EFFECT OF MILK INTAKE LEVELS ON PERFORMANCE OF CALVES DIFFERING IN GROWTH POTENTIAL

By

KENT C. BARNES

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1974

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
December, 1977

EFFECT OF MILK INTAKE LEVELS ON PERFORMANCE

OF CALVES DIFFERING IN GROWTH POTENTIAL

Thesis Approved:

Keith S. Lusby
Thesis Adviser

Richard R Frahm

Gerald W. Horn

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGMENT

The author would like to express his sincere appreciation to Dr. Roger D. Wyatt and Dr. Keith S. Lusby for their advisement and help in conducting this research and in preparation of this thesis.

Grateful acknowledgment is also given to Dr. Richard R. Frahm and Dr. Gerald W. Horn for their helpful suggestions and critical evaluation while serving on the guidance committee.

Special thanks are extended to Dan Hoskins, Ed Stelting, Andrew Stelting, and Jack Eason at the Southwestern Livestock and Forage Research Station for help in caring for the experimental cattle and maintaining necessary records.

Appreciation is also extended to Larry Ridenour, Dr. Ron Lemenager, Bob Wilson and other graduate students for their assistance in the collection of experimental data. Thanks to Dennis Roberts for his help in compiling and organizing the data.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The main goal of any commercial cow-calf producer must be to improve specific traits of economic importance which will in turn improve the overall production efficiency of his herd. Therefore, emphasis has been directed toward traits which contribute to the weaning of heavy calves.

Available research results indicate that calf weight gains are positively related to level of milk consumption. Thus, increased milk production has been investigated as a means of increasing productivity in the beef cow herd. To evaluate the productive efficiency of this strategy for intensification, a study of the total nutrient intake per unit of weight gain by the calf when receiving a higher amount of milk is necessary. From an economic point of view, it is important that we understand the relationships between milk consumption and calf performance. It should be emphasized that the most practical level of milk is not necessarily that level which results in maximum calf weight.

The objectives of the experiments reported herein were; (1) to determine the effects of differing milk levels on preweaning calf gain; (2) determine if additional milk can be efficiently converted to calf gain; (3) compare the effects of increased milk intake on non-milk inputs (forage and creep feed) by the calf; (4) and determine the influence of milk level on total energetic efficiency of the calf.

CHAPTER II

REVIEW OF LITERATURE

This review has been organized into two parts: (1) the influence of milking ability among cows on calf growth and performance and (2) the effects of milk consumption level on the efficiency of calf production.

Effects of Dam's Milking Ability on Calf Growth and Performance

The milk production of a beef cow has a marked effect on the gain of her calf. One of the earliest studies to determine the factors that influence pre-weaning rate of gain in calves was reported by Knapp and Black (1941). Partial correlations indicated that of the feeds consumed, milk level had the greatest influence on rate of gain of Shorthorn calves followed by hay and grain, respectively. Together these variables accounted for 41 percent of the variation in rate of gain during the suckling period. A correlation of .52 was found between daily milk consumption and average daily gain to weaning. Similar observations were reported by Donald (1937) for swine.

Brumby *et al*. (1963) observed that the correlation between milk consumption and weight gain declined with increasing calf age, illustrating the importance of milk consumption upon calf growth in early life. The correlation between milk consumption and calf weaning weight was .70. Other workers (Gifford, 1949, 1953; Neville, 1962; Velasco, 1962; Pope et al., 1963; and Gleddie and Berg, 1968) have reported correlations from .47 to .90 between quantity of milk consumed and calf weight gain to weaning and found correlations to generally decrease as lactation progressed. Schwulst et al. (1966) found lower correlations between milk consumption and average daily gain of .36, .23, .23 at 2, 3, and 5 week intervals following birth.

Drewry et al. (1959) studied relationships among several factors associated with mothering ability of beef cattle. Correlations of -.15, .35, and .48 for the first, third, and sixth month following birth were found between calf gain from birth and estimated milk production of the dam.

Totusek et al. (1973) studied the relationship of milk yield and milk components to performance of calves in drylot. Calves received dam's milk to weaning. After 112 days of age a quantity of supplemental ration was fed to meet calves maintenance requirements. The correlation between 210-day milk consumption and daily gain of calves to 210 days was .88 with lower correlations being observed when a younger calf age (70 and 112 days) was used.

Marshall et al. (1976) reported a .44 correlation between milk production and weaning weight when calves were given ad lib access to creep in drylot. Low associations between these traits have been observed by other workers (Hohenboken et al., 1973; and Carpenter et al., 1973) under similar conditions.

Klett et al. (1965) reported correlations ranging from .66 to .81 between milk consumption and calf weight at different sampling dates among Angus cows, accounting for more than 40 percent of the variation in calf gain from differences in milk intake. Among Hereford cows, small and non-significant correlations were found suggesting that calves at lower milk levels depend more on other sources of nutrients than on their dam's milk.

Gifford (1953) and Pope et al. (1963) noted high correlations between milk yield and calf gain early in calf life. After about three months, this relationship declined as the calf became more dependent on other feeds for gain.

Christians et al. (1965) reported that butterfat yield is more important than milk volume for early growth. This was attributed to a requirement for a highly concentrated source of energy by the calf when consumption is limited due to stomach capacity. Relationships similar to these were reported by Owens (1953) and Burris and Bangus (1955) in sheep.

Many estimates relative to the milk production of beef type cows are available. Melton et al. (1967), Gleddie and Berg (1968), Neel (1973) and Omar et al. (1977) have reported Angus cows to produce from 3.8 to 8.4 kg of milk daily. Furr and Nelson (1964), Gregory et al. (1965), Carpenter et al. (1973), Kress and Anderson (1974) and Omar et al. (1977) reported a range of 3.2 to 4.9 kg of milk daily for Hereford cows.

das Neves et al. (1974) reported the milk production of Hereford cows to be 4.8 and 4.5 kg on range and in drylot. Composition of milk on range and in drylot was respectively, %; butterfat 2.6, 3.2; total solids 11.0, 11.4; and solids-not-fats 8.4, 8.2. Among range Hereford cows, milk production fluctuated with the availability of forage.

Wilstand and Riggs (1966) reported milk production for Santa Gertrudis cows of 5.6 and 7.9 kg in two consecutive years.

Since selection progress for milk production in the beef cow herd is slow, interest has been stimulated in beef x dairy crossbreeding. Cundiff (1970), in a review of crossbreeding studies indicated that beef x dairy calves produced by dairy females had heavier weaning weights than beef cows producing straightbred or beef crossbred calves.

Wilson et al. (1969) in a drylot study with Angus x Holstein cows reported higher milk yields than normally obtained from beef cows.

Deutscher and Whiteman (1971) reported daily milk production for Angus x Holstein and Angus heifers of 5.7 and 4.0 kg, respectively, under range conditions. Boston et al. (1972) reported daily milk production of 6.3 and 5.2 kg for the Angus x Holstein and Angus cows as three-year-olds.

Kropp et al. (1973) using cow breeds of widely differing milk potentials reported higher milk consumption and heavier weaning weights for progeny of Holstein than for either Hereford x Holstein or Hereford cows. Milk production and calf weaning weights for Holstein, Hereford x Holstein and Hereford cows were in kg: 11.0, 279; 8.3, 253; and 5.2, 229, respectively, on range. Milk production among drylot cows was similar to that of cows on range. Holloway et al. (1975a) and Wyatt et al. (1977b) noted comparable levels of milk consumption in subsequent work with these cows.

Effect of Milk Level on Production Efficiency of Calves

The efficiency of milk utilization for calf gain must be considered when determining the value of increased milk production for beef cows. Drewry et al. (1959), Montsma (1960), Klett et al. (1965), Melton et al.

(1967) and Kress, Hauser and Chapman (1968) have reported 4.0 to 12.5 kg of milk per kilogram of calf gain in beef cows. Brumby et al. (1963) reported that for calves consuming only milk there was a linear decrease in apparent efficiency from 9.1 kg of milk per kilogram of calf gain at 6 weeks to 50 kg at 24 weeks of age.

Neville (1962) reported that straightbred Hereford calves receiving 4.0 kg of milk daily from their dams required 12.5 kg of milk per kilogram of calf gain. Calves nursing Hereford cows on a better nutritional treatment consumed 4.8 kg of milk daily and required 23.5 kg of milk per kilogram of gain.

