of lactation.

Several workers (Neville, 1962; Brumby et al., 1963; and Christian et al., 1965) have demonstrated that calves were capable of consuming levels of milk in excess of 9 kg per day during the first 120 days of lactation.

Effect of Nutritional Regime on Milk Production and Efficiency Among Cows

An excessively high plane of nutrition prior to first breeding (as heifers) and subsequent calving may result in reduced milk production and reproductive performance (Cundiff and Gregory, 1968; Arnett et al., 1971; Swanson, 1960; Totusek et al., 1961 and Ludwig et al., 1967).

A nutritional regime that will sustain an optimal milk production response and ensure a high level of reproductive performance among cows is implicit for an efficient cow unit. Flux and Patchell (1954) reported that dairy cows receiving a low plane of nutrition produced less milk and butterfat than cows receiving an adequate level. Dunn et al. (1965) reported data for Angus and Hereford cows indicating that low energy regimes both pre- and post-calving resulted in a reduction in milk yield. Similar findings were reported by Bond et al. (1964) and Hight (1966).

Kropp et al. (1973) and Holloway et al. (1975) reported level of winter supplementation had little affect upon milk yield by Hereford, Hereford x Holstein and Holstein females managed on range or in drylot. Post-partum intervals and conception rates were adversely affected by low supplement levels. Similar effects on reproductive performance were reported by Smithson et al. (1964) and Turman et al. (1964).

Milk yield may be an important factor affecting post-partum interval in cows. Boyd (1967) reviewed several studies with dairy cattle indicating that for each additional 454 kg of milk produced during the first 120 days of lactation, estrus was delayed 1.5 days. Deutscher and Whiteman (1971) reported that only 13% of the heavier milking Angus x Holstein cows rebred during a 90-day breeding season compared to 63% of Angus cows. McGinty et al., 1971, reported similarly poor reproductive performance by heavy milking Brown Swiss x Hereford females compared to Herefords. However, excellent reproductive performance was observed when energy intake by the Brown Swiss x Hereford cows was increased. In an extensive review of studies relating to the postpartum cow, Casida et al. (1968) reported that the suckling stimulus was an important factor responsible for delayed estrus.

Effect of Milk Intake on Rumen Development, Feed Efficiency and Forage Intake by Calves

Composition of the diet is known to be an important factor influencing rumen development (Blaxter, 1952; Savage and McCay, 1942). Blaxter (1952) showed that calves receiving roughage in addition to milk developed larger rumens than calves consuming milk alone. Similar findings were reported by Warner, Flatt and Loosli (1956) who reviewed early work indicating that prolonged milk feeding slowed rumen development.

Ndumbe, Runcie and McDonald (1963) and Otterby and Rust (1965) presented data indicating rumen fermentation in calves by three to four weeks of age. Several workers (Langemann and Allen, 1953; McCarthy and Kesler, 1956; and Conrad, Hibbs and Frank, 1958) have shown that feeding high levels of roughage or concentrate will result in VFA patterns similar to those found in adult animals by 6 to 8 weeks of age.

McCarthy and Kesler (1956) reported that cellulose digestion by calves increased dramatically during the first six months of life. Lusby (1974) reported that calves receiving high milk levels consumed less creep in drylot and less forage on range than calves receiving low milk levels. Level of milk intake did not affect cellulose digestibility among drylot calves. Leaver (1973) reported that concentrate feeding decreased the voluntary intake of forages by dairy calves.

Effect of Twin Rearing on the Performance of Cows and Sheep

Controlled induction of twin conception in beef cows is an area which is currently receiving some research attention. The primary research effort has been directed toward obtaining a better understanding of the physiological mechanisms involved in twin conception (Hammond, 1949; Schilling and Holm, 1963; Turman et al., 1971).

Reproductive performance may be adversely affected by twin rearing. Bellows et al. (1974) reported that cows rearing twins had a longer postpartum interval than cows rearing singles. However, early weaning was an effective means of reducing the interval to first estrus. Similar findings were reported by Casida et al. (1968).

Erb and Morrison (1959) reported a study in which they examined the records of over 7,000 calvings in a Holstein dairy herd spanning over 30 years. In this study, 338 cases of multiple births were recorded. Mortality rate was high among twin births at parturition, averaging 41% of the males and 35% for females. Cows having twins before the fourth calving subsequently produced fewer calves during their remaining productive life.

Data have not been previously published regarding the effects of twin rearing on milk production and supplemental feed requirements of cows. Sheep data have shown that twin rearing may result in a 21 to 41% increase in milk yield by ewes (Alexander and Davies, 1959; Gardner and Hogue, 1964; Gardner and Hogue, 1966).

CHAPTER 3

PERFORMANCE OF 4- AND 5-YEAR-OLD HEREFORD, HEREFORD X HOLSTEIN AND HOLSTEIN COWS ON RANGE AND IN DRYLOT[1,2,3]

Summary

Performance of winter-calving 4- and 5-year-old Hereford, Hereford x Holstein (Crossbred) and Holstein cows under tallgrass native range and drylot confinement conditions was determined. Two levels (Moderate and High) of a 30% protein supplement were fed during the winter to groups of cows within each breed. A group of Holstein cows was fed an additional level (Very High). Drylot cows were fed cottonseed hulls and alfalfa hay as roughage sources to simulate seasonal changes in energy intake of the range cows.

Estimated DE and DP intake within breed group increased with higher levels of winter supplementation. DE and DP intake also increased as percentage of Holstein breeding increased due to increased forage intake by the heavier milking cows. High Crossbreds and Very

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High Holsteins consumed 17 and 45% more forage, respectively, than Moderate Herefords. As milk intake of drylot calves increased, their intake of estimated DE and DP increased in spite of decreased creep intake.

Generally, as level of supplement increased within breed group, winter weight loss decreased; Hereford cows on range were the single exception. All groups except Moderate and High Holsteins regained winter weight losses during the summer months.

As the percentage of Holstein breeding increased, daily milk yields increased. Level of winter supplementation did not consistently influence level of milk yield within breed. As milk intake and percentage of Holstein breeding increased, calf weaning weight increased.

The number of Moderate and High Holstein cows exhibiting estrus and conceiving was low compared to other breed and supplement groups.

These results indicate that the increased input costs associated with heavier milking cows are substantial. The feasibility of increasing milk yield in the beef cow herd as a means of intensification must be evaluated in terms of cost-return analyses under a given set of economic circumstances.

Introduction

Increasing the weaning weight of calves is a principal goal in most commercial cow-calf enterprises. Increased milk production in beef cows results in increased weaning weight of calves (Knapp and Black, 1941; Neville et al., 1960; Velasco, 1962). Milk production in beef cows can be increased most rapidly by introduction of dairy breeding. Angus x Holstein cows produced more milk than Angus cows

(Deutscher and Whiteman, 1971) and Hereford x Holstein cows produced more milk than Hereford cows (Holloway et al., 1975) under range conditions. The cost of the increased energy requirement of larger, higher producing Holstein crossbred cows may offset the advantage in calf growth response. Poor reproductive performance was reported for beef x dairy crossbreds when energy was limited (Deutscher and Whiteman, 1971; McGinty and Frerichs, 1971; Holloway et al., 1975).

The purpose of this paper is to report the influence of level of winter supplement on the performance of 4- and 5-year-old cows differing widely in milk production potential.

Materials and Methods

Lactating Hereford, Hereford x Holstein (Crossbred) and Holstein cows were maintained either on tallgrass native range or under completely confined drylot conditions at the Southwestern Livestock and Forage Research Station (El Reno). During post-weaning gestation periods, all cows were managed under native range conditions. The performance of cows as 4- and 5-year-olds is reported. Detailed management practices were described by Kropp et al. (1973 a,b) and Holloway et al. (1975) who reported the performance of these cows as 2- and 3-year-olds, respectively. Only deviations in management practices from those reported by Holloway et al. (1975) will be discussed in detail here.

Within each breed, groups of cows were fed two levels of winter supplement designated as Moderate and High. An additional group of Holsteins was fed a Very High level. The Moderate, High and Very High levels represented the amount of winter supplement deemed necessary to maintain a high level of reproductive performance in Hereford, Crossbred and Holstein cows, respectively. As 2- and 3-year-olds, Moderate Hereford, High Crossbred and Very High Holstein cows on the range were fed post-calving supplement levels 1.2, 2.4, 3.5 (Kropp et al., 1973b) and 1.4, 2.9 and 4.2 (Holloway et al., 1975) kg/head/day. The average daily supplement (30% crude protein) fed to the cows as 4- and 5-year-olds is shown on table 3.1. Cows on the range were individually fed supplement 5 days each week for periods of 151 days (November 15 to April 16) and 140 days (November 26 to April 16) as 4- and 5-year-olds, respectively.

Drylot cows were individually fed the same supplement for the same period of time as the range cows but on a daily basis. Their supplement was prorated so that the same amount was fed post-calving each week in drylot and on range. Drylot cows were also individually fed forage and concentrates to simulate seasonal changes in the energy intake of range cows. The drylot forage feeding regime consisted of cottonseed hulls, (Cotton, seed hulls IRN 1-01-599) during the winter to mid-April, then alfalfa hay (alfalfa, hay, s-c, mid-blm, IRN 1-00-063) until each cows' calf was weaned at 240 ± 7 days of age. Estimated digestible energy (DE) and digestible protein (DP) intakes were calculated from tabular data (Crampton and Harris, 1969). Drylot cows and their calves were maintained in seven separate pens according to breed and supplement level. Forage was individually fed to cows ad libitum during a 4 hr period each day. Drylot calves received a creep ration ad libitum in individual pens while their dams were being fed. The pelleted creep ration consisted of (%): corn, dent yellow, grain, gr 2 US mn 54 wt., IRN 4-02-931, 49.5; chopped alfalfa hay, 15; cottonseed

TABLE 3.1. INTAKE OF FEED AND ESTIMATED DIGESTIBLE ENERGY AND DIGESTIBLE PROTEIN, AVERAGE OF TWO YEARS

	Breed and level of winter supplementation of cows							
	Hereford		Hereford x Holstein		Holstein			
	Moderate	High	Moderate	High	Moderate[a]	High	Very High	SE[b]
Range cows								
Supplement, kg								
Total winter[c]	127	259	139	265	142	259	395	
Daily, pre-calving	.4	.8	.4	.8	.4	.8	1.1	
Daily, post-calving	1.4	2.6	1.4	2.6	1.4	2.7	3.7	
Drylot cows								
Supplement, kg								
Total winter[c]	153	312	156	319	169	323	523	
Daily, pre-calving	.4	.8	.4	.8	.4	.8	1.1	
Daily, post-calving	1.4	2.6	1.3	2.7	1.7	2.8	4.1	
Total forage intake, kg[d]	2576[g]	2858[gh]	3092[h]	3007[h]	3162[h]	3740[i]	3731[i]	101
Total forage intake, %[e]	100	111	120	117	123	145	145	
Estimated daily DE intake during lactation, Mcal	21.82[g]	24.52[h]	25.27[h]	26.38[hi]	28.21[i]	31.54[j]	32.62[j]	.78
Estimated daily DP intake during lactation, kg	.81[g]	.91[gh]	.92[gh]	.98[hi]	1.08[ij]	1.16[jk]	1.22[k]	.02
Creep feed, drylot calves								
Average daily creep intake, kg	1.77[i]	1.54[gh]	1.55[gh]	1.56[gh]	1.47[gh]	1.45[g]	1.35[g]	.10
Estimated daily DE intake, Mcal[f]	9.18[g]	8.96[g]	9.97[gh]	10.73[hi]	11.40[i]	11.62[i]	11.38[i]	.41
Estimated daily DP intake, kg[f]	.41[g]	.41[g]	.45[gh]	.48[hi]	.51[i]	.53[i]	.53[i]	.02

[a]No Moderate Holstein treatment on range as 5-year-olds due to low rebreeding performance of cows the previous year.
[b]Standard errors are approximate because of unequal subclass numbers.
[c]November 5, 1972 - April 15, 1973 and November 26, 1973 - April 16, 1974.
[d]Intake during lactation.
[e]Expressed as % of Moderate Herefords.
[f]Creep + milk averaged over total pre-weaning period.
[g,h,i,j,k]Means on the same line with the same superscript letter are not significantly different (P>.05).

hulls, 10; soybean, seed wo hulls, solv-extd, mx 3 fbr, IRN 5-04-612, 17.5; sugarcane, molasses, mn 48 invert sugar 79.5 degrees brix, IRN 4-04-696, 5; wheat, flour by-prod, mx 9.5 fbr, IRN 4-05-205, 3.

