EFFICIENCY ON RANGE AND IN DRYLOT OF HEREFORD, HEREFORD X HOLSTEIN AND HOLSTEIN FEMALES AND THEIR PROGENY

By

LARRY DALE RIDENOUR

Bachelor of Science in Agriculture

New Mexico State University

Las Cruces, New Mexico

1975

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

EFFICIENCY ON RANGE AND IN DRYLOT OF HEREFORD, HEREFORD X HOLSTEIN AND HOLSTEIN FEMALES AND THEIR PROGENY

Thesis Approved:

Robert Totusek
Thesis Adviser

Gerald W. Horn

Joseph Whiteman

Norman N. Durham
Dean of Graduate College

ACKNOWLEDGMENTS

I wish to express my appreciation to my major professor, Dr. Robert Totusek, for his support, assistance and encouragement during the course of my work.

Special acknowledgment is extended to Dr. Joe V. Whiteman, Dr. Gerald W. Horn and Dr. Keith S. Lusby for their suggestions and evaluation while serving on the guidance committee.

Special thanks are extended to Leon Knori, Wayne Brown, Ed Stelting and Jack Eason at the Southwestern Livestock and Forage Research Station for their care of the experimental animals. Appreciation is also extended to Mike Brown and Dave Thomas for their assistance with the statistical analysis of the data. Thanks to Dennis Roberts and Julie White in the compiling and organizing of the data.

I would like to thank Dr. Roger Wyatt, Ron Lemenager, Kent Barnes and other former and present graduate students for their encouragement and assistance with the project.

A very special thanks and acknowledgment goes to the author's wife, Melanie, for her understanding, encouragement and cooperation during the course of this program of study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Due to the rising costs of production in the last few years, cattlemen have become more aware of the need to dilute fixed maintenance costs to remain in business. One of the ways to do this on the cow-calf level is to increase weaning weight. The most rapid way of increasing weaning weight is by the infusion of dairy breeding into the herd. This method however, not only increases the milk yield of cows and thus weaning weight, but also increases the nutritive requirements of the cow.

With increased milk levels, the question arises; what are the relative performances in producing beef at different milk levels? Related to this and increased nutritive requirements, is the question, what is the relative efficiency of beef production at different levels of milk production? Answers to these questions will be attempted, but will be studied from an opposite approach; what are the changes in preweaning growth and relative efficiencies of beef production with increasing increments in milk yield over a wide range?

CHAPTER 2

REVIEW OF LITERATURE

This review will survey the literature in regard to: (1) the effect of milk production level of cows on preweaning calf performance; (2) the efficiency of energy utilization for lactation as compared to other body functions, and (3) the efficiency of energy utilization at varying levels of milk production and feed intake.

Effect of Milk Production Level of Cows on Calf Performance

The ability of the dam to produce milk is an important factor in any cow herd. Emphasis placed on weaning weight of the calf automatically results in emphasis placed on the milk production of the dam due to the high correlation between milk intake and weaning weight.

Knapp and Black (1941) found the correlation between daily gain of the calf and quantity of milk consumed was 0.517 ($P<.01$). Of the feeds consumed prior to weaning, milk had the greatest effect on rate of gain, followed in order by grain and hay.

Drewery et al. (1959) published the milk production of 48 Angus cows for a twenty-two hour period in the first, third and sixth month of lactation. Correlations between total gain from birth and estimated daily milk production for these periods were -0.15, 0.35, 0.48, respectively. Velasco (1962) reported correlations between milk production and average daily gain of calves to be 0.96, 0.68 and 0.57 ($P<.01$) for the first three months of lactation, respectively. Correlations decreased thereafter until the month prior to weaning when it increased to 0.77. Velasco (1962) also reported correlations for the entire lactation between daily milk production and daily calf gain from birth to weaning of 0.76 and 0.55 for cows fed a low and high level of winter nutrition. In a similar study, but with fall calving cows Furr (1962) found correlations between milk yield and calf gain to be 0.81 and 0.85 for cows fed a low and high level of winter nutrition. These values agree with results by Pinney (1962).

Gifford (1953) in an extensive study relating to milk production of beef cows and suckling calves determined the daily quantity of milk produced once each month over an 8-month lactation. Correlation coefficients between daily milk production of Hereford dams and monthly gain of calves within months were 0.60, 0.71, 0.52, 0.35, 0.19, 0.24, 0.39 and 0.57 for the first to the eighth month, respectively. This decline in the correlation between milk consumption and weight gain as lactation progresses, also agrees with work done by Brumby et al. (1963), Gleddie and Berg (1968), Neville (1962), and Velasco (1962).

Other workers (Drewery et al., 1959; and Totusek and Arnett, 1965) reported an increase in the correlation between estimated daily milk consumption and calf weight gain as lactation progressed.

Schwulst et al. (1966) obtained milk consumption estimates for the early part of lactation. Non-significant correlations of 0.36, 0.23 and 0.23 between average daily gain and milk consumption were reported for the second, third and fifth weeks after birth. Neville et al. (1952) conducted a similar experiment, only calves were hand fed milk at a rate of 10%, 14% or 18% of their body weight, with adjustments made weekly. Consumption ranged from 9 to 23 pounds of milk daily at the end of six weeks. Differences in growth rate for the first six weeks were significant ($P<.01$) between the 10% and 18% levels and the 10% and 14% levels.

Klett et al. (1965) reported non-significant correlations between milk intake and calf weight at various stages of lactation in a Hereford herd. However, correlations ranging from 0.67 to 0.81 (P?.01) were reported for an Angus herd suggesting that the Angus cows provided a greater proportion of nutrients to their calves in the form of milk than Hereford dams.

Several researchers have indicated that the relationship between average milk composition of the lactation and calf gain is near zero. Klett et al. (1965) concluded that the composition of the milk had little, if any, effect on calf weight as measured by non-significant correlations. Melton et al. (1967a) found that the correlations between total gain of the calf and percent butterfats, solids-not-fat and total solids were near zero in agreement with Wilson et al. (1969).

Gleddie and Berg (1968) reported that average milk yield accounted for 71.3% of the variation in average daily calf gain, while percent total solids accounted for an additional 2.7% and the inclusion of percentages of protein, solids-not-fat and butterfat accounted for only an additional 0.5%.

Christian et al. (1965) however reported a significant correlation of 0.40 between total butter fat yield from 0 to 60 days and calf weaning weight suggesting that this concentrated source of energy was important when rumen development was limited. Similar observations with sheep were made by Burris and Brangus (1955) and Owens (1953).

The most rapid way of increasing the milk production of beef herds is by the infusion of genes from dairy breeds. McGinty and Frerichs (1971) reported average daily milk yield estimates of 8.6, 6.0 and 5.2 kg for Brown Swiss x Hereford cows at 85, 135 and 180 days of lactation; respectively, compared to 4.0, 4.1 and 3.3 kg for Hereford cows on the same days of lactation. Boston et al. (1972) reported that Angus x Holstein cows as two-year-olds produced 5.7 kg of milk daily compared to 4.0 kg for Angus cows. As three-year-olds, the Angus x Holstein cows produced 6.3 kg of milk daily compared to 5.2 kg for Angus cows.

Kropp et al. (1973b) and Holloway et al. (1975a) reported that Holsteins managed under range and drylot conditions weaned heavier calves and produced more milk than either Hereford cows or Hereford x Holstein cows. Hereford cows produced approximately half as much milk as the Holstein cows with the Hereford x Holstein cows being intermediate.

Since there is a positive relationship between increased milk production and increased weaning weight, a consideration of primary importance is the relative efficiency with which this milk is converted to calf gain. Wilson et al. (1969), working with Angus x Holstein females reported a ratio of daily milk yield to daily calf gain of 11.2:1. Milton et al. (1967a) with data from Angus, Charolais and Hereford cows concluded that 5.2 kg of milk were required to produce 1 kg of calf gain. Several other researchers (Montsoma, 1960; Wistrand and Riggs, 1966; Nevil, 1962; and Kress, Houser and Chapman, 1968) reported efficiencies ranging from 4.0 to 23.5 kg of milk per kilogram of calf gain in a wide variety of 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 of age to 50 kg at 24 weeks of age. However, when calves were allowed free access to pasture, Drewry, Brown and Honea (1959) reported that efficiency improved with age. Angus calves in their 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, respectively.