Drewry et al. (1959) in a range study with Angus cows and calves reported 12.5, 10.8 and 6.3 kg of milk were required to produce a kilogram of calf gain in the first, third and sixth month following calf birth. It was reported that calves on higher milking cows made less gain from a given volume of milk than those on lower producing cows, and this relationship could be the result of greater maintenance requirements of the calves or lower fat content of milk.

Lusby et al. (1976) noted that calves of Holstein cows consumed less creep than calves of Hereford x Holstein or Hereford cows in drylot. A range trial suggested a reduction in forage dry matter intake by calves at higher milk levels. Similar observations were made by Kartchner et al. (1974) and Wyatt et al. (1977a).

Holloway et al. (1975b) reported that Holstein calves were less efficient in converting digestible energy from milk and milk plus creep to weight gain as compared to Hereford or Hereford x Holstein calves.

McGinity and Frericks (1971) reported that larger type calves from Brown Swiss x Hereford cows tended to utilize energy from milk and creep more efficiently than Hereford calves. Milk consumption by calves of the Brown Swiss X Hereford cows was about twice that of the Hereford calves.

CHAPTER III

EFFECT OF LOW AND MEDIUM MILK LEVELS ON PERFORMANCE OF TWO CALF TYPES[1,2,3]

Summary

The effect of two levels of milk intake on the performance of calves of two distinctly different growth potentials was determined. Calf types were established by breeding Hereford cows to Angus bulls and Hereford x Friesian (HXF) cows to Charolais x Angus bulls. The experimental design was effected using a reciprocal cross-fostering system allowing calves of similar type to consume a low (Hereford) and a medium (HXF) milk level.

Among AXH calves the medium level of milk resulted in an increased ($P < .05$) weaning weight of 17% on range but did not significantly influence ($P > .25$) weaning weight in drylot. CAXHF calves on medium milk weaned 25 and 16% heavier ($P < .05$) on range and in drylot. Increasing daily milk consumption by calves within the range from 4.3 - 5.0 to

---

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

[2]K. C. Barnes, R. D. Wyatt, K. S. Lusby, and Robert Totusek, Oklahoma State University, Stillwater.

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

6.3 - 8.2 kg resulted in a 26 to 37% reduction in apparent efficiency of conversion of milk to calf gain.

Relative forage intake between calves consuming low or medium milk levels was not affected ($P > .25$) during the early summer (May) or late summer (August). Among AXH and CAXHF calves in drylot, the medium level of milk consumption resulted in 25 and 21% lower ($P < .05$) creep feed intakes than for calves on the low milk level.

Level of milk intake did not affect ($P > .25$) energetic efficiency (DE/kg gain) among either breed of calf in drylot.

Introduction

Increased calf weaning weight is the principal goal in most commercial cow-calf operations. The importance of milk consumption by calves as a factor influencing weaning weight has been well documented (Knapp and Black, 1941; Gifford, 1953; Velasco, 1962; Pinney, 1963). Beef x dairy crossbreeding (Cundiff, 1970) can increase the milk production of beef cows more rapidly than selection within a beef breed. Several studies have been reported investigating the beef-dairy crossbred female as a means of intensifying the cow-calf enterprise (Wilson et al., 1969; Hendrix, 1971; Deutcher and Whiteman, 1971; Kropp et al., 1973; Holloway et al., 1975a; Wyatt et al., 1977b). However, the effects of increased milk consumption on calf performance are not clear, since the effects of milk level were confounded with genetic differences for growth rate potential in calves. Few studies have reported the effects of various milk levels on calf performance and production efficiency within calves of similar genetic composition (Neville et al., 1952; Barnes et al., 1977a; Wyatt et al., 1977a).

This experiment was conducted to compare the effects of low and medium milk levels upon the performance and productive efficiency of two distinctly different calf types.

Materials and Methods

Thirty-nine Hereford and 29 Hereford x Friesian cows were used to determine the effects of two milk levels on the performance and productive efficiency of calves of two growth potentials. Two calf types were established by pasture mating Hereford cows to Angus bulls and Hereford x Friesian cows to Charolais x Angus bulls. A system was employed whereby calves of similar growth potential could be reared on a low (Hereford) and a medium (HXF) level of milk.

The experimental design was effected using the reciprocal cross-fostering scheme described by Wyatt et al. (1977a). Approximately one-half of the calves produced by Hereford cows (AXH) were raised by HXF cows and conversely one-half of the calves produced by HXF cows (CAXHF) were raised by Hereford cows. Thus, within each calf breed (AXH and CAXHF) one group was the recipient of a low level (4.3 - 5.0 kg/day) while another group received a medium level of milk (6.3 - 8.2 kg/day).

Parturition was induced in some cows by administration of 40 mg dexamethazone (Azium[4]) within 10 days of the projected calving date to allow scheduling of the cross-fostering program. Calves were grafted on to foster dams within 12 hours following birth.

All cows were eight-year olds producing their seventh progeny and calved in December and January while on dormant native range. During

---

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

the trial, cows and calves were managed on tall grass native range or in a completely confined drylot system at the Southwestern Livestock and Forage Research Station (El Reno).

On range, each of the four breed-treatment groups were maintained in separate pastures with an ample quantity of forage available throughout the trial. During forage domancy a 30% all natural crude protein supplement was fed at the rate of 1.4 and 2.7 kg per day to Hereford and HXF cows, respectively. These post-partum winter supplement levels were considered adequate for size and milk production level of these cows as determined from previous research at this station (Kropp _et al_., 1973; Holloway _et al_., 1975a; Wyatt _et al_., 1977b). Cows on range were individually fed supplement 4 days each week from December 18, 1976 to April 15, 1977.

Relative forage intake by calves on range was estimated in May and August while calves were on lush native pasture. An external indicator technique using chromic oxide as the indicator was employed. Chromic oxide (8 gm/hd/day) was administered daily by gelatin bolus at 0800 and 1500 hours during a 7-day preliminary and 7-day collection period. Fecal samples were obtained by rectal grab at the time of chromic oxide administration. Composite fecal samples were obtained for each calf by weighing 25 grams of wet feces from each collection over the collection period. After collection, fecal samples were dryed for 48 hr at $60^{\circ}C$, prepared by the method of Williams _et al_. (1962) and analyzed for chromium content by atomic absorption spectroscopy.

Sixteen Hereford and 16 HXF cows were alloted to drylot on the basis of calf sex so that a ratio of 1 male to 1 female was established within each calf breed-treatment group. Two calves (one AXH and one

CAXHF) nursing HXF cows did not complete the trial, and no data from these calves were used in the final analysis. Cow-calf pairs were placed in drylot within one month after calving and each of the four treatment groups were maintained in separate pens. Drylot cows were individually fed daily during approximately a 4-hr period. All cows received corn silage (silage corn variety) ad libitum and supplement (.45 kg/day) from the time they entered drylot to weaning. The supplement was composed of (%); soybean meal, IRN 5-04-612, 68.1; alfalfa hay, 18.6; urea, 5.7; dicalcium phosphate, 3.8; sugarcane molasses, IRN 4-04-696, 3.4; trace mineralized salt, .4; plus vitamin A added at a level of 37,500 IU/kg. of supplement. Drylot HXF cows were fed 2.3 kg corn (IRN 3-02-819) daily from February 23, 1977 til weaning to effect a weight loss pattern similar to Hereford cows and maintain milk production.

Calves in drylot were fed a pelleted creep ration that 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. The creep ration was individually fed ad libitum to drylot calves while their dams were being fed. Calves on range were not creep fed.

All calves were weaned at 240 ± 7 days and weights were adjusted to 240 days. Age adjusted heifer weights were adjusted to a steer equivalent by multiplying by a factor of 1.05 (Smithson, 1966). Calves were assigned subjective scores for condition and conformation at weaning. Condition scores were based on a scale of 1 (very thin) to 9 (very fat) and conformation scores ranged from 1 to 17 with 13 representing average choice. Measurements of height at the withers and length from the point of the shoulder (Proxmial humerus) to the hook bone (Tuber coxae) were obtained at birth and weaning.

Milk consumption of calves was estimated by the calf-suckle technique. Seven monthly estimates of 24-hr milk intake were made. Each estimate represented the cumulative milk consumed during four consecutive determinations made after 6-hr periods of separation of calves from cows.

Digestible energy (DE) and digestible protein (DP) intakes by cows and calves in drylot were calculated using tabular data (Crampton and Harris, 1969).