Calves were born in December, January and February; each calf was weaned at 240 $\pm$ 7 days. Cows were artifically inseminated to one Charolais bull for 60 days and pasture exposed for 30 days to seven Charolais bulls.

Cow weights, cow condition scores, calf weights, calf milk consumption and milk composition estimates were obtained as described by Kropp et al. (1973b). Milk consumption by calves of 4- and 5-year-old cows was estimated at seven (monthly) and three (March, May and July) points, respectively, during lactation.

Because this paper reports the third and fourth calf crops of cows in a long range study, there is a disproportionality of numbers in each breed-supplement level group. Also, different numbers of cattle were available for analysis of different variables. Since some cows were represented in the statistical analysis in both years, correlated variable responses were anticipated. There was no Moderate Holstein subclass on range as 5-year-olds due to the low rebreeding performance by these cows as 4-year-olds. Means reported for Moderate Holsteins on range are least square means for this group based on performance as 4-year-olds. Statistical treatment of the data was effected by taking unweighted breed x supplement least square means across years except in the case of Moderate Holsteins. The variances of such means are a combination of appropriate variance components which were estimated from an analysis of variance to determine the variance of breed x treatment means averaged across the two years. A t-test was used to determine breed and level of supplement effects (Snedecor and Cochran, 1967).

A comparison of range and drylot management systems for cow-calf operations was not an objective of this research. Consequently, management system was not included in the model and was not tested for significance and interactions.

Results and Discussion

Feed Intake. Drylot cows consumed more winter supplement (table 3.1) because they calved earlier and were on post-calving supplement levels longer. Cows on the High supplement level received about twice the amount fed at the Moderate level while cows on the Very High level received about three times that of the Moderate level.

In drylot, Holsteins generally consumed more ($P<.05$) total forage reflecting their increased requirements due to body weight (table 3.2) and milk yield (table 3.3). Forage intake of Crossbreds represented an intermediate tendency, although not statistically different ($P>.10$) from High Herefords and Moderate Holsteins. A calculation of breed effects on forage intake within level of supplementation showed that Crossbreds and Holsteins consumed 13 and 21% more forage than Herefords. The compensating effect of decreased forage intake with increasing supplement intake within breed reported by Holloway et al. (1975) for these cows as 3-year-olds was not apparent in their performance as 4- and 5-year-olds. Alfalfa fed to cows as 3-year-olds was chopped prior to feeding suggesting that the physical form of baled alfalfa used as 4- and 5-year-olds may have limited Moderate level cows in compensating for their low supplement level.

TABLE 3.2. WEIGHT, WEIGHT CHANGE, CONDITION AND CONDITION CHANGE OF COWS, AVERAGE OF TWO YEARS

	Breed and level of winter supplementation of cows							
	Hereford		Hereford x Holstein		Holstein			
	Moderate	High	Moderate	High	Moderate[a]	High	Very High	SE[b]
Range								
Weight, kg								
Fall (pre-calving)	456^{d}	471^{d}	472^{d}	483^{d}	577^{e}	534^{e}	550^{e}	12
Spring (mid-lactation)	382^{d}	394^{d}	374^{d}	396^{d}	439^{e}	439^{e}	457^{e}	10
Fall (post-lactation)	471^{d}	482^{d}	478^{d}	490^{de}	553^{f}	527^{ef}	554^{f}	11
Weight change, kg								
Winter	-74^{d}	-77^{d}	-98^{e}	-87^{de}	-139^{f}	-95^{e}	-93^{e}	5
Summer	89^{d}	88^{d}	104^{ef}	94^{de}	113^{f}	88^{d}	97^{de}	5
Year	15^{f}	11^{f}	6^{ef}	7^{ef}	-26^{d}	-7^{e}	4^{ef}	5
Weight change, %								
Winter	-16.2	-16.3	-20.8	-18.0	-24.0	-17.8	-16.9	
Summer	19.5	18.7	22.0	19.5	20.5	16.5	17.6	
Year	3.3	2.3	1.3	1.4	-4.4	-1.3	.7	
Condition score[c]								
Fall (pre-calving)	7.1^{g}	7.5^{g}	5.9^{f}	5.8^{f}	3.0^{d}	4.0^{e}	4.5^{e}	.2
Spring (mid-lactation)	4.4^{g}	4.8^{g}	2.8^{ef}	3.2^{f}	1.7^{d}	2.0^{de}	2.8^{ef}	.2
Fall (post-lactation)	6.5^{f}	6.7^{f}	5.7^{e}	5.2^{e}	3.4^{d}	3.3^{d}	4.2^{d}	.2
Condition score change								
Winter	-2.7^{d}	-2.7^{d}	-3.1^{d}	-2.6^{d}	-1.3^{e}	-2.0^{e}	-1.7^{e}	.2
Summer	2.1^{e}	1.9^{de}	2.9^{f}	2.0^{de}	1.7^{de}	1.3^{d}	1.4^{d}	.2

TABLE 3.2. (Continued)

Item	Hereford Moderate	Hereford High	Hereford x Holstein Moderate	Hereford x Holstein High	Holstein Moderate[a]	Holstein High	Holstein Very High	SE[b]
Drylot								
Weight, kg								
Fall (pre-calving)	470^{d}	476^{d}	482^{d}	480^{d}	548^{e}	569^{e}	575^{e}	14
Spring (mid-lactation)	402^{d}	448^{ef}	410^{de}	433^{def}	455^{ef}	494^{fg}	535^{g}	13
Fall (post-lactation)	491^{d}	494^{d}	488^{d}	483^{d}	521^{de}	562^{e}	589^{e}	15
Weight change, kg								
Winter	-67^{def}	-28^{g}	-72^{de}	-47^{efg}	-93^{d}	-75^{d}	-40^{fg}	8
Summer	88^{f}	46^{d}	78^{ef}	50^{d}	66^{def}	68^{def}	54^{de}	9
Year	21^{g}	18^{fg}	6^{ef}	3^{ef}	-27^{d}	-7^{de}	14^{fg}	8
Weight change, %								
Winter	-14.2	-5.9	-14.9	-9.8	-16.8	-13.2	-7.0	
Summer	18.7	9.7	16.2	10.4	12.0	12.0	9.4	
Year	4.5	3.8	1.2	.6	-4.9	-1.2	2.4	
Condition score[c]								
Fall (pre-calving)	7.1^{f}	7.3^{f}	6.0^{e}	5.7^{e}	4.1^{d}	4.2^{d}	5.7^{e}	.3
Spring (mid-lactation)	4.9^{e}	6.3^{f}	4.2^{e}	4.7^{e}	2.4^{d}	3.1^{d}	4.6^{e}	.3
Fall (post-lactation)	6.1^{f}	6.5^{f}	5.7^{ef}	5.2^{e}	3.7^{d}	3.5^{d}	4.0^{d}	.3
Condition score change								
Winter	-2.2^{d}	-1.0^{e}	-1.8^{de}	-1.0^{e}	-1.7^{de}	-1.1^{e}	-1.1^{e}	.3
Summer	1.2^{fg}	$.2^{de}$	1.5^{g}	$.5^{ef}$	1.3^{fg}	$.4^{ef}$	$-.6^{d}$	.3

[a]No Moderate Holstein treatment on range as 5-year-olds due to low rebreeding performance of cows the previous year.
[b]Standard errors are approximate because of unequal subclass numbers.
[c]Condition scores based on a scale of 1 to 9; 1=very thin, 9=very fat.
[d,e,f,g]Means on the same line with the same superscript letter are not significantly different (P>.05).

TABLE 3.3. YIELD AND COMPOSITION OF MILK, AVERAGE OF TWO YEARS

	Breed and level of winter supplementation of cows							
	Hereford		Hereford x Holstein		Holstein			
	Moderate	High	Moderate	High	Moderate[a]	High	Very High	SE[b]
Range								
Total lactation yield, kg	1483^{c}	1417^{c}	2151^{d}	2435^{e}	2730^{ef}	2992^{f}	2921^{f}	107
Daily yield, kg	6.2^{c}	5.9^{c}	9.0^{d}	10.1^{e}	11.4^{ef}	12.5^{f}	12.2^{f}	.5
Drylot								
Total lactation yield, kg	1401^{c}	1584^{c}	1926^{d}	2259^{de}	2426^{ef}	2609^{ef}	2752^{f}	118
Daily yield, kg	5.8^{c}	6.6^{c}	8.0^{d}	9.4^{de}	10.1^{ef}	10.9^{ef}	11.5^{f}	.5
Butterfat, %	2.4^{c}	2.5^{cd}	3.1^{f}	2.9^{ef}	2.6^{cde}	2.9^{ef}	2.8^{def}	.1
Solids-not-fat,%	8.2	8.3	8.5	8.3	8.0	8.1	8.0	.2
Total solids, %	10.6	10.8	11.6	11.2	10.6	11.0	11.8	.3

[a] No Moderate Holstein treatment on range as 5-year-olds due to low rebreeding performance of cows the previous year.
[b] Standard errors are approximate because of unequal subclass numbers.
[c,d,e,f,g] Means on the same line with the same superscript letter are not signigicantly different $(P>.05)$.

Daily trends in DE and DP intakes followed the increasing level of supplemental and forage intake in Crossbreds and Holsteins as compared to Herefords. Cows on all treatments exceeded their estimated requirements of DP (N.R.C., 1966) while cows on all treatments except Moderate Holstein received more than the estimated DE requirement for the lactation period.

Weight and Condition of Cows. Within breed of dam, as the level of supplemental feeding increased, winter weight losses tended to decrease in all cases except Herefords managed on range (table 3.2.). This trend was particularly evident in drylot where average calving dates were more uniform across treatment groups. In drylot, increasing the level of supplement resulted in 39 kg less winter weight loss ($P<.05$) in Herefords and a large (25 kg) but non-significant ($P>.20$) decrease in weight loss in the Crossbreds. Within the Holstein breed group, cows receiving the Very High supplement level lost 53 and 35 kg less ($P<.05$) weight during the winter than cows receiving the Moderate or High supplement levels. Winter weight losses by High Holsteins were intermediate but did not differ significantly ($P>.20$) from cows receiving the Moderate level. Kropp et al. (1973b) and Holloway et al. (1975) reported similar observations for these cows as 2- and 3-year-olds, respectively.