Plum and Harris (1971) reported that Holstein calves nursing their dams required 12.2, 12.7, 12.2, 12.0, 11.6 and 11.5 pounds of milk to produce a pound of calf gain at 23.5, 51.5, 83.0, 116.5, 155.0 and 190.5 days after calving, respectively. The mean conversion rate for the entire lactation was 12.0:1 with respect to pounds of milk per pound of calf gain.

Deutscher (1970) observed that the calves of Angus cows required 6.0 kg of milk per kilogram of gain compared to 7.1 for calves of Angus x Holstein cows. Deutscher reasoned this trend of less efficient conversion of milk to calf gain as milk consumption increases, may be to the larger maintenance requirements of the larger calves.

Efficiency of Energy Utilization for Lactation Compared to Other Body Functions

In some of the earliest studies on energy utilization Forbes et al. (1926a) and Fries et al. (1924) found that energy for lactation may be used 22% more efficiently than for body increase. Blaxter (1956) reported that the secretion of milk energy was a more efficient process than fat disposition and that the energy cost of deposited fat synthesis was greater than for milk fat synthesis. Relating growth and muscular work to this, Blaxter noted that growth was more energetically efficient than fattening and muscular work was the least efficient function of all.

Flatt (1964) reported the efficiency of conversion of metabolizable energy (ME) to milk to be 70.2 $\pm$ 4.0%. Similar values were reported by Kellner and Fingerling (1956), Molgaard and Lund (1929), and Ritzman and Benedict (1938) as reported by Coppock et al. (1964a). Slightly higher values of 81% were reported by Fries (1924) and Van Es (1961).

Physiological status of the cow may affect the efficiency of conversion of ME to tissue. Moe, Tyrrell and Flatt (1971) reported that tissue reserves may be replenished in late lactation with an efficiency equal to or exceeding that of milk production. Flatt (1964) noted this increased efficiency during lactation stating that lipogenesis may be more efficient during lactation than after. Reid (1961, 1962) and Blaxter (1962) similarly indicated that utilization of ME for lipogenesis during lactation was 70.2% whereas the corresponding efficiency in non-lactating animals was 58.4%.

Explanations for increased efficiency of gain during lactation vary. It is known that acetate is the precursor of milk fat and that the mammary gland takes up a considerable amount of acetic acid (Coppock, et al., 1964b). Armstrong and Blaxter (1965) hypothesized that removal of acetate left the most efficient metabolites available for body fat synthesis. Orskov and Allen (1966) and Bull et al. (1967) however, found no difference in the efficiency of acetate, propionate, or butyrate to promote gains in body tissue in non-lactating sheep.

Efficiency of Energy Utilization as Milk Production and Feed Intake Increase

Several workers (Mason et al., 1957; Baumgardt, 1967; Moe et al., 1965) have stated that the efficiency of milk production is improved as milk yield increases. However, Moe et al. (1965) reported that as the output of milk increases, the efficiency increases at an ever decreasing rate as the energy input increases.

One reason for increased efficiency at higher levels of production may be the dilution of the fixed cost of maintenance as intake increases (Mason et al., 1967; Wagner and Loosli, 1967). Another possibility reported by Flatt (1964) was that heavy milking breeds (Holsteins) at the peak of lactation may not consume sufficient dietary energy to sustain such levels and commit body tissue to produce milk.

Moe et al. (1965) and Baumgardt (1967) concluded that the diminishing returns effect was brought about by (1) a decrease in digestibility as intake increases, (2) a larger proportion of energy being diverted to new body tissue synthesis and (3) lesser efficiency of tissue synthesis compared to lactation. Baumgardt (1967) reported that another cause of this effect could be increased proportions of energy lost to body heat. However, this is in disagreement with Reid and Tyrrell (1964) who concluded that a diet of constant composition fed at levels of 3x maintenance resulted in a constant proportion of ME lost as heat.

Several workers have noted a decrease in digestibility as intake increases. Flatt (1964) reported a depression in digestibility as intake increases. Flatt (1964) reported a depression in digestibility up to 23% when dairy cows were fed at a level six times the maintenance requirement. Wagner and Loosli (1967) and Reid and Tyrrell (1964) noted similar trends. Brown (1966) working with both sheep and cattle at two levels of intake noted an apparent lower digestibility and therefore less efficient energy intake at the high level for both species.

Blaxter (1962) and Moe, Reid and Tyrrell (1965) investigated the losses of energy in urine and as methane as intake increased. They found no increase or even a slight decrease in energy lost in these forms with increased intake. This resulted somewhat in the stabilization of ME conversion to milk with increasing consumption.

Hashizume et al. (1965) and Baumgardt (1967) reported a linear response between level of ME input and milk energy output with levels of intake of 3 to 4.5 times maintenance, suggesting that a difference in the efficiency of the mammary gland is not a factor. Therefore, it appears that the decrease is digestibility with increased levels of intake is the main factor for the diminishing returns effect.

CHAPTER 3

EFFICIENCY OF BEEF PRODUCTION OF FOUR AND FIVE-YEAR-OLD HEREFORD, HEREFORD X HOLSTEIN AND HOLSTEIN FEMALES ON RANGE AND IN DRYLOT[1,2,3,4]

Summary

Efficiency of production of third and fourth calf Hereford, Hereford x Holstein (Crossbred) and Holstein cows, was compared under both range and drylot conditions. Two levels (Moderate and High) is a 30% protein supplement were fed to groups of cows within each breed. A group of Holstein cows was fed an additional level (Very High). Drylot cows were fed roughages and concentrates to simulate seasonal changes in energy intake of range cows.

Holstein cows in drylot consumed 866 and 577 more Mcal of digestible energy (DE) than Crossbreds which consumed 1083 and

---

[1]Journal article of the Agriculture Experiment Station, Oklahoma State University, Stillwater 74074.

[2]L.D. Ridenour, Robert Totusek, M.B. Gould, J.V. Whiteman, and L.E. Walters, Oklahoma State University, Stillwater 74074.

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

[4]Appreciation to K.S. Lusby and R.D. Wyatt for collection of data.

876 more Mcal than Herefords in the third and fourth years respectively. Holsteins produced more ($P<.05$) milk gross energy (GE) in both years than Crossbreds which produced more than Herefords.

Holstein calves were heavier ($P<.05$) at weaning and consumed more milk DE ($P<.05$) than the other breeds, but were the least efficient in converting milk DE to weaning weight. Herefords were the most efficient ($P<.05$) in this respect with Crossbreds not being ($P>.05$) different from the Holsteins. No advantage was exhibited ($P>.2$) by any breed in converting total DE intake (DE intake by cow and creep DE intake by calf) to weaning weight. This was due to the inverse relationship between the efficiency of cows to convert DE intake to milk GE and the calves ability to convert milk energy to weaning weight.

Herefords and Crossbreds were more efficient ($P<.05$) than Holsteins at converting cow or cow and calf DE intake to kilograms of high priced cuts. Herefords were the most efficient ($P<.05$) at converting DE intake of cow or cow and calf to carcass GE followed by Crossbreds and Holsteins respectively.

Introduction

Increasing milk production potential in the beef cow herd by the infusion of dairy breeding has been shown to increase calf weaning weight (Deutscher and Whiteman, 1971; Holloway et al., 1975a; and Wyatt et al., 1977). Reid, Moe and Tyrrell (1966) and Baumgardt (1967) have shown that increasing the level of milk yield in dairy cows increases the efficiency of lactation.

Holloway et al., (1975b) found that Holstein cows converted DE intake into milk GE more efficiently than did Hereford or Hereford x Holstein cows.

Indications are, however; that progeny from cows with dairy breeding are not as efficient as progeny from beef cows post weaning. Burroughs et al. (1965) and Minish et al. (1966) reported faster but less efficient gains when dairy calves were compared to British breeds when fed to an equal weight endpoint. Dean et al. (1976a) reported that calves of Holstein cows required more feed and a longer feeding period than calves of Hereford cows when slaughtered at approximately equal quality grade. Holloway et al. (1975b) found that Hereford calves were more efficient in converting DE intake to carcass GE than Crossbreds of Holsteins.

The objectives of this research were 1) to compare the efficiencies of converting feed energy to weaned calf weight by cows varying widely in milk production potential and percent dairy breeding and 2) compare the postweaning efficiencies of converting feed energy to carcass weight by calves of these cows when slaughtered at approximately equal grade.