In this study, different numbers of experimental animals were present for various treatment groups on range and in drylot. Not all calves were available for analysis of different variables. Data were considered as a 2 x 2 factorial arrangement of treatments with milk level and calf type as factors. Data for each management system (range and drylot) were subjected to least squares analysis using the statistical analysis system designed by Barr and Goodnight (1972). Means were tested for significant differences by least significant difference (Snedecor and Cochran, 1967).

It was not the objective of this experiment to compare range and drylot management systems for cow-calf production. Therefore, management system was not included in the model and was not tested for significance.

Results and Discussion

Calf Performance

The performance data of AXH and CAXHF calves at low and medium milk levels are shown in Table 3.1. AXH calves on range at the medium milk level consumed 2.6 kg more ($P < .05$) milk per day and weaned 40 kg heavier ($P < .05$) than calves on low milk. This represented a 17% increase in weaning weight or an additional .14 kg per day gain. AXH calves in drylot on medium milk received 1.3 kg more ($P < .05$) milk daily than those on low milk. Weaning weight and average daily gain were not affected ($P > .25$) by milk intake among AXH calves in drylot. On range, AXH calves on medium milk levels had significantly higher ($P < .05$) conformation and condition scores at weaning than calves on low milk. In drylot, milk level did not affect either ($P > .25$) conformation or condition scores.

CAXHF calves on range at the medium milk level consumed 3.5 kg more ($P < .05$) milk per day and weaned 55 kg heavier ($P < .05$) than those on low milk. This represented a 25% increase in weaning weight or an additional .23 kg per day gain. CAXHF calves in drylot on medium milk received 2.9 kg more ($P < .05$) milk daily and weaned 31 kg heavier ($P < .05$) than their counterparts on low milk. This represented a 16% increase in weaned calf weight or an advantage of .13 kg average daily gain. Range calves on medium milk levels had higher ($P < .05$) weaning conformation scores than calves on the low milk levels. This effect was not evident ($P > .25$) among CAXHF calves in drylot.

The additional preweaning weight gain of calves receiving the higher milk level is consistent with data reported by Neville *et al.* (1952); Barnes *et al.* (1977a) and Wyatt *et al.* (1977a).

The larger CAXHF calves showed no advantage in growth rate when reared on equivalent milk levels with AXH calves. This is in agreement with findings of Wyatt *et al.* (1977a) and would suggest that much of

TABLE 3.1

EFFECT OF LOW AND MEDIUM MILK LEVELS AND CALF TYPE ON CALF PERFORMANCE

Item	Breed of Calf and Level of Milk				Std. Dev.
	AXH		CAXHF		
	Low	Med	Low	Med	
RANGE					
Number of calves	15	8	8	7	
Daily milk consumption, kg	4.8[e]	7.4[f]	4.7[e]	8.2[f]	1.28
Birth weight, kg	31.0[e]	31.2[e,g]	33.9[f,g]	36.2[f]	3.31
Weaning weight[a], kg	238[e]	278[f]	224[e]	279[f]	24.35
Daily gain[b], kg	.87[e]	1.01[f]	.78[g]	1.01[f,h]	.10
Conformation score[c]	12.0[e]	13.3[f]	10.9[g]	12.9[f,h]	1.13
Condition score[d]	5.1[e]	6.4[f]	4.5[g]	4.7[e,g]	.86
DRYLOT					
Number of calves	8	7	8	7	
Daily milk consumption, kg	5.0[e]	6.3[f]	4.3[e,g]	7.2[h]	.96
Birth weight, kg	30.5[e,f]	28.9[e]	31.8[e,f]	32.8[f]	3.32
Weaning weight[a], kg	212[e,f]	213[e,f]	195[e]	226[f]	27.56
Daily gain[b], kg	.75[e,f]	.76[e,f]	.67[e]	.80[f]	.11
Conformation score[c]	11.9	12.0	11.1	11.7	1.37
Condition score[d]	5.4[e]	5.1[e,f]	4.4[f]	4.5[f]	.85

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

[b]Birth to weaning.

[c]11 = high good, 12 = low choice, 13 = average choice.

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

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

the observed advantage in growth rate among calves of the larger, later maturing breeds may be associated with higher milk production by the cows of these breeds rather than superior genetic potential for growth within the breed.

Structural Growth

The effects of milk level and calf type on structural growth by calves are shown in Table 3.2. At weaning, AXH calves on range consuming medium milk tended to be taller and longer than calves on low milk; apparent differences were not significant ($P > .25$). AXH calves in drylot on medium milk exhibited no significant advantage for structural growth from birth to weaning.

Among CAXHF calves on range, level of milk intake did not influence ($P > .25$) height at weaning, but calves on medium milk were 8.9 cm longer ($P < .05$) at weaning due to a greater increase in length from birth to weaning than calves on low milk. CAXHF calves in drylot at the medium milk level increased more in height ($P < .05$) from birth to weaning and were 4.6 cm taller ($P < .05$) at weaning than calves on low milk. However, apparent differences in length at weaning and increased length from birth to weaning were not significant ($P > .25$).

At birth, range AXH calves were shorter ($P < .05$) in length and height than CAXHF calves. In drylot AXH calves were shorter in length ($P < .05$) than CAXHF calves and differences in height between calf breeds were approaching significance ($P \sim .08$). These calf breed differences correspond to the earlier maturity and smaller mature size characteristic of this calf type. Inducing parturition (shorter gestation period) among cows did not appear to influence structural size of

TABLE 3.2

EFFECT OF LOW AND MEDIUM MILK LEVELS AND CALF TYPE ON STRUCTURAL GROWTH BY CALVES

Item	Breed of Calf and Level of Milk				Std. Dev.
	Angus X Hereford		Angus-Charolais X Hereford-Holstein		
	Low	Med	Low	Med	
RANGE					
Number of calves	15	8	8	7	
Height at birth, cm	68.7[a]	69.2[a]	71.6[b]	73.0[b]	2.83
Height at weaning, cm	98.4[a]	101.1[a,b]	102.2[b]	103.7[b]	3.98
Increase in height, cm	29.7	31.9	30.6	30.7	3.86
Length at birth, cm	42.9[a]	44.5[a,b]	46.5[b]	46.6[b]	2.91
Length at weaning, cm	73.2[a,b]	76.2[a]	71.5[b]	80.4[c]	4.27
Increase in length, cm	30.3[a]	31.7[a,b,c]	24.9[b]	33.8[c]	4.48
DRYLOT					
Number of calves	8	7	8	7	
Height at birth, cm	68.9	68.0	69.6	70.7	2.47
Height at weaning, cm	98.3[a]	99.0[a]	99.8[a]	104.4[b]	2.87
Increase in height, cm	29.4[a]	31.0[a]	30.2[a]	33.6[b]	2.37
Length at birth, cm	42.5[a,b]	41.9[a]	43.8[b,c]	44.5[c]	2.14
Length at weaning, cm	70.7	68.8	69.3	73.3	5.64
Increase in length, cm	28.2	26.9	25.5	28.8	5.79

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

calves at birth which is consistent with similar birth weights (Table 3.1) observed among calves in which parturition was induced and those in which onset of parturition was naturally occurring.

Forage Intake

Apparent differences in forage dry matter intake between calves consuming low or medium milk levels were not significant (P > .25) during either the May or August intake trials (Table 3.3). These observations are consistent with those reported by Barnes et al. (1977a) but in contrast to those reported by Lusby et al. (1976) and Wyatt et al. (1977a) in which doubling milk intake by calves resulted in a reduction in relative forage intake. However, calves on medium milk tended to consume less forage during both trials.