Both on range and in drylot, all cows except Moderate and High Holsteins regained their winter losses during the subsequent summer months. Similar observations were reported for these cows as 2- and 3-year-olds (Kropp et al., 1973b and Holloway et al., 1975). This suggests that the lower supplement levels (Moderate and High) are inadequate for maintenance of mature body size and productivity in the larger, higher milking Holstein cows.

The effect of winter supplement level on summer weight gains by cows on range varied. Among Herefords and Crossbreds, level of winter supplement did not affect (P>.20) summer gains while Moderate Holsteins gained 25 and 16 kg more (P<.05) than Holsteins receiving the High and Very High levels. In drylot, Moderate Hereford and Crossbred cows gained more (P<.05) weight during the summer months compensating for greater winter weight loss. This is in agreement with results of Kropp et al. (1973b), Holloway et al. (1975), Zimmerman (1960) and Hughes (1971). Level of winter supplement did not affect (P>.10) summer gain among Holstein cows in drylot.

Generally, condition scores followed the trends observed for weight change. As 2-year-olds, cows that lost more condition in winter gained more in the summer (Kropp et al., 1973b). However as 3- (Holloway et al., 1975), 4- and 5-year-olds these trends were not as marked. Within breed groups, level of supplement significantly (P<.05) affected winter condition score change only among Herefords in drylot. A significant (P<.05) breed affect on condition score was apparent both on range and in drylot with Holsteins having the lowest and Herefords the highest condition scores.

Milk Yield. The three breeds of cows produced widely differing milk levels (table 3.3). On range, daily milk yields by High and Very High Holsteins were greater (P<.05) than for Crossbred and Hereford cows. Milk yield by Hereford cows was lower (P<.05) than for Crossbreds which tended to be intermediate. Among Crossbreds on range, cows receiving the moderate supplement level produced 1.1 kg less (P<.05) milk daily than cows on the High level. Level of supplement did not affect milk yield within the Hereford (P>.50) or Holstein (P>.20) breed groups on range. In drylot, level of winter supplement did not significantly (P>.05) affect level of milk yield within breeds, but there appeared to be a trend toward increasing milk yield as supplement level increased.

Milk yields by Hereford and Crossbred cows were similar to those reported by Holloway et al. (1975) for these cows as 3-year-olds, but Holsteins produced less milk than as 3-year-olds. Moderate, High and Very High Holsteins produced 21, 1 and 14% (range) and 25, 24 and 15% (drylot) less milk, respectively, as 4- and 5-year-olds than as 3-year-olds. This response may be due to the accumulative affects of a sub-optimal plane of nutrition for the large, heavy milking Holsteins and would be consistent with the observed weight change and condition score trends.

Milk Composition. Butterfat, total solids and solids-not-fat (drylot only; table 3.3) were similar to those reported for these cows as 2-year-olds (Kropp et al., 1973b). Butterfat and total solids were higher than those reported for these cows as 3-year-olds (Holloway, et al., 1975). Herefords produced milk which was lower (P<.05) in butterfat than that of Crossbreds, High Holsteins and Very High Holsteins. No consistent effect (P>.10) of level of supplement within breed group on butterfat was apparent. Neither breed of dam nor level of supplement affected (P>.10) solids-not-fat or total solids. These results are in contrast to data of Flux and Patchell (1954), Huber et al. (1964) and Gillooly et al. (1967) who reported increased percentages of solids-not-fat as well as butterfat with increasing energy intakes. Failure to observe similar responses in these data can probably be explained in the basis of the relatively small increases (12-16%) in DE intake that accompanied increased supplement levels within breed groups.

Performance of Progeny. Holstein progeny (calves of Holstein dams) on range were heavier at birth (P<.05) than those of Crossbred progeny (calves of Crossbred dams) and Hereford progeny (calves of Hereford dams) (table 3.4). A similar trend was evident in drylot, although differences were not as marked, where only the High Hereford progeny were significantly (P<.05) lighter at birth than Holstein progeny. These trends correspond to differences in mature size of the dams, Holstein cows being heavier (P<.05) than Herefords and Crossbreds.

Supplement level of the dam did not influence (P>.05) birth weight except in the case of Herefords in drylot. Similar observations were reported for these cows by Kropp et al. (1973b) and Holloway et al. (1975). Hughes (1971) and Wiltbank et al. (1962) reported contrasting results for cows on spring calving programs.

As the level of milk intake and percentage of Holstein breeding increased, increased calf weaning weights were observed. On range, Holstein progeny weaned heavier (P<.05) than Herefords and Moderate Crossbreds. High Crossbreds were intermediate in weaning weight but were not significantly (P>.10) different from High and Very High Holsteins. Within breed groups on range, only Crossbreds showed a significant (P<.05) effect due to supplemental level. The 18 kg weaning weight advantage of High Crossbreds compared to that of Moderate Crossbreds is consistent with the higher apparent milk yield by dams of this group (table 3.3). Similar weaning weight trends were observed in drylot, where Holsteins and High Crossbreds were heavier (P<.05) than Moderate Crossbreds and Herefords. Level of supplement of the dam did

TABLE 3.4. CALVING AND WEANING PERFORMANCE, AVERAGE OF TWO YEARS

Item	Breed and level of winter supplementation of cows							SE[b]
	Hereford		Hereford x Holstein		Holstein			
	Moderate	High	Moderate	High	Moderate[a]	High	Very High	
Range								
No. of calves	28	25	25	25	10	16	22	
Birth weight, kg	37^{c}	39^{cd}	41^{d}	40^{d}	47^{e}	47^{e}	44^{e}	1
Adj. weaning weight, kg	266^{c}	264^{c}	284^{d}	302^{e}	325^{f}	320^{ef}	316^{ef}	6
Drylot								
No. of calves	10	10	10	10	9	10	9	
Birth weight, kg	41^{de}	36^{c}	40^{cd}	41^{de}	44^{ef}	45^{f}	44^{ef}	1
Adj. weaning weight, kg	260^{c}	260^{c}	282^{cd}	300^{de}	307^{ef}	327^{f}	331^{f}	8

[a]No Moderate Holstein treatment on range as 5-year-olds due to low rebreeding performance of cows the previous year.
[b]Standard errors are approximate, because of unequal subclass members.
[c,d,e,f] Means on the same line with same superscript letter are not significantly different (P>.05).

not affect (P>.10) weaning weight of calves within breed group in drylot. In previous years, drylot calves failed to gain as rapidly as range calves (Kropp et al., 1973b and Holloway et al., 1975), but higher creep intakes resulting from higher energy density and pelleting of the creep produced comparable weaning weights among range and drylot calves of 4- and 5-year-olds cows.

As milk intake by drylot calves increased especially due to breed of dam (table 3.3), calf creep intake tended to decrease. Even though creep intake decreased with increased milk consumption, estimated DE and DP intake by calves increased with increasing level of milk consumption. Although the weaning weight of calves increased as milk yield and percentage of Holstein breeding increased, additional resource inputs required to maintain the larger, heavier milking cows were high. In drylot, Very High Holsteins consumed 3.4 times more supplement and 45% more forage than Moderate Herefords.

Reproductive Performance. Reproductive performance is summarized in table 3.5. Level of supplement had little affect upon the number of cows exhibiting estrus and subsequently conceiving among Herefords and Crossbreds either on range or in drylot. The number of Holstein cows exhibiting estrus and subsequently conceiving was reduced sharply when Moderate and High supplement levels were fed. Poor reproductive performance was most dramatically illustrated in Moderate Holsteins which were not represented on range as 5-year-olds due to low rebreeding performance as 4-year-olds. The sharp decline in reproductive rate of Moderate and High Holsteins as 4- and 5-year-olds compared to that of 2- and 3-year-olds (Kropp et al., 1973b and Holloway et al., 1975) suggests the importance of accumulative effects of low levels of

TABLE 3.5. REPRODUCTIVE PERFORMANCE, AVERAGE OF TWO YEARS

Item	Breed and level of winter supplementation of cows						
	Hereford		Hereford x Holstein		Holstein		
	Moderate	High	Moderate	High	Moderate	High	Very High
Range							
No. of cows	28	26	26	28	10	18	23
No. of cows exhibiting estrus[b]	26	26	25	26	5	13	21
No. of cows which conceived[c]	26	25	25	23	5	13	20
Drylot							
No. of cows	10	10	10	10	9	10	10
No. of cows exhibiting estrus[b]	10	10	9	10	6	8	9
No. of cows which conceived[c]	10	10	9	10	5	7	9

[a]No Moderate Holstein treatment on range as 5-year-olds due to low rebreeding performance of cows the previous year.
[b]Based upon pasture observations and paint markings by bulls equipped with chin-ball markers.
[c]Based on palpation and verified by calving records the subsequent season.

supplementation. Poor reproductive performance of high producing cows on low supplement levels is in agreement with the findings of Deutcher and Whiteman (1971), McGinty and Frerichs (1971) and Holloway et al., (1975).

The optimum level of milk production in the beef cow herd is a moving target and the justification for using heavier milking breeds is contingent upon economic circumstances affecting the enterprise. This paper presents data which can aid in decision-making regarding the kind of females to be employed in the beef cow herd.

CHAPTER 4

FEEDLOT PERFORMANCE AND CARCASS TRAITS OF PROGENY OF HEREFORD, HEREFORD X HOLSTEIN AND HOLSTEIN COWS[1,2,3]

Summary

The effects of breed of dam on postweaning feedlot performance and carcass traits of 217 steer and heifer calves from Hereford, Hereford x Holstein (Crossbred) and Holstein cows was determined. Calves were all sired by Charolais bulls and were produced in two successive years. Each year calves that had been reared on range preweaning were group-fed while calves that had been reared in drylot were individually-fed during the feedlot finishing period.

Holstein progeny was heavier ($P<.05$) initially (55 kg) and at slaughter (104 kg) than their Hereford contemporaries. Holstein progeny was older ($P<.05$) at slaughter (64 days) and showed more skeletal

[1]Journal article of the Agriculture Experiment Station, Oklahoma State University, Stillwater.

[2]R. D. Wyatt, K. S. Lusby, M. B. Gould, L. E. Walters, J. V. Whiteman and Robert Totusek, Oklahoma State University, Stillwater, Oklahoma 74074.

[3]Department of Animal Sciences and Industry and U.S.D.A., Agricultural Research Service, Southern Region.

height ($P<.05$) and length ($P<.05$) both initially and at slaughter than Hereford progeny. Crossbred progeny was intermediate with respect to these traits.

As Holstein breeding increased, there was a trend toward increased daily and total feed intake and increase in feed required per kilogram of gain.

Holstein progeny produced carcasses which were 37 and 70 kg heavier ($P<.05$) than Crossbred and Hereford progeny. Superior muscling of Hereford progeny was indicated by larger rib-eye-area per 100 kg of carcass weight and a slight tendency toward higher cutabilities. Conformation scores tended to be lower for Holstein progeny when compared to Hereford or Crossbred progeny. Marbling scores and carcass grades of Holstein progeny were as high or higher than those for Hereford and Crossbred progeny.

Introduction

The infusion of dairy germ plasm into beef cow herds as a strategy for intensification of cow-calf production has generated substantial research interest. Work by Kropp et al. (1973), Holloway et al. (1975) and Wyatt et al. (1976) showed that infusion of Holstein breeding into a Hereford cow herd resulted in increased weaned calf weight.