Materials and Methods

Lactating 4- and 5-year-old Hereford, Hereford x Holstein (Crossbreds) and Holstein cows were maintained under drylot conditions or on native tallgrass range at the Southwestern Livestock and Forage Research Station (El Reno). Management practices for these cows were described in detail by Kropp et al.

(1973a,b) and Holloway et al. (1975a) who reported the performance of these cows as 2- and 3-year-olds and Wyatt et al. (1977) who reported their performance as 4- and 5-year-olds. Only a general review of management procedures and practices which deviated from the previous reports will be discussed here. Within each breed, range and drylot groups of cows were fed two levels of winter supplementation designated as Moderate or High. An additional Very High level was fed to another group of Holsteins. The Moderate, High and Very High levels represented the amount of supplementation deemed necessary to maintain a high level of reproductive performance in Hereford, Crossbred and Holstein cows, respectively. Moderate Herefords, High Crossbreds and Very High Holsteins were considered the base groups. The supplementation period was November 15 - April 16 for 4-year-olds and November 26 to April 16 for 5-year-olds. A 30% natural crude protein supplement was fed five times per week on the range and daily in the drylot but prorated so that the same amounts were fed on range as in drylot. Amounts of supplement fed are shown in table 3.1.

All cows were maintained on range prior to calving. Assignment to drylot was made on the basis of calving date and calf sex so that each drylot breed-treatment group contained three males and two female calves.

Drylot cows were individually fed forages 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

TABLE 3.1. SUPPLEMENT AND ROUGHAGE INTAKE LEVELS OF FOUR AND FIVE-YEAR-OLD HEREFORD, HEREFORD X HOLSTEIN AND HOLSTEIN LOWS IN DRYLOT

	Breed and Level of Winter Supplement						
	Hereford		Crossbred		Holstein		
	Moderate	High	Moderate	High	Moderate	High	Very High
Third lactation							
DE intake from supplement (Mcal)	346.8	786.1	338.2	838.7	307.8	844.8	1637.4
DE intake from roughage (Mcal)	4969.7	5712.2	6251.5	6552.1	7063.0	7496.2	6638.8
Fourth lactation							
DE intake from supplement (Mcal)	455.1	881.4	482.8	876.0	592.6	870.4	1199.9
DE intake from roughage (Mcal)	5898.0	6177.3	6949.2	6856.1	7005.0	8760.8	8326.0

until each cow's calf was weaned at 240 $\pm$ 7 days of age. Cows were fed during a 4 hour period each day at which time drylot calves received a creep ration *ad libitum* in individual pens. No creep was fed on range. The pelleted creep ration consisted of (5): corn, dent yellow,grain, gr 2 us mn 54 wt, IRN 4-02-931, 49.5; chopped alfalfa hay, 15; cottonseed hulls, 10; soybean, seed wo hulls, solvextd, mx 3 fbr, IRN 5-04-612, 17.5; sugarcane, molasses, mn 48 invert sugar 79.5 degrees bris, IRN 4-04-696, 5; wheat flour by-product, mx 9.5 fbr, IRN 4-05-205, 3.

Both range and drylot cows were artifically inseminated to one Charolais bull for 60 days and pasture exposed to seven Charolais bulls for 30 days to calve in December, January and February. Most calves in drylot were from the same sire.

Cow weights, 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, July) points, respectively, during lactation.

Postweaning, drylot calves were individually fed in box stalls from 4 pm to 8 am and placed as a group in an outside loafing pen for the remainder of the day. Range calves were group fed. The feedlot rations for the drylot and range calves are shown in tables 3.2 and 3.3, respectively.

Each calf was fed to an estimated quality grade of low-choice based on subjective evaluation of apparent fatness. At slaughter, warm carcass weight, chilled carcass weight, rib-eye area, and fat thickness over the 12th rib were obtained and

TABLE 3.2. 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			
Soybeam 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

TABLE 3.3. 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

percent kidney, heart and pelvic fat was estimated. The equation of Murphey et al., (1960) was employed to calculate percent retail cuts. Gross energy of the carcass of drylot calves was determined by specific gravity (Kraybill, Bitter and Hankins, 1952). Specific gravity data for the fourth calf crop was lost and thus carcass GE estimates for this calf crop were unavailable.

For comparison of range and drylot cows, estimates of energy outputs and inputs of range cows were based on the averages of breed-treatment groups; thereby preventing statistical analysis. DE intake of range cows during lactation was calculated by: DE requirement = DE required for maintenance + DE required for weight gains - DE available from weight loss + DE required for milk production. DE required for maintenance was calculated by $NE_m = 0.077 \text{ weight}^{.75}$ (Nutrient Requirements of Domestic Animals, Number 6, 1976) and assuming that NE is 70% of ME and ME is 82% of DE (Crampton and Harris, 1969). DE required for weight gain and DE available from weight loss were from weight changes and the values of Knott, Hodgson and Ellington (1934) and Swift (1957). DE required for milk production was calculated by: DE milk = 4% fat corrected milk (FCM) x 0.3 lb TDN/lb 4% FCM x 2 Mcal DE/lb TDN. This equation was derived from Moe, Reid and Tyrrell (1965), Moe, Tyrrell and Flatt (1971) and Swift (1957). Milk production in the above equation was estimated from range cows whereas the percent butterfat was estimated from drylot cows. Milk GE of the range cows was estimated by the equations developed by Tyrrell and Reid (1966): Milk GE = milk production (lb) (41.84 (butterfat (%)) + 22.29 (solids-not-fat (%)) - 25.58.

The value for milk production was that estimated for range cows; milk composition was that estimated from drylot cows.

Statistical analysis was appropriate only for the drylot phase. In analyzing variables concerning only the cows the Very High Holstein cows were omitted to create a 3 x 2 factorial design using three breeds (Hereford, Crossbred, Holstein) and two treatments (Moderate and High) as factors. The "F" tests associated with these analyses of variance were employed to determine breed, treatment and breed x treatment effects. Very High Holsteins were then compared to all other groups by the least significant difference (LSD) procedure (Steele and Torrie, 1960). Due to poor rebreeding of the Moderate Holsteins after the third calf crop and calf deaths among other groups, the standard sex distribution in drylot (three steers, two heifers) was not obtained for every breed-treatment group and a disproportionate calf sex distribution resulted. All variables concerning the calf were analyzed by least squares analyses including three breeds, two levels of supplementation (Moderate and High) and two sexes. Discussion of breed and treatment means has reference to these least square means. A least squares analysis of variance was then calculated including the Very High Holsteins; the model included sex of calf and breed treatment group. Including sex in this model resulted in empty cells causing the $(X'X)^{-1}$ matrix not to be of full rank. Thus, these estimates of means and variances are not the best linear unbiased estimates but are unbiased. The breed-treatment means refer to these least square sex adjusted means. The mean square associated with the error term of these breed-treatment groups adjusted for sex was used in calculation of LDS to compare the Very High Holsteins to other breed-treatment groups.

Results and Discussion

The discussion of cows efficiency will be organized into three endpoints of production: milk yield, weaning weight, carcass beef. Discussion will primarily concern the drylot phase but reference will be made to range data for comparison purposes.

Efficiency of Milk Yield

Several limitations of these calculated efficiencies are recognized. First, the gross efficiencies were calculated from tabular material and fail to take into account any individual differences in digestibility by cow and calf due to breed and level of supplementation. Second, cows in different breed and supplementation groups may lose different amounts and types of body tissue during weight loss periods. Since tissue energy is converted to milk energy with an efficiency of 84% and replaced during lactation with an efficiency of 75% (Moe, Tyrrell and Flatt, 1971), the efficiency at which milk energy was produced could be affected, but no detected in these calculations. Tissue energy change could not be monitored in this trial because of the unknown body tissue change (Flatt et al., 1965). Third, the gross efficiencies were based on the estimated milk GE calculated by the equation of Tyrrell and Reid (1966). Although the equation was precise in predicting the energy content in the range of butterfat and solids-not-fat tested, some values observed in this study were outside of the population from which the equation was derived.

These gross efficiencies do however have a practical application because producers are most interested in production efficiency in terms of inputs versus outputs.