Calf Efficiency

Among calves on range, as milk consumed and average daily gain increased, the apparent efficiency with which milk was utilized for gain decreased (Table 3.4). Range AXH calves required 5.8 and 7.3 kg of milk per kg of calf gain (birth to weaning) at low and medium levels of milk intake. This 1.5 kg increase (P < .05) in milk per kg of gain required by calves on medium milk represented a 26% decrease in apparent efficiency of milk utilization compared to calves at low milk. These calves required an additional 18.6 kg of milk to produce an additional kilogram of gain above that of calves at the low level. Range CAXHF calves required 6.0 and 8.2 kg of milk per kg gain at low and medium milk levels. This represented a 2.2 kg increase (P < .05) in milk per kilogram gain or a 37% decrease in efficiency of milk utilization. An additional 25.0 kg of milk was required to produce an additional kilogram of weight

TABLE 3.3

EFFECT OF LOW AND MEDIUM MILK LEVELS AND CALF TYPE ON RELATIVE FORAGE INTAKE BY CALVES

Item	Breed of Calf and Level of Milk				Std. Dev.
	AXH		CAXHF		
	Low	Med	Low	Med	
Trial 1 (May)					
Number of calves	15	8	6	7	
Daily milk consumption[a], kg	5.2	7.7	4.2	8.6	
Forage dry matter intake, kg	2.56	2.46	2.51	2.19	.72
Percent of low AXH	100	96	98	86	
Trial 2 (August)					
Number of calves	15	8	8	7	
Daily milk consumption[b], kg	3.4	7.0	4.0	8.3	
Forage dry matter intake, kg	5.24	5.14	5.27	4.91	.81
Percent of low AXH	100	98	101	94	

[a] Mean of two 24-hr estimates taken 1 week before and 2 weeks after relative forage intake was measured.

[b] One 24-hr estimate taken 3 weeks before relative forage intake was measured.

TABLE 3.4

EFFECT OF LOW AND MEDIUM MILK LEVELS AND CALF TYPE ON CALF EFFICIENCY

Item	Breed of Calf and Level of Milk				Std. Dev.
	AXH		CAXHF		
	Low	Med	Low	Med	
RANGE					
Number of calves	15	8	8	7	
Milk per kg gain,[a] kg	5.8^{c}	7.3^{d}	6.0^{c}	8.2^{d}	1.03
Additional milk per kg additional gain, kg		18.6		25.0	
DRYLOT					
Number of calves	8	7	8	7	
Milk per kg gain[a], kg	6.8^{c}	8.6^{d}	6.7^{c}	9.2^{d}	1.10
Total creep intake, kg	328^{c}	247^{d}	307^{c}	238^{d}	53.45
Daily creep intake, kg	1.36^{c}	1.02^{d}	1.26^{c}	$.99^{d}$	.22
Daily creep DE intake, Mcal	4.15^{c}	3.17^{d}	3.92^{c}	3.01^{d}	.70
Daily milk DE intake, Mcal	3.47^{c}	4.38^{d}	2.99^{c}	5.00^{e}	.67
Total daily DE intake, Mcal	$7.62^{c,d}$	$7.55^{c,d}$	6.91^{c}	8.01^{d}	1.04
Total daily DP intake, kg	$.33^{c}$	$.33^{c}$	$.29^{d}$	$.36^{c}$	.05
DE per kg gain, Mcal	10.37	10.19	10.60	10.30	.84

[a]Gain from birth to weaning.

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

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

gain. These data are in agreement with those reported by Barnes et al. (1977a) and Wyatt et al. (1977a). Drewry et al. (1959) reported that calves on high milk levels required more milk per kilogram of weaned weight than those at lower milk levels, which could be due to higher maintenance requirements for larger calves or lower fat content of milk. Some research suggests that lower apparent efficiencies of milk utilization by calves on high milk is the result of the substitution of milk (having a lower energy density) for grass (Lusby et al., 1976; Wyatt et al., 1977a). If only available milk is considered when expressing efficiency, little is learned about the more important total energetic efficiency.

The drylot management system was employed to allow a more accurate evaluation of total energetic efficiency and more specifically the relationship of milk level and calf type to calf efficiency .

Drylot AXH calves receiving the medium milk level required 26% more ($P < .05$) milk per kilogram of gain above that of calves on the low milk level, an effect also observed on range. Calves on medium milk also consumed 81 kg less ($P < .05$) total creep feed than calves on the low level representing a 25% reduction in daily creep intake (Table 3.4). Calves receiving medium milk consumed 26% more ($P < .05$) milk DE and 24% less ($P < .05$) creep DE, while total DE, total DP and estimated DE per kilogram gain were not influenced ($P > .25$) by level of milk intake (Table 4.4).

Drylot CAXHF calves receiving the medium milk level consumed 37% more ($P < .05$) milk per kilogram gain than calves on low milk. Calves on medium milk consumed 69 kg less ($P < .05$) total creep feed than those on the low level representing a 21% reduction in daily creep intake.

CAXHF calves receiving medium milk consumed 67% more ($P < .05$) milk DE, 16% more ($P < .05$) total DE, 24% more ($P < .05$) total DP and 23% less ($P < .05$) creep DE than calves on the low milk level. Level of milk intake did not affect ($P > .25$) DE required per kilogram gain.

In drylot, milk level x calf type interactions were noted for milk DE ($P < .04$) and total daily DP ($P < .09$).

Milk level did not influence calf efficiency among AXH or CAXHF calves when expressed in terms of total calf nutrient intake. These observations agree with those of Barnes, et al. (1977b). Wyatt et al. (1977a) also reported no effect on energetic efficiency among AXH calves but greater efficiency of CXF calves on a low milk level compared to a high (2 x low) level of milk.

The average daily DE intake by Hereford and HXF cows in drylot was 23.55 and 31.98 Mcal. Assuming that 1.23 Mcal DE is required per kilogram of milk produced (NRC, 1976) the theoretical energy requirement of these cows at a different milk production level can be projected (Table 3.5). Thus, a Hereford cow producing the medium level of milk, 6.3 kg (Table 3.1), would require approximately 25.15 Mcal DE per day while a HXF cow producing 4.3 kg of milk (low level) would require about 28.41 Mcal DE daily. From these values, one can estimate the total DE (cow and calf) required as feed inputs per kilogram of calf gain. These calculations suggest that increasing milk production 67% among HXF cows (low to medium level) decreases the total DE requirement per kilogram of calf gain. This effect is in agreement with Wyatt et al. (1977a) who made a similar comparison using Hereford and Friesian cows. This apparently results from the stimulating affect of increased milk level upon DE intake of the calf (Table 3.4) and a greater dilution of

TABLE 3.5

PROJECTED ENERGETIC EFFICIENCY OF HEREFORD AND HEREFORD X FRIESIAN COWS AT TWO MILK LEVELS

	Breed of Cow and Level of Milk			
	Hereford		HXF	
Item	Low	Med	Low	Med
Daily DE intake by cow[a], Mcal	23.55	25.15	28.41	31.98
Creep DE intake by calf, Mcal	4.15	3.17	3.92	3.01
Total DE intake[b], Mcal	27.70	28.32	32.33	34.99
DE per Kg gain, Mcal	36.93	37.26	48.25	43.74

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

[b]Total DE intake include feed inputs of corn silage, supplement and corn and calf creep.

the total maintenance requirement. CAXHF calves in drylot consumed 16% more total daily DE ($P < .05$) on medium milk compared to calves on low milk.

Among Hereford cows, similar calculations suggest that increasing milk yield 26% (5.0 to 6.3 kg) does not influence total DE requirement per kilogram of calf gain. This may seem inconsistent with the greater calculated energetic efficiency of HXF cows at medium milk levels. However, Barnes et al. (1977b) reported similar results when milk production of HXF and Friesian cows differed 12% and 6%, respectively. The 24% lower efficiency of HXF compared to Hereford cows is consistent with the larger size and maintenance requirement of these cows. Increases in milk production among cows can result in greater energetic efficiency, but the costs of providing the additional DE required by high milking cows may limit the economy of this strategy for intensification.

These results indicate that increasing the milk consumption level of calves can be an effective tool for increasing calf preweaning growth. It should be noted, that higher milk consumption by calves is also accompanied by a depression in non-milk feed intake (creep or forage) and a reduction in the apparent efficiency with which milk is utilized for calf gain. However, in drylot calf efficiency was similar at both milk levels when expressed in terms of total nutrient intake by the calf.

The desirability of increasing milk production in the beef cow will depend to a high degree on economic relationships between the cost of meeting the additional energy requirements of heavier milking cows and the return from additional calf gain.

CHAPTER IV

EFFECT OF MEDIUM AND HIGH MILK LEVELS ON PERFORMANCE OF TWO CALF TYPES[1,2,3]

Summary

The effect of two levels of milk intake on the performance of calves of two growth potentials was studied. The experimental design was effected by breeding Hereford x Friesian (HXF) cows to Charolais x Angus bulls and Friesian cows to Charolais bulls, followed by a reciprocal cross-fostering scheme whereby calves of each breed combination were exposed to medium (HXF) or high (Friesian) levels of milk. In this study, a smaller than anticipated difference between the medium and high levels of milk production was observed due to a lower than normal milk production by the Friesian cows. The reduced milk level of the Friesians may be the result of the accumulative effects of six consecutive years of production under native range conditions or on low quality harvested forage in drylot.