Information relating to the feedlot performance and carcass traits of the progeny of dairy and dairy x beef crossbred cows is limited. Several workers (Hanke et al., 1964; Burroughs, et al., 1965; Minish, et al., 1966) reported faster but less efficient gains when straightbred dairy calves were compared to British breeds when fed to an equal time or weight end-point. Work by Cole et al. (1964); Minish et al.

(1966); and Garrett (1971) showed that Holstein calves were lower in quality and conformation grade than calves of British breeds when fed to an equal slaughter weight. Dean et al. (1976) reported that the progeny of Hereford and Hereford x Holstein cows gained faster and more efficiently than those of Holstein cows when fed to an equal degree of finish.

The objective of this research was to further determine the feedlot performance and carcass traits of calves with 0, 25 and 50% Holstein breeding when fed to a similar degree of finish.

Materials and Methods

The feedlot performance and carcass characteristics of 217 calves with 0, 25 or 50% Holstein breeding were determined. Calves were from 4- and 5-year-old Hereford, Hereford x Holstein (Crossbred) and Holstein dams, sired by Charolais bulls and produced in two successive years.

Cows and calves were maintained either on tallgrass native range (154 calves) or confined in drylot (63 calves) from birth to weaning. Treatments consisted of two levels of winter supplement (Moderate and High) fed to cows of each breed on range and in drylot. An additional supplement level (Very High) was fed to a group of Holstein cows and resulted in calves produced by cows of seven breed-supplement combinations. Allotment to drylot was made on the basis of calf sex so that a ratio of 3 males:2 females was established within dam breed-treatment combinations each year. Calves were born in December, January and February and weaned at 240$\pm$7 days. Drylot calves were creep-fed while range calves received only grazed forage. Detailed descriptions of management practices and preweaning performance for dams and their calves were reported by Wyatt et al. (1976).

At weaning, calves were fasted for 6 hr, weighed, photographed and vaccinated for blackleg, parainfluenza-3 and infectious bovine rhinotraecheitis. Calves were placed directly into the feedlot at weaning.

Skeletal size was estimated from either 20.3 x 25.4 cm photographs or 5.1 x 5.1 cm slides taken with each calf behind a grid at weaning and prior to slaughter. Height was defined as the distance from hip (tuber coxae) to the floor and length as the horizontal distance from the point of the shoulder (dorsal anterior humerus) to hip. The hip and point of shoulder were marked with contrasting chalk prior to photographing to facilitate more accurate measurements.

Calves from drylot cows were individually-fed ad libitum in box stalls from 4 p.m. to 8 a.m. and placed as a group in an outside loafing area for the remainder of the day. Calves from range cows were group-fed ab libitum in a bar with a covered feeding area and an outside loafing area.

Group-fed calves received a 75% concentrate diet shown in table 4.1. Individually fed calves received a 92% concentrate, whole corn based diet shown in table 4.2.

Each calf was fed to an estimated quality grade of low choice based on subjective evaluation of apparent fattness. Final weights and photographs were taken after a 12 hr fast.

Group-fed calves were slaughtered in a commercial packing plant and chilled for 72 hr before quality grade, marbling score, maturity, conformation score and kidney, heart and pelvic (KHP) fat were estimated

TABLE 4.1. RATION COMPOSITION FOR GROUP-FED CALVES

Ingredient	International Reference No. (IRN)	Unit	Amount
Ground corn	4-04-992	%	60.2
Cottonseed hulls	1-01-599	%	15.0
Alfalfa hay	1-00-108	%	10.0
Cottonseed meal	5-01-621	%	8.0
Sugarcane molasses	4-04-696	%	5.0
Urea, mn 45% nitrogen	5-05-070	%	1.0
Calcium phosphate, dibasic	6-01-080	%	.5
Salt, NaCl	6-04-152		.3
Chlortetracycline	8-01-224	mg/kg	15.0
Vitamin A		IU/kg	6795.8

TABLE 4.2. RATION COMPOSITION FOR INDIVIDUALLY-FED CALVES

Ingredient	International Reference No. (IRN)	Unit	Amount
Whole corn	4-02-992	%	87.0
Cottonseed hulls	1-01-599	%	5.0
Supplement, pelleted			
Composition of Supplement			
Soybean meal	5-04-612	%	50.0
Urea, mn 45% nitrogen	5-05-070	%	10.0
Cottonseed meal	5-01-621	%	19.8
Wheat middlings	4-05-205	%	3.5
Salt, NaCl	6-01-080	%	4.5
Potassium chloride, KCl	6-03-756	%	3.3
Calcium carbonate, $CaCO_3$	6-01-069	%	7.5
Trace mineral		%	.64
Chlortetracycline	8-01-224	mg/kg	105.0
Vitamin A		IU/kg	3400.0

by a U.S.D.A. grader. Individually-fed calves were slaughtered at the Oklahoma State University Meat Laboratory and were evaluated in the carcass by a staff member. Rib eye area (REA) and back fat thickness were measured from a tracing at the 12th-13th rib separation on each carcass. Carcass grades were based on the Official U. S. Standards for Grades of Carcass Beef (1973). Cutability was predicted as described by Murphey et al. (1960).

Since a least squares analysis using breed of dam, supplement level of dam and sex of calf showed no evidence (P>.10) that dam's supplement level affected postweaning feedlot performance or carcass traits of calves and no sex x supplement level of dam, sex x breed x supplement level of dam interactions were found (P>.05), a second analysis was conducted pooling across supplement levels within breed of dam. The second least squares analysis was conducted using breed, sex and year as classification factors. Since no breed x sex, year x sex or breed x year x sex interactions were observed (P>.05), breed means were obtained by averaging across year and sex. The location of breed differences was determined using the t-test (Snedecor and Cochran, 1967).

Results and Discussion

Feedlot Performance. Feedlot performance of group-fed and individually-fed calves is summarized in table 4.3 and 4.4, respectively. As the percentage of Holstein breeding increased, the initial weight (weaning weight) increased (P<.05) among both group and individually-fed calves. Crossbred progeny (calves from crossbred dams) and Holstein progeny (calves from Holstein cows) averaged 30 and 55 kg heavier initial weights than Hereford progeny (calves from Hereford

TABLE 4.3. EFFECT OF BREED OF DAM ON FEEDLOT PERFORMANCE OF GROUP-FED CALVES SIRED BY CHAROLAIS BULLS, AVERAGE OF TWO YEARS

Item	Breed of dam: Hereford	Hereford x Holstein	Holstein	SE[a]
Initial wt, kg[b]	258[d]	286[e]	313[f]	3.42
Slaughter wt, kg	455[d]	495[e]	550[f]	7.18
Age at slaughter, days[c]	432[d]	449[e]	476[f]	5.55
Days fed	192[d]	209[e]	236[f]	5.55
Daily gain, kg	1.05	1.01	1.03	.03
Daily feed intake, kg	8.9	9.3	11.0	
Total feed intake, kg	1703	1935	2592	
Kg feed/ kg gain	8.45	9.17	10.66	
Skeletal size				
Initial height, cm	100.3[d]	104.9[e]	109.8[f]	.49
Initial length, cm	71.2[d]	72.4[d,e]	74.4[e]	.66
Slaughter height, cm	118.5[d]	120.1[d]	126.1[e]	.94
Slaughter length, cm	82.8[d]	85.5[e]	93.3[f]	.90

[a]Standard errors are approximate due to unequal subclass numbers (Range = 50 to 53).

[b]Actual weaning weight.

[c]240 days + average days fed.

[d,e,f]Means on the same line with the same superscript letter are not significantly different ($P < .05$).

TABLE 4.4. EFFECT OF BREED OF DAM ON FEEDLOT PERFORMANCE OF INDIVIDUALLY-FED CALVES SIRED BY CHAROLAIS BULLS, AVERAGE OF TWO YEARS

	Breed of dam			
Item	Hereford	Hereford x Holstein	Holstein	SE[a]
Initial wt, kg[b]	255[d]	286[e]	310[f]	4.43
Slaughter wt, kg	446[d]	503[e]	558[f]	9.19
Age at slaughter, days[c]	402[d]	460[e]	486[f]	7.33
Days fed	162[d]	220[e]	246[f]	7.33
Daily gain, kg	1.20[e]	1.00[d]	1.02[d]	.04
Daily feed intake, kg	8.1[d]	8.2[d]	9.1[e]	.23
Total feed intake, kg	1321[d]	1793[e]	2232[f]	70.00
Kg feed/kg gain	6.88[d]	8.26[e]	9.04[f]	.21
Skeletal size				
Initial height, cm	103.6[d]	107.4[e]	110.8[f]	.56
Initial length, cm	67.4[d]	69.4[d]	73.5[e]	1.07
Slaughter height, cm	112.8[d]	119.1[e]	124.8[f]	1.80
Slaughter length, cm	81.3[d]	83.3[e]	87.1[f]	1.30

[a]Standard errors are approximate due to unequal subclass numbers (Range = 18 to 26).

[b]Actual weaning weight.

[c]240 days + average days fed.

[d,e,f]Means on the same line with the same superscript letter are not significantly different ($P<.05$).

dams). Heavier initial weights were a reflection of the higher preweaning milk intakes and larger mature size as Holstein breeding increased (Wyatt et al., 1976).

Slaughter weight trends were similar to those for initial weight. As percentage of Holstein breeding increased, slaughter weight increased ($P<.05$) among both group and individually fed calves. Crossbred and Holstein progeny was 49 and 104 kg heavier at slaughter than Herefords These observations are consistent with those reported by Dean et al. (1976a) for calves of similar breed composition and reflect the increased age at slaughter and longer feeding period as Holstein breeding increased.

As the percentage of Holstein breeding increased, the number of days on feed required to reach the estimated low choice carcass grade increased ($P<.05$). Since all calves were placed on feed at 240 ± 7 days, longer feeding period resulted in comparable increases in age at slaughter.

Among group-fed calves, breed of dam did not affect ($P>.50$) average daily gain. However, among individually-fed calves Hereford progeny gained .20 and .18 kg daily faster ($P<.05$) than those of Crossbred or Holstein dams. In a similar study, Dean et al. (1976a) reported faster gains for Hereford progeny than those of Holsteins. These data are in contrast to those of Cole et al. (1964), Hanke et al. (1964), Burroughs et al. (1965) and Minish et al. (1966) who reported faster gains for straightbred Holstein than Herefords when fed to a weight or time equal basis. Growth trials based on time or weight equal end-points favor later maturing Holsteins over the smaller, earlier maturing Herefords. In experiments reported in this paper and those reported by Dean et al. (1976a), calves were fed from an equal initial age to a similar degree of fatness at slaughter.

Statistical analysis of feed intake and efficiency was appropriate only for individually-fed calves. Among group-fed calves, there was a trend toward increased feed intake (daily and total) and poorer feed efficiency (more feed/gain) as Holstein breeding increased. Among individually-fed calves, Holstein progeny consumed 1.0 and .9 kg more ($P<.05$) daily feed than Hereford and Crossbred progeny. Daily feed intake was similar ($P>.50$) for Hereford and Crossbred progeny. Total feed consumed during the feeding period increased ($P<.05$) as Holstein breeding increased. Feed required per gain among individually-fed calves decreased ($P<.05$) with incremental increases in Holstein breeding. These observations are consistent with those previously reported by Dean et al. (1976).