Breed affected ($P<.01$) the amount of DE intake in both years. Herefords, Crossbreds and Holsteins consumed 5,907, 6,990, 7,856 and 6,706, 7,582, 8,159 Mcal during their third and fourth lactation, respectively (table 3.4). Increases in the fourth lactation are due to increases in roughage intake. Level of winter supplementation affected ($P<.01$) the amount of DE consumed with High level cows consuming 984 (13.3%) and 709 (9.0%) more Mcal than the Moderate level cows in the third and fourth lactation, respecitvely. Very High Holsteins however consumed slightly less DE than High Holsteins in both years. As two- and three-year-olds Very High Holsteins did not consume more ($P>.05$) DE than High Holsteins, Holloway et al., (1975b). Theoretical energy requirements calculated for the range cows were comparable to values of DE intake for drylot cows.

Breed ($P>.2$) and level of supplement ($P>.1$) had no major effect on percent butterfat in the third lactation, however Crossbreds in the fourth lactation produced milk with the highest percent butterfat ($P<.01$). Neither breed or level of supplementation affected ($P>.5$) percent solids-not-fat in either year.

Holsteins produced 8.6% and 11.6% more ($P<.3$) Mcal of milk

TABLE 3.4. LACTATION EFFICIENCY OF FOUR AND FIVE-YEAR-OLD COWS

Item	Breed and Level of Winter Supplement							
	Hereford		Crossbred		Holstein			
	Moderate	High	Moderate	High	Moderate	High	Very High	S.E.
Drylot Third Lactation								
N	5	5	5	5	5	5	5	
DE intake during lactation, Mcal	5317[c]	6498[d]	6590[d]	7391[de]	7371[de]	8341[e]	8276[e]	280.9
Butterfat, %	2.70	2.83	3.04	3.17	2.68	3.24	2.88	.199
Solids-not-fat, %	6.18	6.50	6.83	6.24	6.27	5.62	6.48	.320
Total milk produced, kg[b]	1607[c]	1774[c]	1950[c]	2412[d]	2480[de]	2670[de]	2844[e]	117.1
Milk GE density, kcal/kg	496.4	524.3	559.6	542.4	498.5	518.4	527.2	19.39
Total milk GE produced, Mcal	797[c]	931[cd]	1081[de]	1309[efg]	1229[ef]	1386[fg]	1503[g]	64.5
Efficiency of conversion of DE consumed by cow to milk GE, %	15.07	14.29	16.49	17.70	16.83	16.59	18.11	.869
Drylot Fourth Lactation								
N	5	5	5	5	5	5	5	
DE intake during lactation, Mcal	6353[c]	7059[cd]	7432[d]	7732[d]	7598[d]	8719[e]	8714[e]	239.9
Butterfat, %	2.28	2.59	3.41	3.20	2.78	2.86	2.86	.204
Solids-not-fat, %	9.53	9.55	9.34	9.37	9.14	9.09	9.14	.164
Total milk produced, kg	1195[c]	1428[cd]	1903[cde]	2105[def]	2371[ef]	2548[ef]	2822[f]	157.5
Milk GE density, kcal/kg	622.6	652.0	717.2	698.8	649.2	654.6	656.2	21.22
Total Milk GE produced, Mcal	742	928	1372	1462	1542	1663	1857	113.5
Efficiency of conversion of DE consumed by cow to milk GE, %	11.67	13.14	18.33	18.77	20.57	19.07	21.30	1.345
Range Third Lactation								
N	12	13	10	14	10	11	11	
Energy requirement during la tation (Mcal DE)	5433	5747	6175	6455	7016	7737	7659	
Calculated energy produced n milk (Mcal GE)	697	757	1129	1184	1362	1502	1505	
Efficiency of conversion of DE intake to Milk GE, %	12.83	13.17	18.28	18.34	19.41	19.41	19.65	
Range Fourth Lactation								
N	14	12	14	13	a	7	12	
Energy requirement during lactation(Mcal DE)	5269	5537	6806	6463		7386	7367	
Calculated energy produced in milk (Mcal GE)	802.4	873	1543	1612		2020	1962	
Efficiency of conversion of DE intake to milk GE, %	15.23	16.56	22.67	24.95		27.34	26.64	

[a]No Moderate Holsteins on range Fourth Lactation due to poor rebreeding previous year.
[b]240-day lactation period
[c,d,e,f,g]means on the same line with the same superscript are not significantly different (P>.05).

GE than Crossbreds which produced 27.6% and 41.0% more ($P<.01$) Mcal than the Herefords in the third and fourth lactations, respectively. Although Holsteins produced the most total milk GE, Crossbred cows had a greater ($P<.1$) milk energy density. This is a reflection of only a slightly smaller amount of total milk GE (113 and 186 Mcal less for third and fourth years) being produced in a substantially lesser amount of total milk (393 and 456 kilograms for the third and fourth years) by the Crossbreds.

In drylot, level of supplement did not significantly affect ($P>.5$) the efficiency with which estimated DE intake was converted to milk GE. However, as supplementation increased, the efficiency of DE conversion to milk GE tended to increase. Similar calculations for range cows revealed the same trends. Breed did affect ($P<.01$) the efficiency of conversion of DE intake to milk GE. Holsteins and Crossbreds were not significantly different ($P>.1$) in either year but were more efficient ($P<.05$) than Herefords in both years.

Efficiency of Weaned Calf Production

Daily total DE intake of calf (creep and milk) was influenced by breed of dam ($P<.07$ and $P<.01$) in both years of production (Table 3.5). Daily sex adjusted total DE intakes for calves of Holstein, Crossbred and Hereford cows were 10.3, 10.2, 9,3 (third year) and 10.1, 9.4, 7.6 (fourth year) Mcal. DE intake from creep was not significantly affected ($P>.25$) by breed for level of supplementation.

TABLE 3.5. EFFICIENCY OF FOUR AND FIVE-YEAR-OLD COWS TO TIME OF WEANING PROGENY

Item	Breed and Level of Winter Supplement: Hereford Moderate	Hereford High	Crossbred Moderate	Crossbred High	Holstein Moderate	Holstein High	Holstein Very High	S.E.[a]
Drylot Third Lactation								
Creep DE intake by calf, Mcal/day	6.35	5.30	5.07	5.89	5.42	4.73	4.35	.473
Daily total DE intake by calf, Mcal/day	9.55	9.01	9.38	10.99	10.30	10.30	10.26	.505
Weaning weight, kg	253^{bc}	248^{b}	274^{bc}	296^{cd}	293^{cd}	308^{d}	308^{d}	12.1
Efficiency of conversion of milk DE to weaning weight, kg/Mcal	0.3393^{d}	0.2839^{c}	0.2656^{bc}	0.2435^{bc}	0.2535^{bc}	0.2352^{bc}	0.2180^{b}	.01454
Efficiency of conversion of DE intake by cow to weaning weight of calf, kg/Mcal	0.0477^{c}	0.0384^{b}	0.0416^{b}	0.0401^{b}	0.0393^{b}	0.0369^{b}	0.0375^{b}	0.00155
Efficiency of conversion of feed DE intake by cow and calf to weaning wt of calf, kg/Mcal	0.0371	0.0318	0.0351	0.0336	0.0335	0.0324	0.0332	0.00131
Efficiency of conversion of DE intake by calf to weaning weight kg/Mcal	0.1108	0.1144	0.1232	0.1123	0.1191	0.1251	0.1251	0.00509
Drylot Fourth Lactation								
Creep DE intake by calf, Mcal/day	4.62	4.09	3.94	3.70	3.77	4.30	3.54	.333
Daily total DE intake by calf, Mcal/day	7.49^{b}	7.71^{bc}	9.32^{cd}	9.52^{d}	6.83^{b}	10.83^{de}	11.19^{e}	.449
Weaning weight, kg	254^{b}	255^{b}	274^{bc}	287^{c}	297^{c}	329^{d}	330^{d}	8.3
Efficiency of conversion of milk DE to weaning weight, kg/Mcal	0.3734^{d}	0.2953^{c}	0.2197^{b}	0.2172^{b}	0.2027^{b}	0.2122^{b}	0.1894^{b}	0.02071
Efficiency of conversion of DE intake by cow to weaning weight of calf, kg/Mcal	0.0399	0.0365	0.0373	0.0372	0.0337	0.0379	0.0379	0.00126
Efficiency of conversion of feed DE intake by cow and calf to weaning wt.of calf, kg/Mcal	0.0340	0.0308	0.0331	.0334	0.0314	0.0339	0.0345	0.00105
Efficiency of conversion of DE intake by calf to weaning wt kg/Mcal	0.1421	.1377	0.1245	0.1266	0.1776	0.1277	0.1235	0.00540
Range Third Lactation								
Weaning weight, Kg	245^{b}	253^{b}	266^{bc}	286^{cd}	321^{e}	310^{de}	308^{de}	7.2
Efficiency of conversion of milk DE to weaning weight, kg/Mcal	0.3699	0.3518	0.2480	0.2543	0.2481	0.2173	0.2154	
Efficiency of conversion of DE intake by cow to weaning wt of calf kg/Mcal	0.0451	0.0440	0.0431	0.0443	0.0458	0.0401	0.0402	
Range Fourth Lactation								
Weaning weight, kg	271^{bc}	264^{b}	287^{cd}	292^{de}		319^{f}	308^{ef}	5.7