---

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

[2]K. C. Barnes, L. D. Ridenour, R. D. Wyatt, K. S. Lusby, M. B. Gould, and Robert Totusek, Oklahoma State University, Stillwater.

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

The high level of milk consumption resulted in a 13% increase ($P < .05$) in weaning weight among Charolais-Angus X Hereford-Friesian (CAXHF) calves on range but did not significantly influence ($P > .25$) weaning weights of calves in drylot. Increasing the level of milk consumption ($P < .05$) from 8.7 to 11.4 kg per day on range and from 8.4 to 9.4 kg per day in drylot resulted in a reduction in apparent efficiency of conversion of milk to calf gain of 15% and 19%, respectively, in (CAXHF) calves. CXF calves on the high level of milk consumed only .5 - .9 kg more milk ($P > .2$) per day than calves on the medium level of milk.

Relative forage intake was reduced ($P < .05$) 31% in CXF calves on the high level of milk but was not affected by milk level in CAXHF calves. Among CAXHF and CXF calves in drylot, those at the high milk level consumed 35% ($P < .05$) and 19% ($P < .1$) less total creep feed than those at the low milk level.

Level of milk intake did not affect ($P > .25$) energetic efficiency (DE/kg gain) among either breed of calf in drylot.

Introduction

Weaning weight is an important factor in the economy of a commercial cow-calf operation. The milk production of a beef cow has a marked effect on the weaning weight of her calf (Knapp and Black, 1941; Gifford, 1953; Drewry et al., 1959; Neville et al., 1960; Velasco, 1962; Totusek et al., 1973). Cundiff (1970) concluded that beef x dairy cross breeding can result in increased milk yield and growth rate as compared to beef cows producing straightbred or beef crossbred calves. Interest in introducing genes from dairy animals as a means of increasing production of beef females has stimulated research interest in the beef x dairy crossbred female (Wilson et al., 1969; Hendrix, 1971; Deutcher and Whiteman, 1971; Kropp et al., 1973; Holloway et al., 1975a; Wyatt et al., 1977).

However, in most studies, the effects of increased milk consumption on calf performance was not clear, since milk level effects were confounded with genetic differences for growth rate potential in the calves. There are few data available regarding the effects of various milk levels on calf performance and production efficiency within various calf types Neville et al. (1952). Wyatt et al. (1977a) reported the performance of calves of AXH and CXF breeding raised on cows differing widely in milk production potential.

The objective of this study was to compare the effects of medium and high milk levels upon the performance and productive efficiency of two distinctly different calf types.

Materials and Methods

Fifty-eight Hereford X Friesian (HXF) and Friesian cows were used to study the effects of a medium (HXF) and a high (Friesian) level of milk intake on the performance of calves of two growth potentials. Two calf types were established by pasture mating HXF cows to Charolais x Angus bulls and Friesian cows to Charolais bulls. A system was employed whereby calves of similar growth potential could be exposed to a medium (HXF) and a high (Friesian) level of milk consumption.

The experimental design was effected using a reciprocal cross-fostering scheme described by Wyatt et al. (1977a). Approximately one-half of the calves produced by HXF cows (CAXHF) were reared by Friesian cows and one-half of the calves produced by Friesian cows (CXF) were reared by HXF cows. Thus, within each calf type (CAXHF and CXF), one group was the recipient of a medium level while another group received a high level of milk.

Parturition was induced in some cows by administration of 40 mg dexamethazone (Azium[4]) within 10 days of the projected calving date to allow scheduling of the cross-fostering program. Calves were grafted on to foster dams within 12 hours following birth.

All cows were seven-year olds producing their sixth progeny and calved in December, January and February while on dormant native range. During the trial, cows and calves were managed on tall grass native range or in a completely confined drylot system at the Southwestern Livestock and Forage Research Station (El Reno).

On range, each of the four breed-treatment groups were maintained in separate pastures with an ample quantity of forage available throughout the trial. During forage dormancy a 28% all natural crude protein supplement was fed at the rate of 2.5 and 3.5 kg per day to HXF and Friesian cows, respectively. These post-partum winter supplement levels were considered adequate for size and milk production level of these cows as determined from previous research at the Fort Reno Station (Kropp *et al.*, 1973; Holloway *et al.*, 1975a; Wyatt *et al.*, 1977a). The cows on range were individually fed supplement 5 days each week from December 2, 1975 to April 30, 1976.

Relative forage intake by calves on range was estimated in August while calves were on lush native pasture. An external indicator

---

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

technique employing chromic oxide as the indicator was used. Chromic oxide (8 gm/hd/day) was administered daily by gelatin bolus at 0800 and 1500 hours during a 6-day preliminary and 6-day collection period. Fecal samples were obtained by rectal grab at the time of chromic oxide administration. Composite fecal samples were obtained for each calf by weighing 25 grams of wet feces from each collection over the collection period. After collection, fecal samples were dryed for 48 hr at 60^{o}C, prepared by the method of Williams et al. (1962) and analyzed for chromium content by atomic absorption spectroscopy.

Fourteen HXF and 14 Friesian cows were assigned to drylot according to sex of calf so that a ratio of four male to three female calves was established within each calf breed-treatment group. One CXF calf nursing a HXF cow did not complete the trial, and no data from the calf was used in the final analysis. Cow-calf pairs were placed in drylot within two weeks after calving and each of the four treatment groups were maintained in a separate pen. Cows were individually fed supplement daily from January 19, 1975 to April 17, 1976. The drylot roughage program for cows consisted of cottonseed hulls (IRN 1-01-599) during winter to mid-April and alfalfa hay (IRN 1-00-063) from mid-April until calves were weaned. Forage was offered to cows ad libitum in individual pens during a four hour period each day.

Calves in drylot were fed a pelleted creep ration that 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. The creep ration was individually fed ad libitum to drylot calves while their dams were being fed. Calves on range were not creep fed.

All calves were weaned at 240 ± 7 days and weights were adjusted to 240 days. Age adjusted heifer weaning weights were adjusted to a steer equivalent by multiplying by a factor of 1.05 (Smithson, 1966). Calves were assigned subjective scores for condition and conformation at weaning. Condition scores were based on a scale of 1 (very thin) to 9 (very fat) and conformation scores ranged from 1 to 17 with 13 representing average choice. Measurements of height at the withers and length from the point of the shoulder (Proximal humerus) to the hook bone (Tuber coxae) were obtained at birth and weaning.

Milk consumption of calves was estimated by the calf-suckle technique. Seven monthly estimates of 24-hr milk intake were made. Each estimate represented the cumulative milk consumed during four consecutive determinations made after 6-hr periods of separation of calves from cows.

Digestible energy (DE) and digestible protein (DP) intakes by cows and calves in drylot were calculated using tabular data (Crampton and Harris, 1969).

In this study, different numbers of experimental anaimals were present for various treatment groups on range and in drylot. Not all calves were available for analysis of different variables. Data were considered as a 2 x 2 factorial arrangement of treatments with milk level and calf type as factors. Data for each management system (range and drylot) were subjected to least squares analysis using the statistical analysis system designed by Barr and Goodnight (1972). Means were tested for significant differences by least significant difference (Snedecor and Cochran, 1967).

It was not the objective of this experiment to compare range and drylot management systems for cow-calf operations. Therefore, management system effects were not included in the model and were not tested for significance.

Results and Discussion

Calf Performance

Performance data of CAXHF and CXF calves at medium and high milk levels are shown in Table 4.1. CAXHF calves on range consumed 8.7 and 11.4 kg of milk daily ($P < .05$) while their counterparts in drylot consumed 8.4 and 9.4 kg of milk daily ($P < .05$) at the medium and high milk levels. CXF calves on range consumed 9.5 and 10.4 kg of milk daily ($P > .2$) and CXF calves in drylot consumed 8.6 and 9.1 kg of milk daily ($P > .2$) at the medium and high levels. In previous years, calves reared by Friesian cows had consumed from 11.3 to 13.6 kg of milk per day on range and from 11.0 to 13.9 kg of milk per day in drylot over the 240 day lactation period. Apparently, the cumulative effects of six consecutive lactations under native range conditions or on a low quality forage regime in drylot reduced the milking ability of the Friesian cows. Lower milk production was especially noticeable among the Friesian cows rearing CXF calves. This may be partially attributed to the 32 day later average calving date of the CXF calves. Later calving dates with a resulting longer portion of the lactation in late summer would tend to reduce milk production and weaning weights. A similar milk production response was seen for HXF cows rearing CAXHF calves.