Initial skeletal measurements indicated that Holstein progeny was taller ($P<.05$) and longer ($P<.05$) than Hereford progeny. Crossbred progeny was intermediate in height and length between Hereford and Holstein progeny. Crossbred progeny was taller ($P<.05$) but not significantly ($P>.20$) longer than Hereford progeny.

At slaughter, Holstein progeny averaged 9 cm taller ($P<.05$) and 8 cm longer ($P<.05$) than Hereford progeny. Crossbred progeny was again intermediate in height and length but apparent differences in slaughter height between Crossbred and Hereford progeny were significant ($P<.05$) only among individually-fed calves.

Carcass Traits. Carcass traits of group-fed and individually-fed calves are summarized in tables 4.5 and 4.6, respectively. Carcass

TABLE 4.5. EFFECT OF BREED OF DAM ON CARCASS TRAITS OF GROUP-FED CALVES SIRED BY CHAROLAIS BULLS, AVERAGE OF TWO YEARS

	Breed of dam			
Item	Hereford	Hereford x Holstein	Holstein	SE
Hot carcass wt, kg	281^{f}	308^{g}	349^{h}	4.39
Carcass wt/day of age, kg	$.66^{f}$	$.69^{f,g}$	$.73^{g}$	.01
Rib eye area, cm^2	76.1^{f}	80.4^{g}	81.1^{g}	1.18
REA/100 kg carcass, cm	27.3^{g}	26.2^{g}	23.3^{f}	.34
Fat thickness[b], cm	1.79	1.77	1.74	.06
Fat thickness/100 kg carcass[b], cm	$.63^{g}$	$.58^{g}$	$.50^{f}$	.02
KHP fat[c], %	3.42^{g}	3.15^{f}	$3.27^{f,g}$	.07
KHP fat/100 kg carcass[c], %	1.14	1.03	.94	.02
Cutability, %	48.8	48.7	48.1	.23
Conformation score[d]	11.5^{g}	$11.0^{f,g}$	10.6^{f}	.24
Marbling score[e]	12.2^{f}	12.5^{f}	14.3^{g}	.42
Carcass grade[d]	8.9^{f}	9.1^{f}	9.7^{g}	.18

[a]Standard errors are approximate due to unequal subclass numbers (Range = 43 to 53).

[b]Average of three measurements taken 1/4, 1/2 and 3/4 length of the longissiums dorsi muscle of the 12th-13th rib separation.

[c]Kidney, heart and pelvic fat.

[d]9 = high good, 10 = low choice, 11 = average choice.

[e]12 = slight +, 13 = small -, 14 = small, 15 = small +.

[f,g,h]Means on the same line with the same superscript letter are not significantly different (P>.05).

TABLE 4.6. EFFECT OF BREED OF DAM ON CARCASS TRAITS OF INDIVIDUALLY-FED CALVES SIRED BY CHAROLAIS BULLS, AVERAGE OF TWO YEARS

Item	Breed of dam: Hereford	Hereford x Holstein	Holstein	SE[a]
Hot carcass wt, kg	274[f]	315[g]	346[h]	5.98
Carcass wt/day of age, kg	0.68	0.69	0.72	.01
Rib eye area, cm^2	77.4	81.7	80.3	1.74
REA/100 kg carcass, cm	28.4[h]	26.1[g]	23.2[f]	.68
Fat thickness[b], cm	1.42[f]	1.80[g]	1.54[f]	.08
Fat thickness/100 kg carcass[b], cm	0.52[f,g]	0.57[g]	0.45[f]	.03
KHP fat[c], %	3.14[f]	3.32[f,g]	3.64[g]	.15
KHP fat/100 kg carcass[c], %	1.15	1.07	1.07	.05
Cutability, %	49.8[g]	48.5[f]	47.8[f]	.40
Conformation score[d]	10.9[g]	10.4[g]	9.3[f]	.22
Marbling score[e]	14.6	14.5	14.4	.50
Carcass grade[d]	10.1	10.1	10.1	.21

[a]Standard errors are approximate due to unequal subclass numbers (Range = 15 to 26).

[b]Average of three measurements taken 1/4, 1/2 and 3/4 length of the longissimus dorsi muscle at the 12th to 13th rib separation.

[c]Kidney, heart and pelvic fat.

[d]9 = high good, 10 = low choice, 11 = average choice.

[e]12 = slight +, 13 = small -, 14 = small, 15 = small +.

[f,g,h]Means on the same line with the same superscript letter are not significantly different (P<.05).

weight increased (P<.05) with incremental increases of Holstein breeding. Crossbred and Holstein progeny produced carcasses 33 and 70 kg heavier than those of Hereford contemporaries. These observations are consistent with those reported by Dean et al. (1976b) and are a reflection of the larger mature size and longer feeding period as Holstein breeding increased.

Carcass weight per day of age tended to increase as Holstein breeding increased. However, apparent differences were significant (P<.05) only among group-fed calves where Holstein progeny produced 0.07 kg more carcass weight daily than Hereford progeny.

Group-fed Holstein and Crossbred progeny produced carcasses with 5.0 and 4.3 cm^2 larger (P<.05) REAs than Herefords. A similar trend was evident among individually fed calves although differences were not significant (P>.27). The superiority of Hereford progeny for muscling was apparent when REA was expressed per 100 kg of carcass weight. On this basis, REA/100 kg of carcass weight decreased (P<.05) with each increment of increased Holstein breeding. These observations are in agreement with other reported comparisons between British and Holstein breeds (Cole et al., 1964; Judge et al., 1965; Minish et al., 1966; Wellington, 1971; and Dean et al., 1976b).

External fatness was one of the criteria used to estimate carcass grade of the live animal and subsequently determine the time of slaughter. Therefore, some control was exercised over fat thickness in the carcass. Among group-fed calves, fat thickness did not differ (P>.89) due to breed of dam. Among individually-fed calves, Crossbred progeny were fatter (P<.05) than Hereford or Holstein progeny.

Kidney-heard and pelvic fat did not show a consistent trend due to breed of dam. Among group-fed calves, Hereford progeny had a lower (P<.05) percentage of KHP fat thatn Crossbred progeny with Holsteins intermediate. Among individually fed calves, Hereford progeny had a lower (P<.05) percentage of KHP fat than Holstein with Crossbred progeny being intermediate.

Cutability tended to decrease as percentage of Holstein breeding increased. However, apparent differences in cutability were significant (P<.05) only among individually-fed calves where Hereford progeny were 1.3 and 2.0% higher than Crossbreds and Holsteins. These observations are in contrast to previous data reported by Hanke et al. (1964), Burroughs et al. (1965), Larson et al. (1966) and Minish et al. (1966) who reported higher cutabilities for Holsteins compared to British breeds when fed to a time or weight equal end-point. The later maturing Holsteins would have a predictably higher cutability, when compared on this basis, due to their younger physiological age and lower fatness.

Conformation score tended to decrease as Holstein breeding increased. Group-fed Hereford progeny had higher (P<.05) conformation scores than Holstein progeny with Crossbreds being intermediate and not significantly (P<.05) different from Hereford or Holstein progeny. Among individually fed calves, Hereford and Crossbred progeny had higher (P<.05) conformation scores than Holsteins. Similar findings were previously reported by Minish et al. (1966), Garrett (1971), Larson et al. (1966) and Dean et al. (1976b).

Among group-fed calves, Holstein progeny was higher (P<.05) in marbling score and carcass grade than Hereford or Crossbred progeny. Marbling score and carcass grade was not affected (P>.94) by breed of dam among individuall-fed calves. Higher marbling scores and carcass grades with increased Holstein breeding was previously reported by Dean et al. (1976b).

Data presented herein suggest that longer feeding periods and decreased feed efficiency may adversely affect the profitability of feeding calves with high percentages of Holstein breeding compared to beef breeds when fed to an equal carcass grade. Calves of 25 or 50% Holstein breeding will yield carcasses of comparable quality to beef calves when fed to an equivalent compositional end-point. However, Holstein crossbred progeny will produce larger carcasses which may be difficult to merchandise.

CHAPTER 5

EFFECT OF MILK LEVEL AND BIOLOGICAL TYPE ON CALF GROWTH AND PERFORMANCE[1,2,3]

Summary

The effect of two levels of milk intake on the performance of calves of two biological types was determined. The experimental design was effected by breeding Hereford cows to Angus bulls and Holstein cows to Charolais bulls, followed by reciprocal cross-fostering of about one-half of the calves of each group.

The high level of milk consumption (produced by Holsteins) among AxH calves resulted in increased ($P<.05$) weaning weights by 20 and 19% on range and in drylot. Among CxH calves, the high level of milk consumption resulted in increased ($P<.05$) weaning weights by 23 and 22% on range and in drylot. Increasing the level of milk intake from 4.8 - 5.5 to 9.8 - 11.0 kg per day resulted in a reduction of the apparent efficiency of conversion of milk to calf gain of 51 to 72%.

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[1]Journal article of the Agriculture Experiment Station, Oklahoma State University, Stillwater.

[2]R. D. Wyatt, M. B. Gould, J. V. Whiteman and Robert Totusek, Oklahoma State University, Stillwater.

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Relative forage intake was reduced (P<.05) 32 and 38% in AxH and CxH calves on high levels of milk intake in early summer (May). In late summer (August) forage intake was reduced (P<.05) 29% in AxH calves on the high milk intake level, but forage intake was not affected (P>.50) by level of milk intake in CxH calves.

Level of milk intake did not affect (P>.50) energetic efficiency (DE/kg gain) among AxH calves in drylot. CxH calves consuming the low milk level required 8.5% less (P<.05) DE per kg gain than calves at the high milk level.

Introduction

Several workers (Knapp and Black, 1941; Gifford, 1953; Drewry et al., 1959; Neville et al., 1960; Velasco, 1962; Totusek and Arnett, 1965) have reported correlations ranging from .40 - .88 between level of milk consumption and weight gain among calves.

Research at this station (Deutscher and Whiteman, 1971; Kropp et al., 1973; Holloway et al., Wyatt et al., 1975) has shown that introduction of germ plasm from dairy breeds into beef cow herds results in increased milk production and heavier calf weaning weights. However, the effects of level of milk consumption and genetic potential for growth were confounded in these studies since milk consumption levels did not vary greatly among calves of similar genetic composition. Data relative to the effect of milk level upon calf performance and production efficiency within various calf types is limited (Neville et al., 1952).

The purpose of this experiment was to determine the effects of two widely differing milk levels upon the performance and productive efficiency of calves of two biological types.

Materials and Methods

Forty Hereford and 41 Holstein cows were used in a system devised to expose calves of two biological types to a low (Hereford) or high (Holstein) level of milk. Two distinct biological calf types were produced by breeding Hereford cows to Angus bulls and Holstein cows to Charolais bulls.

The experimental design was accomplished by using a reciprocal cross-fostering scheme in which about one-half of the calves born to Hereford dams (AxH) were reared by Holstein cows and conversely, one half of the calves born to Holstein dams (CxH) were reared by Hereford cows. Thus, within each biological calf type (AxH and CxH) some calves received a low milk level (4.8-5.5 kg/day) while others received a high level of milk (9.8-11.0 kg/day).

Calves were cross-fostered within 12 hr after birth. Scheduling of the cross-fostering program was facilitated by induction of parturition in some cows with 40 mg dexamethazone (Axium[4]) within 10 days previous to projected calving date.