TABLE 3.5. (Continued)

Item	Breed and Level of Winter Supplement							S.E.[a]
	Hereford		Crossbred		Holstein			
	Moderate	High	Moderate	High	Moderate	High	Very High	
Efficiency of conversion of milk DE to weaning weight, kg/Mcal	0.3555	0.3183	0.1958	0.1907		0.1662	0.1652	
Efficiency of conversion of DE intake by cow to weaning weight of calf kg/Mcal	0.0514	0.0477	0.0422	0.0452		0.0432	.0418	

[a] Standard errors computed on N=5 for third lactation and N=4 for fourth lactation.
[b,c,d,e,f] Means on the same line with the same superscript are not significantly different (P>.05).

Breed of dam affected ($P<.01$) calf weaning weight. As the amount of dairy breeding of the dam increased so did the calf weaning weight. Level of supplementation did not significantly affect ($P>.2$) weaning weight in the third year, although in the fourth year High level cows produced heavier ($P<.05$) weaning weights. This agrees with the slightly higher total intakes of DE per day by calves from dams on the high level of supplementation in the fourth years.

Hereford calves in drylot were more efficient ($P<.05$) in both years than Crossbred or Holstein calves in converting milk DE to weaning weight. Efficiencies for Crossbreds and Holsteins were not different ($P>.5$) in either year. However, from theoretical calculations, Crossbred calves on range were consistently more efficient than Holstein calves and Hereford calves were again the best in converting milk DE to weaning weight.

Gifford (1953) and Deutscher (1970) reported decreased efficiencies for larger calves and concluded that reduced efficiency was due to the higher maintenance requirements of larger calves. In this study, however; differences in maintenance requirement cannot totally account for the increased efficiencies of Herefords over Holsteins. Holsteins had greater preweaning average daily gains than Herefords thus increasing the dilution of their maintenance requirements. Preweaning weight gains were 1.26, 1.32 kg/day for Holsteins and 1.04, 1.06 kg/day for Herefords in third and fourth years respectively. Holloway et al. (1975b) suggested that increased efficiencies by Herefords vs Holsteins for converting milk to weaning weight were due to inherent metabolic differences resulting from years of selection pressure for progeny performance in the Hereford breed.

Level of supplementation affected ($P<.05$) the efficiency at which milk DE was converted to weaning weight in the third year. As supplementation increased, efficiencies decreased due to slightly larger DE intakes from milk by calves of High level cows and a nonsignificant increase in their weaning weight. Supplementation did not have a significant affect ($P>.05$) in the fourth year.

Efficiencies of conversion of total daily calf DE intake to weaning weight was not significantly affected by breed ($P>.2$) in the third year. In the fourth year however, breed did have an effect ($P<.05$). Herefords were 5.3% more efficient than Holsteins who were 5.2% more efficient than Crossbreds. Holstein calves were more efficient than Crossbred calves partially due to the fact that Holsteins were slightly more efficient in converting milk DE to weaning weight that year. Level of supplementation did not have a significant effect in the third ($P>.2$) or fourth ($P>.4$) year.

In the third year of production, breed and level of supplementation affected ($P<.05$) the efficiency at which cow DE intake was converted to weaning weight. Herefords were best in this respect being 5.3% more efficient than Crossbreds who were 6.6% more efficient than Holsteins. Moderate cows were 10.3% more efficient ($P<.05$) than cows fed the High level. High level cows consumed more DE ($P<.05$) in the form of roughage and supplement and there were no significant increases in the weaning weights of their calves. Efficiencies were not affected by breed ($P>.5$) or level of supplementation ($P>.8$) in the fourth year. When comparing the efficiency of converting cow DE intake to weaning weight between range and drylot cows, differences in efficiencies can be partially explained due to increased stress (daily handling) encountered by drylot cows.

Conversion of total DE input (DE intake by cow and creep DE intake by calf) to weaning weight was not significantly affected by breed in either year ($P>.2$ and $P>.25$ third and fourth year). This resulted since cow efficiencies were inversely related to calf efficiencies thereby canceling out any advantage a breed had in one area. Supplement level affected the efficiency of conversion of total DE to weaning weight in the third year when Moderate cows were more efficient ($P<.05$) than High level cows. The affect of supplement level on conversion of cow and calf DE consumption to weaning weight in the fourth year approached significance $P<.15$).

Efficiency of Slaughtered Beef Production

Breed of dam of drylot calves influenced ($P<.01$) the amount of DE intake in the feedlot during both years. Significant ($P<.05$) breed x treatment interactions were encountered in both years. In the third year calves of High level Holsteins and Crossbreds consumed 1,267 and 109 more Mcal DE than calves of Moderate level cows (table 3.6). The trend was reversed with Moderate Hereford calves consuming 1,155 more Mcal DE than High

TABLE 3.6. EFFICIENCY OF FOUR AND FIVE-YEAR-OLD COWS TO TIME OF SLAUGHTER OF PROGENY

	Breed and Level of Winter Supplementation							
	Hereford		Crossbred		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	S.E.[a]
Drylot Third Lactation								
N	5	4	5	5	5	5	5	
Feedlot DE intake, Mcal	4469^{b}	3314^{c}	6216^{d}	6325^{d}	6545^{d}	7812^{e}	7304^{e}	445.4
High priced cuts, %	49.58	48.91	48.25	48.66	50.19	47.62	46.99	0.826
Chilled carcass weight, kg	276.1^{c}	254.7^{b}	303.2^{d}	297.7^{d}	306.6^{d}	327.2^{e}	375.0^{f}	12.19
High priced cuts, kg	136.7^{b}	129.6^{b}	146.1^{c}	155.5^{d}	153.9^{d}	155.7^{d}	176.1^{e}	5.88
Efficiency of conversion of DE intake by calf to high priced cuts, kg/Mcal	0.0204^{cd}	0.0238^{d}	0.0174^{bc}	0.0174^{bc}	0.0171^{bc}	0.0151^{b}	0.0184^{bc}	0.00089
Efficiency of conversion of feed DE intake by cow and calf to high priced cuts, kg/Mcal	0.0113^{e}	0.0108^{de}	0.0097^{cd}	0.0095^{c}	0.0093^{bc}	0.0083^{b}	0.0099^{cd}	0.00032
Carcass water, %	43.2	43.5	42.9	43.1	43.0	42.9	42.6	0.26
Carcass fat, %	39.3	38.8	39.7	39.5	39.6	39.7	40.3	0.42
Carcass protein, %	14.1	14.2	13.9	14.0	14.0	13.8	13.7	0.14
Carcass GE, Mcal	1237.6^{c}	1131.9^{b}	1368.4^{d}	1439.6^{de}	1381.2^{d}	1477.9^{e}	1708.5^{f}	57.17
Efficiency of conversion of DE intake by calf to carcass GE, Mcal/Mcal	0.1840^{cd}	0.2084^{d}	0.1623^{bc}	0.1608^{bc}	0.1535^{bc}	0.1437^{b}	0.1789^{cd}	0.00879
Efficiency of conversion of DE intake by cow and calf to carcass GE, Mcal/Mcal	0.1024^{e}	0.0943^{cde}	0.0904^{bcd}	0.0881^{bcd}	0.0838^{bc}	0.0789^{b}	0.0960^{de}	0.00328
Drylot Fourth Lactation								
N	5	5	5	5	4	4	5	
Feedlot DE intake, Mcal	3760.0^{b}	5131.8^{c}	6723.7^{d}	5990.7^{cd}	9386.9^{f}	6693.0^{d}	8169.2^{e}	624.62
High priced cuts, %	49.61	48.86	48.96	48.49	41.98	48.65	47.47	0.495
Chilled carcass weight, kg	268.0^{b}	280.9^{bc}	306.9^{cd}	302.9^{cd}	442.4^{f}	329.7^{de}	352.7^{e}	9.21
High priced cuts, kg	132.9^{b}	137.1^{bc}	150.2^{cd}	146.6^{bcd}	194.9^{f}	160.4^{de}	167.5^{e}	4.24
Efficiency of conversion of DE intake by calf to high priced cuts, kg/Mcal	0.0210^{d}	0.0197^{cd}	0.0170^{bc}	0.0182^{bcd}	0.0206^{d}	0.0177^{bcd}	0.0157^{b}	0.00094
Efficiency of conversion of feed DE intake by cow and calf to high priced cuts, kg/Mcal	0.0105	0.0098	0.0093	0.0092	0.0106	0.0089	0.0086	0.00032

[a]Standard errors computed on N = 4.