CAXHF calves on range at the high milk level consumed 2.7 kg more ($P < .05$) milk per day and were 34 kg heavier ($P < .05$) at weaning than

TABLE 4.1

EFFECT OF MEDIUM AND HIGH MILK LEVELS AND CALF TYPE ON CALF PERFORMANCE

Item	Breed of Calf and Level of Milk				Std. Dev.
	CAXHF		CXF		
	Med	High	Med	High	
RANGE					
Number of calves	9	8	8	6	
Daily milk consumption, kg	8.7[e]	11.4[f]	9.5[g]	10.4[f,g]	1.53
Birthweight, kg	30.9[e]	36.3[e,f]	40.9[f]	40.1[f]	6.64
Weaning weight[a], kg	268[e]	302[f]	306[f,g]	318[f,h]	25.14
Daily gain[b], kg	.99[e]	1.10[f]	1.10[f]	1.16[f]	.10
Conformation score[c]	11.9[e]	10.9[f]	10.4[f]	11.0[f]	.90
Condition score	5.9[e]	6.8[f]	5.1[e,g]	4.5[g]	.96
DRYLOT					
Number of calves	7	7	6	7	
Daily milk consumption, kg	8.4[e]	9.4[f]	8.6[e,f]	9.1[e,f]	1.07
Birth weight, kg	32.9[e]	32.9[e]	43.8[f]	41.7[f]	5.14
Weaning weight[a], kg	275	264	287	284	28.08
Daily gain[b], kg	1.01	.98	1.00	1.01	.12
Conformation score[c]	11.4[e]	11.3[f]	11.2[e,g]	11.1[g]	1.16
Condition score	5.3[e]	6.6[f]	4.8[e,g]	4.1[h]	.62

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

[b]Birth to weaning.

[c]11 = High good; 12 = low good; [d]1 = very thin, 9 = very fat.

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

calves receiving the medium level. This represented a 13% increase in weaning weight or an additional .11 kg per day gain. CAXHF calves in drylot on the high milk level consumed 1.0 kg more ($P < .05$) milk daily than those on medium milk. Weaning weight and average daily gain were not affected ($P > .25$) by milk intake among the CAXHF calves. Calves on high milk levels had higher ($P < .05$) weaning condition scores than calves on the medium level both on range and in drylot.

CXF calves on range and in drylot consumed .9 and .5 kg more milk respectively ($P < .2$) on the high milk level than calves receiving the medium level. The apparent differences in weaning weight, average daily gain and weaning condition scores were not significant ($P > .25$).

The trend toward additional preweaning weight gain of calves at higher milk levels agrees with the findings of Neville et al. (1952) and Wyatt et al. (1977a). In this study the smaller type CAXHF calves showed a rate of gain similar to the larger CXF calves when consuming the high milk level (1.10 vs 1.16 kg/day on range; .98 vs 1.01 kg/day in drylot). This is in agreement with data reported by Wyatt et al. (1977a) and would suggest that much of the observed advantage in growth rate among calves of the larger, later maturing breeds (CXF) may be the result of higher milk production by the cows of these breeds as well as greater genetic potential for growth within the breed.

At birth, calves of Friesian cows were heavier ($P < .05$) than progeny of HXF cows. These breed differences are consistent with the larger mature size of the Friesians. Observed differences in birth weights between cross-grafted calves and those raised by their natural dam were not significant ($P > .25$). This would indicate that inducing parturition did not affect calf birth weight.

Structural Growth

The effect of milk level and calf type on structural growth by calves is shown in Table 4.2. At weaning, CAXHF calves on range receiving high milk were 8.3 cm longer ($P < .05$) than calves on medium milk as a result of increased length ($P < .05$) from birth to weaning. Range CAXHF calves on high milk were 7.6 cm taller ($P < .05$) at weaning than those on medium milk. However, much of the apparent height advantage of these calves at the high milk level can be accounted for by height differences ($P < .05$) at birth. CAXHF in drylot on high milk exhibited no advantage ($P > .25$) for structural growth from birth to weaning.

Among CXF calves, differences in height and length from birth to weaning were quite variable and not affected ($P > .25$) by level of milk consumption within the narrow range observed in this study.

The effect of breed on structural measurements at birth was evident. CAXHF calves on range and in drylot were shorter in height ($P < .05$) and tended to be shorter in length at birth than CXF calves. This effect corresponds to the somewhat smaller mature size and earlier maturity associated with this calf type. Range CAXHF calves assigned to medium milk were shorter ($P < .05$) in height at birth than CAXHF calves on the high milk level.

Inducing parturition (shorter gestation period) among cows did not appear to influence the structural size of calves at birth which is consistent with similar birth weights (Table 4.1) observed among calves in which parturition was induced and those in which onset of parturition was naturally occurring.

TABLE 4.2

EFFECT OF MEDIUM AND HIGH MILK LEVELS AND CALF TYPE ON STRUCTURAL GROWTH BY CALVES

Item	Breed of Calf and Level of Milk				Std. Dev.
	CAXHF		CXF		
	Med	High	Med	High	
RANGE					
Number of calves	8	8	8	6	
Height at birth, cm	65.9^{a}	70.5^{b}	74.3^{c}	75.4^{c}	4.47
Height at weaning, cm	100.3^{a}	107.9^{b}	109.7^{b}	108.4^{b}	3.55
Increase in height, cm	$34.5^{a,b}$	37.5^{a}	$35.4^{a,b}$	33.0^{b}	4.55
Length at birth, cm	45.6	45.9	49.4	47.0	4.65
Length at weaning, cm	75.2^{a}	83.4^{b}	81.1^{b}	82.4^{b}	4.08
Increase in length, cm	29.6^{a}	37.5^{b}	$31.7^{a,c}$	$35.4^{b,c}$	5.81
DRYLOT					
Number of calves	6	7	6	7	
Height at birth, cm	67.1^{a}	$67.9^{a,c}$	$72.0^{b,c}$	76.0^{b}	4.91
Height at weaning, cm	103.1^{a}	103.6^{a}	109.9^{b}	109.1^{b}	3.89
Increase in height, cm	35.9	35.7	37.9	33.1	5.04
Length at birth, cm	48.3^{a}	43.7^{b}	$47.2^{a,b}$	$46.6^{a,b}$	4.75
Length at weaning, cm	76.9^{a}	$77.6^{a,c}$	$80.6^{b,c}$	81.5^{b}	3.46
Increase in length, cm	28.6^{a}	$33.9^{a,b}$	$33.4^{a,b}$	34.9^{b}	5.82

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

Forage Intake

Means for relative forage intake by calves is shown in Table 4.3. Milk production levels of cows of both breeds were similar and low during August when forage intake of calves was estimated. The small differences in milk consumption between the medium and high levels make interpretation of the data difficult. Based on previous studies at this station (Lusby et al., 1976; Wyatt et al., 1977a) the differences in milk consumption levels at the time of the trial would not be expected to affect calf forage intake, however, calf breed differences were noted. CXF calves consumed 26% more forage ($P < .05$) than CAXHF calves as they approached weaning age. The higher forage intake by the CXF calves is consistent with their greater size and capacity to consume forage.

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 (Table 4.4). Range CAXHF calves required 9.2 and 10.6 kg of milk per kg of calf gain (birth to weaning) at medium and high levels of milk intake. This 1.4 kg increase ($P < .05$) in milk per kg of gain required by calves at the high level represented a 15% decrease in apparent efficiency of milk utilization. These findings are in agreement with Wyatt et al. (1977a) who reported an additional 4 kg of milk required per kg of gain when milk level doubled and are somewhat higher requirements than those shown by Drewry et al. (1959), Neville (1962), and Klett (1963) for beef cows. Range CAXHF calves on high milk required an additional 24.5 kg of milk to produce an additional kilogram of gain above that of calves at the medium milk level. Range CXF calves

TABLE 4.3

EFFECT OF MEDIUM AND HIGH MILK LEVELS AND CALF TYPE ON RELATIVE FORAGE INTAKE BY CALVES

Item	Breed of Calf and Level of Milk				Std. Dev.
	CAXHF		CXF		
	Med	High	Med	High	
Number of calves	9	8	8	6	
Daily milk consumption[a], kg	5.0	5.2	5.1	5.7	
Forage dry matter intake, kg	1.90[b]	2.16[b]	3.00[c]	2.08[b]	.50
% of Med CAXHF	100	113	158	109	

[a]One 24-hr estimate taken 1 week after relative forage intake was measured in August.