All cows were 6-year-olds producing their fifth calves and calved during the months of December, January and February. Calves were weaned at 240 ± 7 days and placed directly into the feedlot. Heifer weaning weights were adjusted to a steer equivalent using a factor of 1.05 (Smithson, 1966).

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[1]Azium brand, Schering Corporation, Bloomfield, New Jersey 07003.

Cow-calf pairs were maintained either on tallgrass native range or in a completely confined drylot system (cows and calves individually fed) at the Southwestern Livestock and Forage Research Station (El Reno).

A winter supplement (30% all-natural crude protein) was fed to cows from December 2, 1974 to April 17, 1975 during forage dormancy. Postpartum supplement levels of 1.3 and 2.19 kg/daily for Hereford and Holstein cows, respectively, were based on results of earlier work with these cows (Kropp et al., 1973; Holloway et al., 1975; Wyatt et al., 1976).

Each of the four treatment groups was maintained in a separate pen in drylot. The drylot forage feeding regime for cows consisted of cottonseed hulls (IRN 1-01-599) during the winter to mid-April, then alfalfa hay (IRN 1-00-063) to weaning.

Forage was individually fed to cows ad libitum during a four-hour period each day. Drylot calves were fed a creep ration ad libitum in individual pens while their dams were being fed. The pelleted creep ration consisted of (%): corn, IRN 4-02-931, 49.5; alfalfa hay, 15; cottonseed hulls, 10; soybean meal, IRN 5-04-612, 17.5; sugarcane molasses, IRN 4-04-696, 5; wheat midds, IRN 4-05-205, 3. Range calves were not creep-fed.

Forage intake by range calves was estimated in May and August; lush vegetation was available in ample quantity during both trials. Relative forage intake by calves was estimated using chromium sesquioxide as an external indicator. The chromium sesquioxide was administered at 8:00 AM and 4:00 PM by gelatin bolus during the 7-day preliminary and 7-day collection periods. Fecal samples were obtained by rectal grab at the time of indicator administration. Fecal samples were dryed at 60°C, prepared by the method of Williams et al. (1962) and analyzed for chromium content by atomic absorption spectroscopy.

Estimates of 24-hr milk consumption by calves were made at seven monthly intervals using the calf-suckle technique. Each estimate represented the cumulative total milk consumed during four consecutive determinations made after 6-hr periods of separation of calves from their dams.

Estimated digestible energy (DE) and digestible protein (DP) intake by cows and calves in drylot were calculated from tabular data (Crampton and Harris, 1969).

The data were treated statistically as a 2^2 factorial arrangement of treatments. Statistical analyses were effected using a least squares analysis of variance employing the Statistical Analysis System designed by Barr and Goodnight (1972). A t-test was used to determine the location of calf breed and milk level effects (Snedecor and Cochran, 1967).

The comparison of range and drylot management systems was not an objective of the research; therefore, management system was not included in the model and a comparison of management systems was not made.

Results and Discussion

Calf Performance. The performance of AxH and CxH calves consuming low and high milk levels is summarized in table 5.1 AxH calves on high milk consumed more ($P<.05$) milk, were heavier ($P<.05$) at weaning and gained faster ($P<.05$) than calves on low milk. Range AxH calves on

TABLE 5.1. EFFECT OF MILK LEVEL AND BIOLOGICAL TYPE ON CALF PERFORMANCE

Item	Breed of calf and level of milk: Angus x Hereford, Low	Angus x Hereford, High	Charolais x Holstein, Low	Charolais x Holstein, High	SE
Range					
Number of calves	13	9	9	14	
Daily milk consumption, kg	5.5[e]	11.0[f]	4.8[e]	10.1[f]	.46
Birth weight, kg	30.5[e]	30.3[e]	39.7[f]	47.1[g]	1.44
Weaning weight,[a] kg	232[e]	279[g]	255[f]	313[h]	6.10
Daily gain,[b] kg	.84[e]	1.04[f]	.90[e]	1.11[f]	.30
Conformation score[c]	12.7[e,f]	12.8[e,f]	12.0[e]	13.4[f]	.40
Condition score[d]	5.6[f]	6.9[g]	4.5[e]	4.9[e]	.28
Drylot					
Number of calves	9	9	9	9	
Daily milk consumption, kg	5.2[e]	9.8[f]	5.2[e]	10.2[f]	.39
Birth weight, kg	30.2[e]	32.3[e]	44.4[f]	42.1[f]	1.42
Weaning weight,[a] kg	226[e]	270[f]	245[g]	298[h]	7.19
Daily gain,[b] kg	.82[e]	1.00[f]	.84[e]	1.07[g]	.03
Conformation score[c]	11.9	11.9	11.7	11.8	.40
Condition score[d]	5.6[g]	7.0[h]	3.9[e]	4.7[f]	.18

[a]Adjusted to 240-day, steer basis.

[b]Birth to weaning.

[c]12=low choice, 13=average choice, 14=high choice.

[d]1=very thing, 9=very fat.

[e,f,g,h]Means on the same line without a common superscript are significantly different (P<.05).

high milk consumed 5.5 kg more milk daily and were 47 kg heavier at weaning than calves on low milk. This represents a 20% increase in weaning weight. Drylot AxH calves on the high milk level consumed 4.6 kg more milk daily and were 44 kg heavier at weaning than their counterparts on low milk, representing a 19% increase in weaned calf weight. The apparent fatness (condition score) of AxH calves on high milk was greater ($P<.05$) both on range and in drylot.

CxH calves on high milk consumed more ($P<.05$) milk, were heavier ($P<.05$) at weaning and gained faster ($P<.05$) than calves on the low milk level both on range and in drylot. Drylot calves on high milk had higher ($P<.05$) condition scores at weaning than calves on low milk. This effect was not evident ($P>.20$) among CxH calves on range. Range CxH calves on high milk consumed 5.3 kg more milk daily and were 58 kg heavier at weaning, a 23% increase in weaned calf weight. Drylot CxH calves on high milk consumed 5.0 kg more milk daily and were 53 kg heavier at weaning than those on low milk. This represents a 22% increase in calf weaning weight.

At the high milk level, AxH and CxH consumed similar amounts (10.4 vs 10.2 kg) of milk. Thus, it appears that the potential growth rate of calves had little effect on milk intake in this study. This is in contrast to earlier data reported by Cole and Johansson (1933), Gifford (1953) and Schwulst et al. (1966) which suggested that the calf's capacity for milk might be a limiting factor in milk production by the dam. The upper range in milk consumption observed in these trials should include levels which would be encountered under most range beef cattle production situations.

The advantage in growth rate for calves receiving the high milk level is in agreement with data reported by Neville et al. (1952). It is interesting to note that at low milk intake, the advantage in growth rate of the larger CxH calves was not great (.84 vs .90 kg/day on range; .82 vs .84 kg/day in drylot). This would suggest that much of the observed increase in growth rate among calves of the larger, later maturing breeds may be associated with higher milk production by the cows of those breeds rather than superior genetic potential for growth within the breed.

Structural Growth. The effects of milk level and biological type on structural growth of calves are summarized in table 5.2. At birth, AxH calves were shorter in height ($P<.05$) at the withers and length ($P<.05$) measured from the point of the shoulder (Proximal humerus) to the hook bone (Tuber coxae) than CxH's both on range and in drylot. This is consistent with the earlier maturity and smaller mature size of calves of this biological type. Range CxH calves assigned to low milk were shorter ($P<.05$) in height and length at birth than their counterparts on high milk. This is consistent with the lighter birth weight of these calves (table 5.1) and may be due to a shorter gestation period among cows in which parturition was induced.

Range AxH calves receiving high milk tended to be taller and longer at weaning, however, apparent differences were not significant ($P>.20$). In drylot, AxH calves on high milk were 6 cm taller ($P<.05$) and 7.3 cm longer ($P<.05$) at weaning due to greater increase in height ($P<.05$) and length ($P<.05$) from birth to weaning than calves on low milk.

TABLE 5.2. EFFECT OF MILK LEVEL AND BIOLOGICAL TYPE ON STRUCTURAL GROWTH BY CALVES

Item	Breed of calf and level of milk				SE
	Angus x Hereford		Charolais x Holstein		
	Low	High	Low	High	
Range					
Height at birth, cm	67.6[a]	68.3[a]	75.4[b]	78.2[c]	.89
Height at weaning, cm	96.8[a]	99.3[a,b]	104.4[b]	113.3[c]	1.78
Increase in height, cm	29.2[a]	31.0[a,b]	29.0[a]	35.1[b]	1.83
Length at birth, cm	43.9[a]	43.2[a]	47.0[b]	49.8[c]	.84
Length at weaning, cm	73.4[a]	77.2[a]	78.7[a]	88.1[b]	1.88
Increase in length, cm	29.5[a]	34.0[a]	31.7[a]	38.3[b]	1.98
Drylot					
Height at birth, cm	67.0[a]	67.9[a]	76.9[b]	77.4[b]	.96
Height at weaning, cm	97.7[a]	103.7[b]	107.7[b,c]	110.6[c]	1.89
Increase in height, cm	30.7[a]	35.8[b]	30.8[a]	33.2[a,b]	1.98
Length at birth, cm	44.2[a]	42.9[a]	50.5[b]	49.9[b]	.89
Length at weaning, cm	70.7[a]	78.0[b]	78.2[b]	85.9[c]	2.60
Increasing in length, cm	26.5[a]	35.1[b]	27.7[a]	36.0[b]	2.74

[a,b,c]Means on the same line without a common superscript are significantly different ($P < .05$).

Among range CxH calves, those on high milk increased more in height ($P<.05$) and length ($P<.05$) from birth to weaning than those on low milk. In drylot, CxH calves on high milk increased more in length ($P<.05$) from birth to weaning and were longer ($P<.05$) at weaning than calves on low milk. However, apparent differences in height at weaning and increased height from birth to weaning were not significant ($P>.20$).

Forage Intake. Increasing milk intake by calves of both biological types resulted in a reduction in relative forage intake ($P<.05$) during the May intake trial (table 5.3). AxH and CxH calves on high milk consumed 32 and 38% less forage dry matter than their counterparts on the low levels, in agreement with Lusby (1974). During the August intake trial, AxH calves on high milk consumed 29% less forage ($P<.05$) than those on low milk while milk intake had little affect on forage intake ($P>.50$) by CxH calves. Apparently the larger CxH calves were able to consume more milk without decreasing forage intake as they approached weaning age. This resulted in a significant ($P<.01$) milk level x calf type interaction during the August intake trial.

Calf Efficiency. Among calves on range, as milk consumption and rate of gain increased, the apparent efficiency with which milk was utilized for gain decreased. Range AxH calves receiving high milk required 4.1 kg more milk ($P<.05$) per kilogram gain (table 5.4; 10.6 - 6.5 = 4.1). This represents a 63% decrease in efficiency of milk utilization by calves at the higher intake level. An additional 27.6 kg of milk was required to produce an additional kilogram of gain above that of calves receiving the low level. Range CxH calves consuming the high

TABLE 5.3. EFFECT OF MILK LEVEL AND BIOLOGICAL TYPE ON RELATIVE FORAGE INTAKE BY CALVES

Item	Breed of calf and level of milk				SE
	Angus x Hereford		Charolais x Holstein		
	Low	High	Low	High	
Trial 1 (May)					
Forage dry matter intake, kg	2.2^{a}	1.5^{b}	2.6^{a}	1.6^{b}	.15
% of low AXH	100	68	118	73	
Trial 2 (August)					
Forage dry matter intake, kg	4.5^{a}	3.2^{b}	5.0^{a}	4.8^{a}	.29
% of low AXH	100	71	111	107	

[a,b]Means on the same line without a common superscript are significantly different ($P<.05$).