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

Herefords. This interaction can be partially explained by the fact that calves from High Herefords were slaughtered 38 days sooner (average slaughter ages were 403 and 365 days for Moderate and High levels, respectively) than calves from Moderate Herefords. In the fourth year, trends were reversed from those seen in the third year. Calves of Moderate Holsteins and Crossbreds consumed 2,694 and 734 more Mcal DE than calves of High Holsteins and Crossbreds. Calves of High Herefords consumed 1,372 more Mcal DE than did Moderate Hereford calves.

Due to the relatively small differences in percent high priced cuts (maximum range within one year was 1.8%) the influence of breed ($P<.01$) on total kilograms of high priced cuts produced was primarily due to breed influences on carcass weights. Averaging both years, Holsteins produced 9.9 kg more high priced cuts than Crossbreds which produced 15.5 kg more than Herefords.

Although Hereford calves produced the least amount of high priced cuts, they were the most efficient in converting total DE intake (milk and creep + feedlot) to kilograms of high priced cuts. Hereford calves were an average of 27% more efficient than Crossbred calves which were an average of 9.5% more efficient than Holstein calves. Treatment of dam did not significantly affect ($P>.35$ and $>.15$ third and fourth years) the efficiency at which calves converted DE intake to high priced cuts.

The efficiency at which total DE intake of cow and calf was converted to kilograms of high priced cuts was affected ($P<.01$) by breed of dam. Again, Herefords were more efficient (11.5%) than Crossbreds which were an average of 6% more efficient than

Holsteins. Cattle on Moderate level of supplementation were more efficient ($P<.05$) than cattle on High level of supplementation in the third year but not ($P>.5$) in the fourth.

Due to missing specific gravity data for the fourth year of production any further discussion will apply to only the third year of production.

Since cattle were fed to approximately the same degree of fatness, no breed or treatment affects were noted ($P>.4$) on carcass gross energy density. A possible bias does exist with the use of specific gravity to determine carcass energy due to differences in percent bone of beef and dairy breeds. Estimates of differences in bone between Hereford and Holstein carcasses vary from .2 to 2.4% (Cole, Orme and Kincaid, 1960; Bond et al., 1972 and Callow, 1961). However, due to the common breed of sire of the calves, these differences should be small.

As a result of common degree of fatness at slaughter, differences in carcass gross energy due to breed ($P<.01$) were mainly a reflection of the differences in carcass size. Holsteins produced the most carcass GE (1429.4 Mcal) followed by Crossbreds (1403.9 Mcal) and Herefords (1184.3 Mcal).

Although Holsteins produced the most carcass GE, Herefords were the most efficient in converting total calf DE intake (milk and creep and feedlot) to carcass GE. Herefords were 18% more efficient than Holsteins. Garret (1969) reported that Herefords were 20% more efficient in converting feed energy to carcass energy than Holsteins, which is in agreement with these results. He suggested that the difference between the breeds was not due to differences in efficiency of body tissue, but more likely due to different metabolic rates resulting from different selection pressures in the two breeds.

When the conversion of total cow and calf DE (cow intake and milk and creep and feedlot) intake to carcass GE was evaluated, Herefords were more efficient than Crossbreds and Holsteins (9% and 18% respectively). Cattle on the Moderate supplement levels were more efficient ($P<.05$) in converting total cow and calf DE intake to carcass GE than the High supplement level cattle.

CHAPTER 4

EFFICIENCY OF MILK YIELD CONVERSION TO PREWEANING GAIN OF CALVES OF HEREFORD, HEREFORD X HOLSTEIN AND HOLSTEIN FEMALES[1,2,3,4]

Summary

Regression of preweaning gain on 240-day milk yield was calculated for calves of winter-calving 2, 3, 4 and 5-year-old Hereford, Hereford x Holstein (crossbred), and Holstein females. All cows were bred to Angus bulls the first year and to Charolais bulls the following three years. Milk yield in Herefords accounted for 42 to 59% of the variation in 240-day calf weight gain while in Holsteins, it accounted for only 1.1 to 27.3 of the variation. Gain responses to milk intake were highest among calves of Hereford dams (.0344 to .0868) and slightly lower for

---

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

[2]L.D. Ridenour, Robert Totusek, J.W. Holloway, K.S. Lusby, and J.V. Whiteman. Oklahoma State University, Stillwater 74074.

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

[4]Appreciation is expressed to R.D. Wyatt and J.R. Kropp for collection of data.

calves of Crossbred cows (.0344 to .0560 kg calf gain per kg milk produced). Among calves of Holsteins, regression of kg gain per kg milk were consistently low (.0065 to .0220). The data suggested that as milk yield increased, calf weight gain depended increasingly on other factors (non-milk nutrient intake, genetic potential).

Introduction

Increasing the milk production of beef cows has been shown to increase weaning weights of calves due to the strong association between level of milk production and weaned calf weight (Knapp and Black, 1941; Neville et al., 1952; Totusek and Arnett, 1965; Gleddie and Berg, 1968). The most rapid method of increasing milk production is through introduction of dairy breeding into the beef cow herd. Beef x dairy breeds produce more milk than beef breeds but require additional winter supplementation to maintain adequate reproduction (Deutscher and Whiteman, 1971; Kropp et al., 1973b; Holloway et al., 1975). There are also indications that as milk yield increases, more milk per unit of gain is required (Wilson et al., 1969; Deutscher, 1970; Holloway et al., 1973; Wyatt et al., 1977).

This report explores the relationship between milk yield and preweaning weight gain over a wide range in milk yields produced by Hereford, Hereford x Holstein and Holstein cows.

Materials and Methods

Forty-two Hereford, 42 Hereford x Holsteins and 50 Holstein heifers were assembled and maintained under tallgrass native rnage conditions at the Southwestern Livestock and Forage Research Station (El Reno). Detailed management practicies were described by Kropp et al. (1973a,b) and Holloway et al. (1975) who reported the performance of these cows as 2- and 3-year-olds, and Wyatt et al. (1977) who reported their performance as 4- and 5-year-olds. Only a general review of management practices will be presented here.

Hereford and Hereford x Holstein females were allotted to two levels of winter supplementation (Moderate and High) while Holsteins were allotted to three levels (Moderate, High and Very High) from first calving. Moderate, High and Very High represented the levels of winter supplement deemed necessary to maintain a high level of reproductive performance in Hereford, Crossbred and Holstein cows, respectively.

First calves produced by the females were sired by Angus bulls while the following three calf crops were sired by Charolais bulls. All calves were born during December, January and February.

Twenty-four hour milk consumptions were estimated by the calf suckle method (Kropp et al. 1973) at seven (monthly points) for progeny of 2, 3 and 4-year-olds and at 3 points (March, May July) for progeny of 5-year-olds. Calves were weighed within 24 hours of birth (birth weight) and 240 $\pm$ 7 days of age (weaning weight). Bull calves were castrated within 42 days of birth and heifer weaning weights were adjusted to a steer equivalent by multiplying actual weaning weight by 1.05 (Smithson, 1966).

Regression coefficients were first determined for each year-breed-level of winter supplementation group. Level of winter supplementation of the dam was determined by least squares analysis of variance not to affect ($P<.05$) either milk yield or weaning weight and was omitted from the model in analysis of each year.