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

TABLE 4.4

EFFECT OF MEDIUM AND HIGH MILK LEVELS AND CALF TYPE ON CALF EFFICIENCY

Item	Breed of Calf and Level of Milk				Std. Dev.
	CAXHF		CXF		
	Med	High	Med	High	
RANGE					
Number of calves	9	8	8	6	
Milk per kg gain[a], kg	9.2[c]	10.6[d]	9.0[c]	9.1[c]	1.47
Additional milk per kg additional gain[b], kg		24.5		15.0	
DRYLOT					
Number of calves	7	7	6	7	
Milk per kg gain[a], kg	8.5[c]	10.1[d]	8.8[c]	9.3[c,d]	1.11
Total creep intake, kg	310[c]	202[d]	329[c]	268[c,d]	77.38
Daily creep intake, kg	1.31[c]	.86[d]	1.35[c]	1.11[c,d]	.33
Daily creep DE intake, Mcal	4.02[c]	2.64[d]	4.15[c]	3.43[c,d]	1.03
Daily milk DE intake, Mcal	5.79[c]	6.53[d]	5.93[c,d]	6.30[c,d]	.74
Total daily DE intake, Mcal	9.81	9.17	10.08	9.73	1.31
Total daily DP intake, kg	.43	.41	.44	.43	.06
DE per kg gain, Mcal	9.91	9.82	10.29	9.89	.24

[a]Gain from birth to weaning.

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

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

consuming the medium and high milk levels were comparable in efficiency with which milk was utilized for gain. The similarity in efficiency could be expected from the milk consumption of these calves. Drewry et al. (1959) reported that calves at high milk levels required more milk per kg of gain than those at lower milk levels, which could be due to higher maintenance requirements for larger calves or lower fat content of milk. Some research suggests that lower apparent efficiencies of milk utilization by calves on higher milk levels is the result of the substitution of milk (having a lower energy density) for grass (Lusby et al., 1976; Wyatt et al., 1977a). If only available milk is considered when expressing efficiency, little is learned about the more important question total energetic efficiency.

The drylot management system allowed a more precise evaluation of total energetic efficiency and more specifically the relationships of milk level and calf type to calf efficiency (Table 4.4). Drylot CAXHF calves receiving the high milk level required 19% more ($P < .05$) milk per kilogram of gain than those at the medium level, an effect also observed on range. Calves at the high milk level also consumed 108 kg less ($P < .05$) total creep feed than calves at the medium level representing a 34% reduction in daily creep intake. Calves receiving high milk consumed 35% less ($P < .05$) creep DE and 13% more ($P < .05$) milk DE while total DE; total DP and estimated DE per kg gain were not influenced ($P > .25$) by level of milk intake (Table 4.4). Thus, milk level did not affect calf efficiency when expressed in terms of total nutrient intake by the calf. Wyatt et al. (1977a) reported similar observations among AXH calves, but reported a lower energetic efficiency of CXF calves on a high milk level compared to counterparts on low milk.

Drylot CXF calves on the high level of milk received only .5 kg more milk (P > .20) per dry than calves on the medium level of milk but followed trends in calf efficiency similar to those of CAXHF calves. Calves at the high milk level required 6% more (P > .20) milk per kg of gain but consumed 61 kg or 19% less (P < .10) creep feed than calves at the medium level of milk. CXF calves on high milk consumed 6% more milk DE (P > .20) and 17% less (P > .20) creep DE. Total DE, total DP and DE per kg of gain were similar (P > .25) between calves at the medium and high milk levels.

Reduction in creep intake by both CAXHF and CXF calves in drylot at the high milk level follow trends previously reported by other researchers (Holloway _et al_., 1975a; Lusby _et al_., 1976; Wyatt _et al_., 1977a). However, a larger than expected reduction based on the small difference between milk levels in drylot was observed. The reasons for the large reduction in creep intake of CAXHF and CXF calves consuming only .5 to 1.0 kg more milk daily at the high level are not clear.

In drylot the average daily DE intake by HXF and Friesian cows was 33.49 and 37.39 Mcal. It is possible to calculate the theoretical energy requirement of these cows at different levels of milk production (Table 4.5) assuming that 1.23 Mcal DE is required per kilogram of milk produced (NRC, 1976). A HXF cow producing 9.4 kg of milk (high level) would require about 34.72 Mcal DE daily while a Friesian cow producing 8.6 kg of milk (medium level) would require about 36.78 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 was not influenced by

TABLE 4.5

PROJECTED ENERGETIC EFFICIENCY OF HEREFORD X FRIESIAN AND FRIESIAN COWS AT TWO MILK LEVELS

Item	Breed of Cow and Level of Milk			
	HXF		Friesian	
	Medium	High	Medium	High
Daily DE intake by cow[a], Mcal	33.49	34.72	36.78	37.39
Creep DE intake by calf, Mcal	4.02	2.64	4.15	3.43
Total DE intake, Mcal	37.51	37.36	40.93	40.82
DE per kg gain, Mcal	37.14	38.12	40.93	40.42

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

milk level within cow breed. The advantage in projected energetic efficiency reported by Wyatt et al. (1977a) for high milk levels when comparing Hereford and Friesian cows was not evident here in a similar comparison of HXF and Friesian cow types.

The lower efficiency of Friesians compared to HXF cows is consistent with the larger size and maintenance requirement of these cows.

These results indicate that increases in milk consumption among calves can increase calf preweaning growth rate. It should be noted that increased milk intake by calves is accompanied by a decrease in non-milk feed intake (creep or forage) and a reduction in the apparent efficiency with which milk is utilized for calf gain. However, calf efficiency was similar at both milk levels when expressed as a function of total calf nutrient intake.

The economic feasibility of increasing milk production in the beef cow will depend largely on the relationship between cost of the higher energy and protein requirement of heavier milking cows and return from additional calf gain.

SELECTED BIBLIOGRAPHY

Barnes, K. C., L. D. Ridenour, M. B. Gould, K. S. Lusby and Robert Totusek. 1977a. Effects of two milk levels on performance of two calf types. Okla. Agr. Exp. Sta. MP-101 p. 13.

Barnes, K. C., L. D. Ridenour, R. D. Wyatt, K. S. Lusby, M. B. Gould and Robert Totusek. 1977b. Effect of milk level and biological type on calf growth. Abstr. 69th Ann. Meet. Amer. Soc. of Ani. Sci., Madison, Wisconsin. July 23-27, 1977.

Boston, A. C., G. H. Deutscher, J. V. Whiteman and R. R. Frahm. 1972. Comparison of productivity of young Angus X Holstein crossbred and grade Angus cows. Okla. Agr. Exp. Sta. MP-87 p. 7.

Brumby, P. T., D. K. Walker and R. M. Gallagher. 1963. Factors associated with growth in beef cattle. New Zealand J. Agr. Res. 6:526.

Burris, M. J. and C. A. Bangus. 1955. Milk consumption and growth of suckling lambs. J. Anim. Sci. 14:186.

Carpenter, J. A., Jr., H. A. Fitzhugh, Jr., T. C. Cartwright and R. C. Thomas. 1973. Relationships between performance and mature size in beef cows. J. Anim. Sci. 37:231. (Abstr.).

Christian, L. L., E. R. Hauser and A. B. Chapman. 1965. Association of pre-weaning and post-weaning traits with weaning weight in cattle. J. Anim. Sci. 24:652.

Crampton, E. W. and L. E. Harris. 1969. Applied Animal Nutrition (2nd Ed.). W. H. Freeman and Company, San Francisco, California.

Cundiff, L. V. 1970. Experimental results on crossbreeding cattle for beef production. J. Anim. Sci. 30:694.

das Neves, Armando, Joe D. Wallace and Carlton Herbel. 1974. Milk production by Hereford cows. Proc. West. Sec. Amer. Soc. Anim. Sci. 25:310.