TABLE 5.4. EFFECT OF MILK LEVEL AND BIOLOGICAL TYPE ON CALF EFFICIENCY

Item	Breed of calf and level of milk				SE
	Angus x Hereford		Charolais x Holstein		
	Low	High	Low	High	
Range					
Milk per kg gain,[a] kg	6.5[d]	10.6[f]	5.3[c]	9.1[e]	.53
Additional milk per kg additional gain,[b] kg		27.6		25.7	
Drylot					
Total creep intake, kg	397.8[e]	293.5[c]	364.5[e]	347.9[d]	21.56
Daily creep intake, kg	1.66[e]	1.23[c]	1.53[e]	1.45[d]	.09
Daily creep DE intake, Mcal	5.12[e]	3.80[c]	4.70[e]	4.47[d]	.27
Daily milk DE intake, Mcal	3.59[c]	6.79[d]	3.63[c]	7.06[d]	.27
Total daily DE intake, Mcal	8.71[c]	10.58[d]	8.33[c]	11.53[e]	.35
Total daily DP intake, kg	.37[c]	.47[d]	.36[c]	.51[e]	.02
Milk per kg gain,[a] kg	6.5[c]	10.1[d]	6.5[c]	9.8[d]	.37
Additional milk per kg additional gain,[b] kg		26.3		21.7	
DE per kg gain,[a] Mcal	10.9[d]	10.97[d]	10.22[c]	11.09[d]	.24

[a]Gain from birth to weaning.

[b]Additional milk per kg additional $= \frac{\text{gain on high milk level-gain on low milk level.}}{\text{milk on high level - milk on low level}}$

[c,d,e,f]Means on the same line without a common superscript are significantly different ($P<.05$).

milk level required 3.8 kg more milk (P<.05) per kilogram gain compared to calves receiving the low milk level. This represents a 72% decrease in efficiency of utilization of milk compared to calves receiving low milk. An additional 25.7 kg of milk was required to produce an additional kilogram of weaned weight. The lower apparent efficiencies of milk utilization by calves on high milk levels is the result of the substitution of milk (which has a lower energy density) for grass. The expression of efficiency as the function of a single input gives limited insight into the more compelling question of total energetic efficiency which can be more appropriately evaluated in drylot.

The drylot management system provided a more precise evaluation of the relationships between milk level and calf type with regard to productive efficiency. AxH calves in drylot receiving high milk consumed 26% less (P<.05) creep feed than calves on the low level (table 5.4). Calves receiving high milk consumed 89% more milk DE (P<.05), 21% more total DE (P<.05), 27% more total DP (P<.05), and 26% less (P<.05) creep DE than calves on the low milk level. Calves receiving high milk consumed 3.6 kg more (P<.05) milk per kilogram gain than calves on the low milk level representing a 55% decrease in efficiency. An additional 26.3 kg of milk was required to produce an additional kilogram gain above that of calves receiving the low milk level. Level of milk intake did not affect (P>.50) the estimated DE required per kilogram gain in AxH calves.

CxH calves in drylot receiving high milk consumed 94% more milk DE (P<.05), 38% more total DE (P<.05) and 42% more total DP (P<.05) than calves on the low milk level. Apparent differences in total creep intake and daily creep DE between calves on the high and low milk levels were not significant (P>.50) but followed trends similar to those of AxH calves. Calves receiving the high milk level consumed 3.3 kg more (P<.05) milk per kilogram gain than calves on the low milk level representing a 51% decrease in efficiency. An additional 21.7 kg of milk was required to produce an additional kilogram of gain above that of calves receiving the low milk level. CxH calves receiving the high milk level required more (P<.05) DE per kilogram than calves on the low level.

In drylot, calf type x milk level interactions were noted for total creep (P<.05), daily creep (P<.05), daily creep DE (P<.05), total daily DE (P<.07), total daily DP (P<.09) intakes and DE per kilogram gain (P<.09).

The reasons for the greater energetic efficiency of CxH calves on the low milk level are obscure. An obvious potential explanation is that the lower energetic efficiency of CxH calves on the high milk level is a reflection of the more extensive fat deposition by calves on that milk level and fat deposition is an energetically expensive process. The apparent fatness of calves on the high milk level was greater than that of calves on the low milk level (table 5.1). However, similar differences in apparent fatness were observed between CxH calves on the two milk levels and no effects on energetic efficiency were observed. A more extensive characterization of body composition at weaning might have produced additional insight into the relationships between milk level and energetic efficiency.

The average daily DE intake by Hereford and Holstein cows in drylot was 25.46 and 35.75 Mcal, respectively. If one assumes that 1.23 Mcal DE is required per kilogram of milk produced (NRC, 1976) it is possible to project the theoretical energy requirement of these cows at different levels of milk yields (table 5.5). On this basis a Hereford cow producing 9.8 kg of milk (high level) would require about 31.11 Mcal DE daily while a Holstein cow producing only 5.2 kg of milk (low level) would require about 29.60 Mcal DE daily. Using these values, it is possible to estimate the total DE (cow and calf) required as feed inputs (cow forage and supplement and calf creep) per kilogram of calf gain. These calculations indicate that the total DE requirement per kilogram of calf gain is lower at high milk levels among both cow types. This apparently results from the stimulating affect of high milk level upon DE intake of the calf (table 5.4) and a greater dilution of the total maintenance requirement. AxH and CxH calves in drylot consumed 21 and 38% more total daily DE (P<.05), respectively, when consuming the high milk level compared to calves on low milk. The lower efficiency of Holstein cows compared to Herefords is consistent with the larger size and maintenance requirement of these cows. The calculated energetic efficiency of cow-calf systems at the high milk levels is 7.19% greater than that for the low milk levels. Increasing milk yield among cows may result in an increased energetic efficiency but the costs of providing the additional DE required by the high milking cows may limit the economy of this strategy for intensification.

Data reported here indicate that increasing the level of milk consumption among calves is an effective means of increasing calf growth from birth to weaning and is an energetically efficient process. It is important to note, however, that increasing milk intake results in a reduction in consumption of non-milk inputs (forage or creep) by the

TABLE 5.5 PROJECTED ENERGETIC EFFICIENCY OF HEREFORD AND HOLSTEIN COWS AT TWO MILK LEVELS

	Breed of cow and level of milk			
	Hereford		Holstein	
Item	Low	High	Low	High
Daily DE intake by cow,[a] Mcal	25.46	31.11	29.60	35.75
Creep DE intake by calf, Mcal	5.12	3.80	4.70	4.47
Total DE intake, Mcal	30.58	34.91	34.30	40.22
DE per kg gain, Mcal	37.29	34.91	40.83	37.59

[a]Daily DE intake by Hereford cows on the high milk level and Holstein cows on the low milk level were projected assuming 1.23 Mcal DE required per kilogram of milk produced.

calf and an apparent decrease in the efficiency of utilization of milk for additional calf gain.

The economy of increasing milk production in the cow herd as a means of intensification of the cow-calf enterprise will be dictated by the relationships between the resource requirements (and associated costs) of heavier milking cows and the value of additional calf gains.

CHAPTER 6

EFFECTS OF SINGLE VS SIMULATED TWIN REARING ON COW AND CALF PERFORMANCE[1,2,3]

Summary

Forty-six Hereford x Holstein cows were employed to determine the performance of cows and their calves reared as singles or simulated twins. Simulated twins were produced by grafting a second newborn calf onto cows at the time of birth of their natural calf.

Cows rearing simulated twins produced 39% more (P<.05) milk and required 72% more winter supplement to sustain a winter weight loss comparable to cows rearing single calves.

Cows rearing simulated twins had extended postpartum anestrus periods which were apparently due to higher suckling intensities to which they were exposed. Cows rearing simulated twins were nursed more frequently (4.8 vs 3.4 times daily) and for a longer (P<.05) total interval each day (41.9 vs 33.4 min).

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[1]Journal article of the Agriculture Experiment Station, Oklahoma State University, Stillwater.

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Cows rearing simulated twin pairs weaned 60% more total calf weight than cows rearing single calves. Grafted calves nursed less frequently and for a shorter ($P<.05$) total interval daily and were 43 kg lighter at weaning than their natural born mates.

Introduction

The possibility of induced twin conception in beef cows has generated much interest recently. Work at several laboratories (Hammond, 1949; Schilling and Holm, 1963, Turman et al., 1971) has been directed toward gaining a better understanding of the physiological mechanisms involved in twin conception in cattle.

Many problems are intrinsic to induced multiple fetation in the cow (Hafez et al., 1964). However, substantial progress has been made toward the solution of technical problems.

To date, no research has been directed toward defining the relationships between twin rearing, lactation response and nutrient requirements of beef cows or performance of their calves. The purpose of this experiment was to determine the effect of twin rearing upon milk yield, supplemental feed requirements and reproductive performance of Hereford x Holstein cows and the performance of their calves.

Materials and Methods

Forty-six 6-year-old Hereford x Holstein cows were pastured on tallgrass native range at the Southwestern Livestock and Forage Research Station (El Reno). Eighteen of the cows raised natural single calves. Fourteen cows raised a natural calf plus a foster calf which was grafted to her at the time of birth of her natural calf. The remaining 14 cows served as calf donors and were not involved in the experiment subsequent to parturition. Parturition was induced in both donor and simulated twin rearing cows with 40 mg dexamethazone (Azium)[4] to facilitate cross-grafting. Parturition was induced within 10 days of the cows projected calving date based on previous breeding season records. All calves were sired by Angus bulls and were born during December, January and February.

During the winter forage dormancy period, cows were individually fed their allocation of a 30% natural crude protein supplement five times weekly. Supplement was fed during a 137 day period from December 2, 1974 to April 17, 1975. The pelleted supplement was composed of, %: soybean, seed wo hulls, solv-extd grnd, mx 3 fbr, IRN 5-04-612, 60.1; sorghum grain variety, grain, grnd, IRN 4-04-379, 30.3; alfalfa, leaves, dehy, grnd, IRN 1-00-137, 5.0; calcium phosphate, dibasic, comm, IRN 6-01-080; wood, molasses (Masonex)[5], IRN-4-05-502, 1.2; sodium chloride (salt), 15; plus vitamin A added at a level of 33,000 IU/kg. Pre-partum supplement level was .49 kg/hd/day for all cows. Postpartum supplement level for cows rearing single calves was 1.8 kg/day. The supplemental feed requirement of cows rearing simulated twins was estimated by determining the amount of feed required to effect winter weight change patterns similar to those of cows rearing single calves. Cow weights were taken biweekly and appropriate adjustments in supplement feeding levels were made. A body weight loss (including weight loss at parturition) of 20% was projected as desirable for these cows based on earlier

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[4]Azium Brand, Schering Corporation, Bloomfield, New Jersey 07003.

[5]Masonite Corporation, 29 N. Wacker Drive, Chicago, Illinois 60606.

research at this station.