Results and Discussion

Within lactation and breed of dam regression of calf weight gain from birth to weaning on 240-day milk yield is shown in table 4.1 and figures 4.1, 4.2, 4.3 and 4.4 for years 1 through 4, respectively. All correlations (R^2) between cow milk yield and calf weight gain, except for Holsteins in the second and fourth years fall in the range of .40 to .81 which agree with estimates of Christian et al. (1965). Klett et al. (1965), Melton (1967), and Velasco (1962).

Milk consumption by calves consistently accounted for less variation in calf preweaning weight gain among Holstein than for Hereford and Hereford x Holstein cows during each of the four calf crops. This indicates that those calves were approaching maximal milk intakes and their weight gains depended on factors other than dam milk yield (genetic growth capacity, non-milk nutrient intake). In a similarly designed study under drylot conditions, Holstein calves consumed a lower proportion of total nutrient intake from non-milk sources than calves from Crossbreds and Herefords (Kropp 1970; Holloway, 1975a; Wyatt, 1977) suggesting that genetic differences may be more important than non-milk nutrient intake in accounting for the unexplained variation. Lusby et al. (1976) using these same cow breeds, has also shown that level of milk consumption was negatively correlated with calf forage intake on range.

Differences in the within breed R^2 values between years (table 4.1) were probably due to differences in environment and also breed of sire. The highest correlations between milk intake and weaning weight were observed during the first and third years when milk consumptions were the lowest, consistent with previously noted within breed trends. Similar R^2 values are found in the literature but the relatively large standard error of estimates (12.38 to 24.87 kg) limit the value of the equations for prediction purposes.

Regression coefficients for calves of Hereford and Crossbred dams are similar to values found in literature for beef breeds (Montsoma, 1960; Wistrand and Riggs, 1966; Neville, 1962; Kress, Hauser and Chapman, 1968) which reports ratios ranging from 4.3 to 2.5 kg calf gain per 100 kilograms milk yield. Ratios for calves from Hereford dams in this study ranged from 8.68 to 3.44 kg calf weight gain per 100 kg increased milk yield and in three of the four years they exhibited the largest responses to increase in milk yield. There is no apparent explanation for the decreased Hereford response in the second year. Holstein calves consistently showed less response to increases in milk yield (.0065 to .0318 kg of weight gain per 100 kilograms increased milk yield).

Previous work (Wilson et al., 1969) has indicated that as

TABLE 4.1. REGRESSION EQUATIONS FOR PREDICTING PREWEANING GAIN OF CALVES USING 240-DAY MILK PRODUCTION OF DAM

Year	Breed of Dam	Intercept	S.E.	Milk[1,2]	S.E.	R^2	Sy.x	Calf wt. Gain Y	Milk 1 X	n
	Hereford	80.9***	20.90	.0868***	.00694	.5941	15.11	198	1351	24
1	Crossbred	109.1***	24.41	.0560***	.00548	.4834	16.58	221	2003	25
	Holstein	185.2***	23.23	.0220*	.00399	.1733	15.78	243	2625	32
	Hereford	176.7***	13.99	.0344**	.00411	.4202	12.38	229	1519	22
2	Crossbred	147.0**	42.62	.0431*	.00794	.2516	22.11	251	2417	20
	Holstein	267.1***	55.42	.0065	.00724	.0110	20.01	299	3457	17
	Hereford	112.9***	20.42	.0732***	.00633	.5235	16.81	219	1444	27
3	Crossbred	134.7***	32.33	.0528**	.00682	.3591	24.87	247	2123	24
	Holstein	183.7***	27.59	.0318**	.00439	.2726	20.43	274	2826	31
	Hereford	171.0***	14.14	.0426***	.00414	.4658	15.82	235	1512	27
4	Crossbred	181.5***	23.16	.0344**	.00464	.3098	18.30	258	2226	27
	Holstein	249.0***	26.92	.0078	.00395	.0512	18.72	273	3045	17

[1]Total 240-day milk yield

[2]Regression coefficient

*Probability of a larger $|T| = 0.05$, $Ho = \beta = o$

**Probability of a larger $|T| = 0.01$, $Ho = \beta = o$

***Probability of a larger $|T| = 0.001$, $Ho = \beta = o$

level of milk yield increases, the increase in calf weight gain per unit of milk yield decreases. Increases in milk intake are accompanied by decreases in non-milk nutrient intake. At high milk intakes the apparent lower utilization of milk is a substitution of milk (which has a lower energy density) for grass or creep (Holloway et al., 1975a; Wyatt et al., 1977 Lusby et al., 1974). Deutscher (1970) also observed the lower efficiency at high milk levels and offered the explanation that the less efficient conversion could be due to the larger maintenance requirements.

Efficiency of conversion could also be influenced by differences in the body composition of the calves. Determination of body composition might have given more insight in the explanations of the different efficiencies at different levels of milk yield.

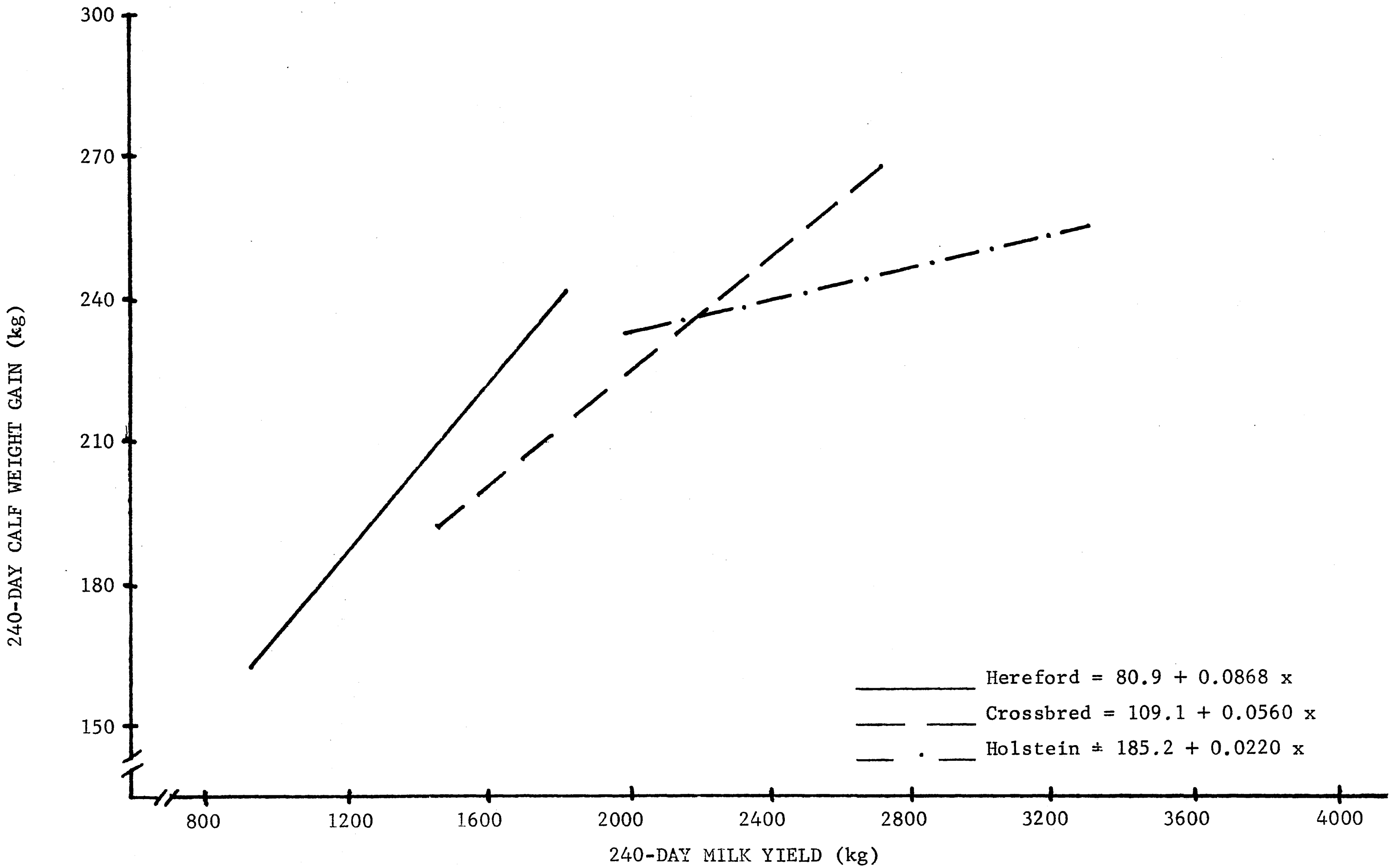

Figure 4.1. Regression of Calf Weight Gain on 240-Day Milk Yield for First-Calf Hereford, Crossbred and Holstein Females