Deutscher, G. H. and J. V. Whiteman. 1971. Productivity as two-year-olds of Angus X Holstein crossbreds compared to Angus heifers under range conditions. J. Anim. Sci. 33:337.

Donald, H. P. 1937. The milk consumption and growth of suckling pigs. Empire Jour. Expt. Agr. 5:349.

Drewry, K. J., C. J. Brown and R. S. Honea. 1959. Relationships among factors associated with mothering ability in beef cattle. J. Anim. Sci. 18:938.

Furr, R. D. and A. B. Nelson. 1964. Effect of level of supplemental winter feed on calf weight and on milk production of fall-calving range beef cows. J. Anim. Sci. 23:775.

Gifford, W. 1949. Importance of high milk production in beef cows found overestimated. J. Anim. Sci. 8:605. (Abstr.).

Gifford, Warren. 1953. Milk production of dams and growth of calves. Ark. Agr. Exp. Sta. Bull. 531.

Gleddie, V. M. and T. R. Berg. 1968. Milk production in range beef cows and its relationship to calf gains. Can. J. of Anim. Sci. 48:323.

Gregory, K. E., L. A. Swiger, R. M. Koch, L. J. Sumption, W. W Rowden and J. E. Ingalls. 1965. Heterosis in preweaning tracts of beef cattle. J. Anim. Sci. 24:21.

Hendrix, Kern S. 1971. A study of methods for estimating milk production in range beef cows and factors associated with the milk production estimate. M.S. Thesis. Oklahoma State University, Stillwater.

Hohenboken, W. D., E. R. Houser, A. B. Chapman and L. V. Cundiff. 1973. Phenotypic correlations between dam traits expressed during development and lactation and traits of progeny in cattle. J. Anim. Sci. 37:1.

Holloway, J. W., D. F. Stephens, J. V. Whiteman and Robert Totusek. 1975a. Performance of 3-year-old Hereford, Hereford X Holstein and Holstein cows on range and in drylot. J. Anim. Sci. 40:114.

Holloway, J. W., D. F. Stephens, J. V. Whiteman and Robert Totusek. 1975b. Efficiency of production of 2- and 3-year-old Hereford, Hereford X Holstein and Holstein cows. J. Anim. Sci. 41:855.

Kartchner, R. J., L. R. Rittenhouse and R. J. Raleigh. 1974. Feed intake by spring and fall cow-calf pairs. Proc. West. Sec. Amer. Soc. Anim. Sci. 25:182.

Klett, R. H., T. R. Mason and J. K. Riggs. 1965. Milk production of beef cows and its relationship to the weaning weight of their calves. Proc. West. Sec. Amer. Soc. Amer. Sci. 16:VI.

Knapp, Bradford, Jr., and W. H. Black. 1941. Factors influencing rate of gain of beef calves during the suckling period. Jr. Agr. Res. 63:249.

Kress, D. D. and D. C. Anderson. 1974. Milk production in Hereford cattle. J. Anim. Sci. 38:1320. (Abstr.).

Kress, D. D., E. R. Hauser and A. B. Chapman. 1969. Efficiency of production and cow size in beef cattle. J. Anim. Sci. 29:373.

Kropp, J. R., D. F. Stephens, J. W. Holloway, J. V. Whiteman, Leon Knori and Robert Totusek. 1973. Performance on range and in drylot of two-year-old Hereford, Hereford X Holstein and Holstein females as influenced by level of winter supplementation. J. Anim. Sci. 37:1222.

Lusby, K. S., D. F. Stephens and Robert Totusek. 1976. Effects of milk intake by nursing calves on forage intake on range and creep intake and digestibility in drylot. J. Anim. Sci. 43:1066.

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

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

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

McGinty, D. D. and W. G. Frerichs. 1971. Milk yields and calf performance from crossbred and Hereford cows. J. Anim. Sci. 33:210. (Abstr.).

Neel, James Barkett. 1973. The influence of initial cow weight on progency performance and TDN efficiency in production of slaughter cattle. Ph.D. Thesis. University of Tennessee, Knoxville.

Neville, W. E., Jr. 1962. Influence of dams milk production on 120- and 240-day weight in Hereford calves. J. Anim. Sci. 21:315.

Neville, W. E., M. C. McCullough, O. E. Sell and D. M. Baird. 1952. The effect of three levels of milk feeding to young calves on their growth rate and feed consumption. J. Anim. Sci. 11:772. (Abstr.).

N.R.C. 1976. Nutrient Requirements of Domestic Animals, No. 4. Nutrient Requirements of Beef Cattle. National Research Council, Washington, D.C.

Omar, M. A., R. R. Frahm, R. H. Mizell and A. B. Cobb. 1977. A comparison of milk production in Angus and Hereford cattle under range conditions. Okla. Agr. Exp. Sta. MP-101 p. 17.

Owens, J. B. 1953. Milk yield of hill ewes. Nature 172:636.

Pinney, D. O. 1963. Effect of extremes in winter nutrition on growth and production performance of beef females. Ph.D. Thesis. Oklahoma State University, Stillwater.

Plum, M. and L. Harris. 1971. Holstein cows and calves under beef cattle management. J. Dairy Sci. 54:1086.

Pope, L. S., L. Smithson, D. F. Stephens, D. O. Penney and M. Velasco. 1963. Factors affecting milk production of range beef cows. Okla. Agr. Exp. Sta. Progr. Rpt. p. 69.

Schwulst, F. J., L. J. Sumption, L. A. Swiger and V. H. Arthand. 1966. Use of oxytocin for estimating milk production of beef cows. J. Anim. Sci. 25:1045.

Smithson, L. J. 1966. An analysis of the relative difference in the weights of bovine males and females at birth and weaning. M.S. Thesis. Oklahoma State University, Stillwater.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods. (6th Ed.). Iowa State University Press, Ames, Iowa.

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

Velasco, M. 1962. Level of winter feeding of range beef. M.S. Thesis. Oklahoma State University, Stillwater.

Williams, C. H., D. L. David and O. Iismaa. 1962. The determination of chromic oxide in feces samples by atomic absorption spectrophotometry. J. Agr. Sci. 59:381.

Wilson, L. L., J. E. Gillooly, M. C. Rugh, C. E. Thompson and H. R. Purdy. 1969. Effects of energy intake, cow body size and calf sex on composition and yield of milk by Angus-Holstein cows and pre-weaning growth rate of progeny. J. Anim. Sci. 28:789.

Wistrand, G. C. and J. K. Riggs. 1966. Milk production of Santa Gertrudis cows as measured by calf nursing and machine milking methods. J. Anim. Sci. 25:263. (Abstr.).

Wyatt, R. D., M. B. Gould, J. V. Whiteman and Robert Totusek. 1977a. Effect of milk level and biological type on calf growth and performance. J. Anim. Sci. (In press).

Wyatt, R. D., K. S. Lusby, J. V. Whiteman, M. B. Gould and Robert Totusek. 1977b. Performance of 4- and 5-year-old Hereford, Hereford X Holstein and Holstein cows on range and in drylot. J. Anim. Sci. (In press).

VITA

Kent C. Barnes

Candidate for the Degree of

Master of Science

Thesis: EFFECT OF MILK INTAKE LEVELS ON PERFORMANCE OF CALVES DIFFERING IN GROWTH POTENTIAL

Major Field: Animal Science

Biographical:

Personal Data: Born in Stillwater, Oklahoma, February 17, 1952, the son of Elmo and Inez Barnes.

Education: Graduated from Perkins High School, Perkins, Oklahoma, 1970; received the Associate of Science, Agriculture, degree from Murray State College, Tishomino, Oklahoma in May, 1972; received the Bachelor of Science degree from Oklahoma State University, Stillwater, Oklahoma, with a major in Animal Science in May, 1974; received the Master of Science degree in December, 1977.

Professional Experience: Raised on a farm and ranch in Central Oklahoma; worked on livestock farm at Murray State College, 1970-1972; employed by the Cimmarron Valley Co-op, 1974; Extension Agent, 4-H for Oklahoma State University Extension Service 1975 - 1976; research and teaching assistant in the Department of Animal Science and Industry, Oklahoma State University, Stillwater, Oklahoma, 1976 - 1977.

Professional Organizations: Oklahoma Associations of County Extension Agents, American Society of Animal Science, Omicron Delta Kappa, Alpha Zeta, Phi Kappa Phi, and Phi Theta Kappa.