Estimates of 24-hour milk consumption by calves were made at six monthly intervals using the calf-suckle technique. Each estimate represented the cumulative total milk consumed during four consecutive determinations made after 6-hr periods of separation of calves from their dams.

Calves were weaned at 240±7 days of age and weights were adjusted to 240 days. Age-adjusted weaning weights of the heifer calves were corrected to a steer equivalent by multiplying by 1.05 (Smithson, 1966).

Relative forage intake was measured during two intake trials using cows and calves. Forage intake was estimated using chromium sesquioxide as an external indicator. Relative forage intake by cows was measured in March (dormant forage) and May (lush forage). The indicator (16 g/head/day) was incorporated into supplement (March) or ground corn (May: 227g/feeding) and administered at 8:00 a.m. and 4:00 p.m. during a 7-day preliminary and 7-day collection period. Relative forage intake by calves was estimated in May and August. Indicator (8g/head/day) was administered at 8:00 a.m. and 4:00 p.m. by gelatin bolus during the 7-day preliminary and 7-day collection period, dried at 60°C, ground and analyzed for chromium content (Williams et al., 1962). Since a diurnal chromium excretion curve was not established, actual forage intake was not estimated. Values for forage intake serve only as indices of relative forage intake.

Variances of appropriate response variables were estimated by pooling within subclass variance estimates (Snedecor and Cochran, 1967). The location of treatment effects was determined using students "t" test.

Results and Discussion

Cow Performance. Cow performance is summarized in table 6.1. Post-calving supplemental feeding levels were 1.8 and 3.1 kg/day for cow rearing single and simulated twin calves, respectively. These supplemental levels resulted in similar weight losses for cows rearing single and simulated twin calves (94 vs 95 kg) and suggest a substantial (72%) increase in the supplemental feed requirements of cows rearing twins. Weights losses represented 19.0 and 18.6% of the fall weight of cows rearing singles and simulated twins.

Single and simulated twin rearing cows produced 6.6 and 9.2 kg of milk daily. This represents a 39% increase ($P<.01$) in milk yield by simulated twin rearing cows and is consistent with data reported by Gardner and Hogue (1964, 1966) and Alexander and Davies (1959) for ewes. The higher supplemental feed requirements for cows rearing simulated twin calves may be attributed to the nutrient requirements for sustaining a higher level of milk production (Kropp et al., 1973; Holloway et al., 1975).

Apparent differences in relative forage intake (table 6.2) between cows rearing single and simulated twin calves were not significant ($P>.20$) during either the winter (March) or spring (May) intake trials. However, forage intake tended to be higher among cows rearing simulated twins during both trials. These observations are in contrast to those reported by Lusby et al. (1976) in which increasing supplemental feed level resulted in decreased forage intake among cows rearing a single calf. The high nutrient demands to support higher milk production apparently resulted in a maintenance of the level of forage consumption

TABLE 6.1 PERFORMANCE OF COWS REARING SINGLE OR SIMULATED TWIN CALVES

Item	Cows rearing		SE
	Single calves	Twin calves	
Daily winter supplement, post-calving, kg	1.8	3.1	
Fall weight, kg	495	508	12
Spring weight, kg	401	413	10
Winter weight loss, kg	94	95	6.2
Winter weight loss, %	19.0	18.6	1.1
Daily milk yield, kg	6.6[a]	9.2[b]	.3
Calving date	12-29-74	12-27-74	

[a,b]Means on the same line with the same superscript are not significantly different (P>.05).

TABLE 6.2 RELATIVE FORAGE DRY MATTER INTAKE BY GRAZING COWS REARING SINGLE OR SIMULATED TWIN CALVES

Item	Cows rearing		SE
	Singles	Twins	
Trial 1 (March)			
Forage DM intake,[a] kg	14.0	14.9	.6
% of singles	100	107	
Trial 2 (May)			
Forage DM intake,[a] kg	22.6	23.0	1.1
% of singles	100	101	

[a]Forage dry matter (DM) intakes serve as indexes of relative intake rather than estimates of actual forage consumed.

in cows rearing simulated twins in spite of higher supplement intake.

Supplemental feed provided about 76% of the estimated digestible protein requirement of cows rearing a single calf (NRC, 1976). Cows rearing simulated twins and consuming the higher supplement level received about 136% of their estimated digestible protein requirement. Based upon observed differences in milk production (2.6 kg daily), cows rearing simulated twins had a calculated total digestible nutrient requirement 13.4% higher than cows rearing a single calf. Simulated twin rearing cows consumed approximately 12.9% more total digestible nutrients daily as a result of their higher supplement intake (assuming no differences in forage intake).

During the April (trial 1) pasture observations the average calf age was 3.5 to 4.0 months. At this time, cows rearing simulated twin calves were nursed more frequently (table 6.3) and for a longer ($P<.05$) total interval each day (46.1 vs 32.4 min). Interval nursed/nursing was not affected ($P>.50$) by single vs simulated twin rearing. The number of calves nursing concurrently was quite variable among cows rearing simulated twin pairs. Occasionally, as many as four calves nursed simultaneously while at other times cows would be nursed by only one calf. The average number of calves suckled at each nursing was 1.4 in the simulated twin rearing group. Cross-nursing was also frequently observed among cows rearing simulated twins. These phenomena appeared to be quite dependent upon the disposition of the cow. Multiple or cross-nursing was not observed among cows rearing a single calf.

During the August (trial 2) pasture observation, cows rearing simulated twin calves were again nursed more frequently. However, differences in total interval nursed and interval nursed/nursing were

TABLE 6.3 NURSING BEHAVIOR OF COWS REARING SINGLE OR SIMULATED TWIN CALVES

Item	Cows rearing: Single calves	Cows rearing: Twin calves	SE
Trial 1 (April)			
Times nursed/day	3.4	4.1	
Total interval nursed, min.	32.4^{a}	46.1^{b}	3.4
Interval nursed/nursing, min	9.9	9.3	.6
Number of calves nursing concurrently	1.0	1.4	
Trial 2 (August)			
Times nursed/day	3.4	4.4	
Total interval nursed, min	34.4	37.6	4.0
Interval nursed/nursing, min	9.9	8.8	.5
Number of calves nursing concurrently	1.0	1.5	

^{a,b}Means of the same line with the same superscript are not significantly different (P>.05).

were not significant (P>.10). The average number of calves nursing was 1.0 and 1.5 for cows rearing single and simulated twin calves, respectively.

Cows rearing simulated twin calves had longer postpartum anestrus intervals (table 6.4) than those rearing singles. Only 14% of the simulated twin rearing cows displayed an estrus by 60 days postpartum compared to 36% of the cows rearing single calves. By 90 days postpartum, 71% of the cows rearing single calves had displayed estrus contrasted to 43% of the simulated twin rearing cows. Longer postpartum anestrus periods were apparently due to the greater suckling intensity experienced by cows rearing simulated twins. Suboptimal nutritional regime does not appear to be a predisposing factor since winter weight losses by single and simulated twin rearing cows were similar (table 6.1). These data are consistent with those reported by Bellows et al. (1974) and Casida et al. (1968) who reported increased postpartum anestrus intervals in cows rearing twin calves. Erb and Morrison (1959) reported data from over 7000 calvings in Holstein-Fresian cows which indicated that lifetime reproductive rate was significantly reduced subsequent to twinning.

Calf Performance. Calf performance data are summarized in table 6.5. It is important to note that the performance of calves reared as simulated twins cannot be equated with the performance of maternal twins due to differences in genetic composition and prenatal environment. The low level of performance obtained with grafted calves of simulated twin pairs suggests that twin simulation was only partially successful.

TABLE 6.4. POSTPARTUM ANESTRUS INTERVAL OF COWS REARING SINGLE OR SIMULATED TWIN CALVES

Item	Cows rearing	
	Single calves	Twin calves
Cows cycling by 60 days postpartum,[a] %	36	14
Cows cycling by 90 days postpartum,[a] %	71	43

[a]Date of estrus based on observations employing vasectomized bulls equipped with chin-ball markers.

TABLE 6.5. PERFORMANCE OF CALVES REARED AS SINGLES OR SIMULATED TWINS

Item	Single	Simulated twins		SE
		Natural	Grafted	
Birth weight, kg	33.1	32.6	31.3	1.0
Weaning weight,[a] kg	252[d]	223[e]	180[f]	5.8
Condition score[b]	6.1[d]	5.3[e]	4.3[f]	.2
Conformation score[c]	12.3[d]	11.9[d]	10.6[e]	.3

[a]Adjusted 240-day, sex corrected weaning weight.

[b]Based upon subjective evaluation of apparent fatness. 1=very thin... 9=very fat.

[c]Based upon subjective evaluation of structure and muscling. A score of 12=low choice.

[d,e,f]Means on the same line with the same superscript are not significantly different (P>.05).

Calves reared as singles averaged 50 kg heavier ($P<.05$) and were fatter ($P<.05$) at weaning than simulated twins. Grafted calves of simulated twin pairs were 43 kg lighter at weaning ($P<.05$) and thinner ($P<.05$) in condition than their natural born mates.

The reluctance of cows to readily accept grafted calves was a major factor contributing to their low level of performance. Grafted calves of simulated twin pairs nursed less frequently and the average total interval nursed was 11 minutes shorter ($P<.05$) than that of their natural born mates during the two pasture observation periods (table 6.6).

Apparent differences in forage dry matter intake by calves were not significant ($P>.20$) during either the May or August intake trials (table 6.7) However, calves reared as simulated twins tended to consume more forage during both trials.

Induced twinning among beef cows would obviously provide an interesting alternative for intensification of the cow-calf enterprise. Data reported in this paper indicate that twin rearing may result in substantial increases in milk yield among cows (Hereford x Holstein) which have a relatively high genetic potential for milk production. The effect of twin rearing on milk yield among cows with a genetic potential for low milk production is yet to be determined. However, it would appear that cows with a low milk production potential would not provide a maternal environment conducive to twin rearing.

Higher levels of milk yield will be accompanied by increased supplemental feed requirements when cows are maintained on low quality native pasture during lactation periods. Prolonged anestrus periods resulting from higher suckling intensities to which twin rearing cows

TABLE 6.6. NURSING BEHAVIOR OF NATURAL AND GRAFTED CALVES OF SIMULATED TWIN PAIRS

Item	Simulated twins		SE
	Natural	Grafted	
Trial 1 (April)			
Times nursed/day	4.1	3.3	
Total interval nursed, min	36.9[a]	26.5[b]	3.2
Interval nursed/nursing	9.1	8.4	.7
Trial 2 (August)			
Times nursed/day	3.9	2.4	
Total interval nursed, min	29.8[a]	18.3[b]	3.1
Interval nursed/nursing	7.8	7.7	.5

[a,b]Means on the same line with the same superscript are not significantly different (P>.05).

TABLE 6.7. RELATIVE FORAGE DRY MATTER INTAKE BY CALVES REARED AS SINGLES OR SIMULATED TWINS

Item	Single	Simulated twins		SE
		Natural	Grafted	
Trial 1 (May)				
Forage DM intake,[a] kg	2.1	2.4	2.3	.2
% of singles	100	110	108	
Trial 2 (August)				
Forage DM intake,[a] kg	4.0	4.9	4.5	.3
% of singles	100	119	108	

[a]Forage dry matter (DM) intakes serve as indices of relative intake rather than estimates of actual forage consumed.

are exposed may hamper attempts to maintain a yearly calving rate in the cow herd.

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