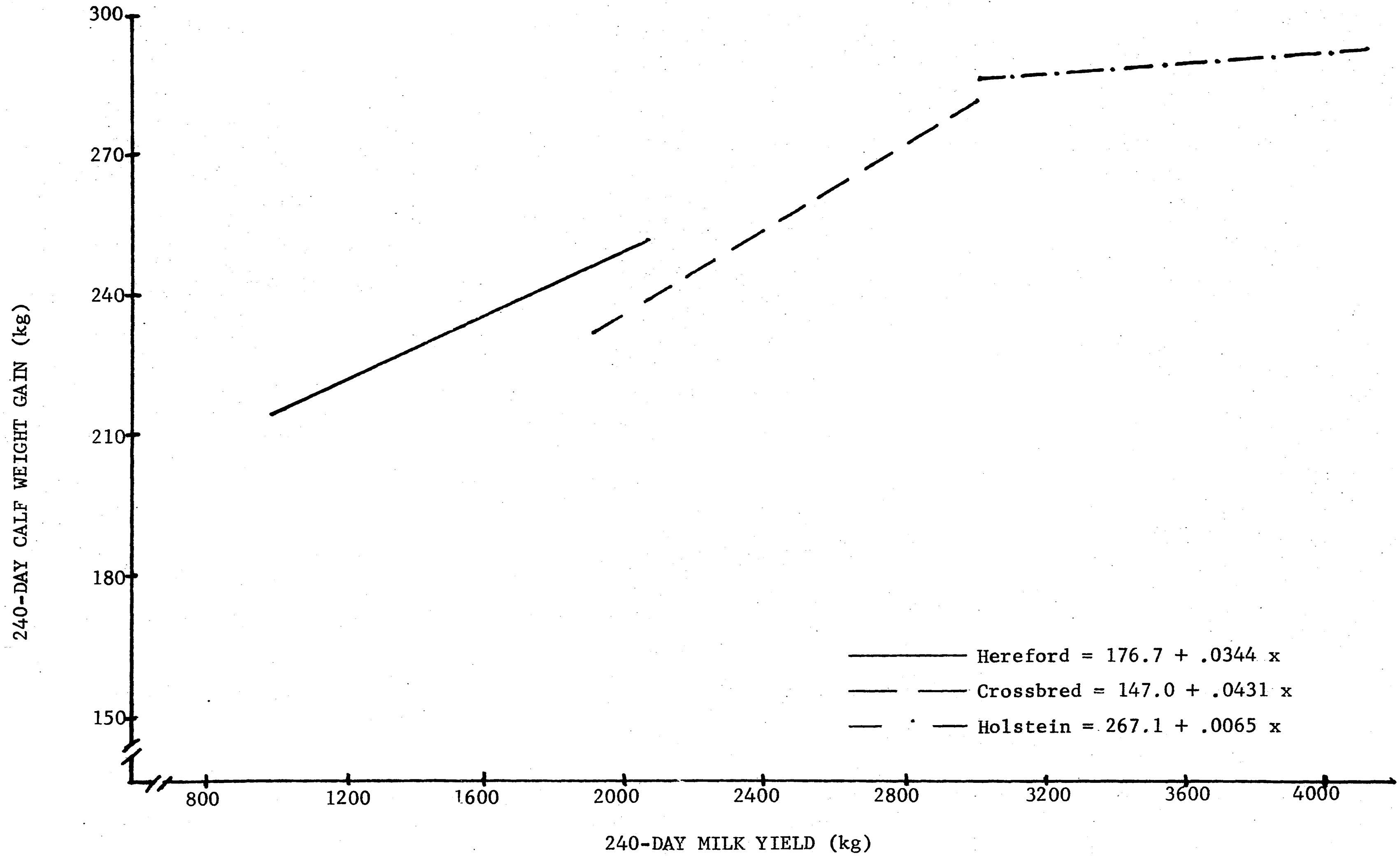

Figure 4.2. Regression of Calf Weight Gain on 240-Day Milk Yield for Second-Calf Hereford, Crossbred and Holstein Females

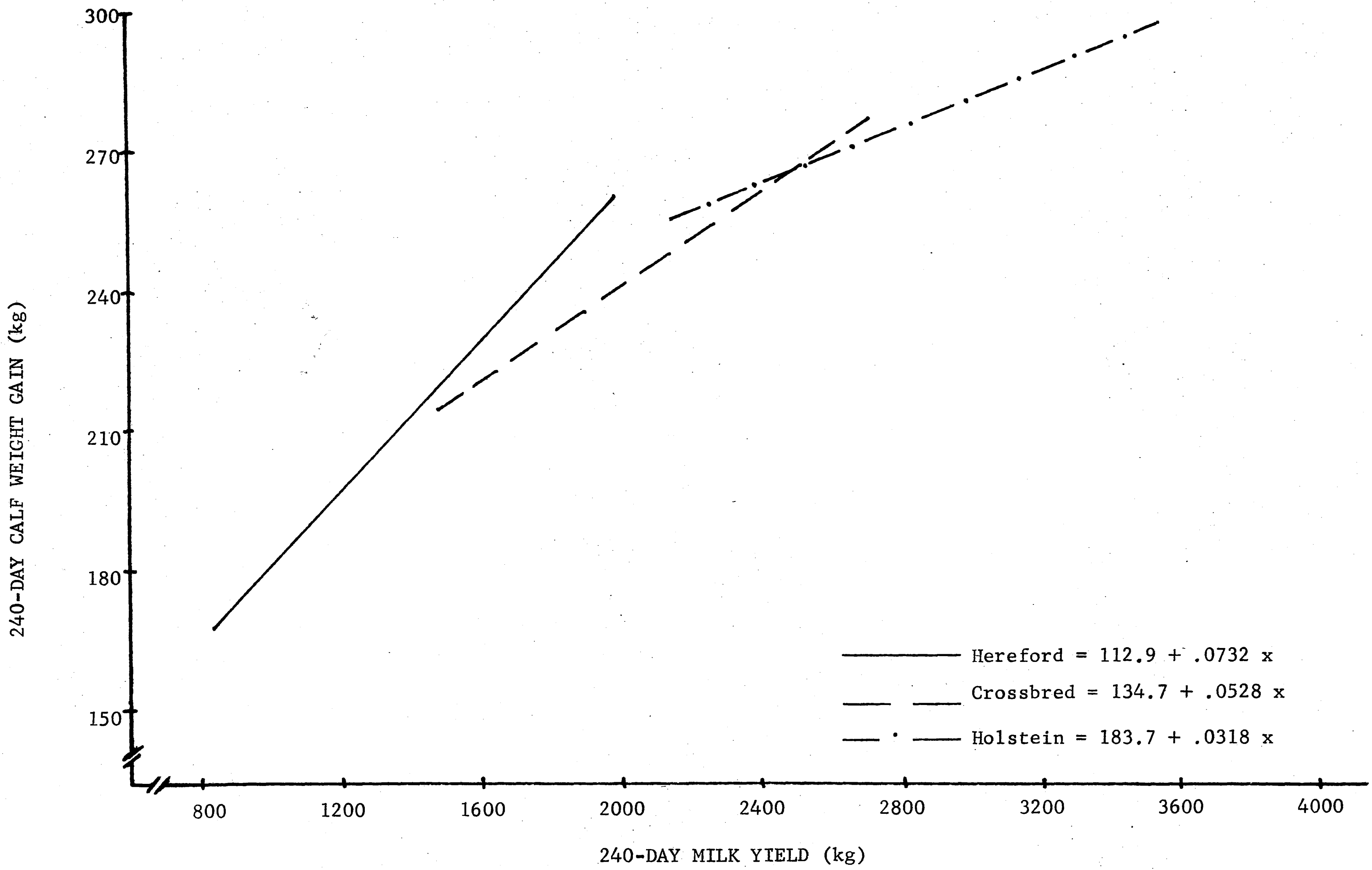

Figure 4.3. Regression of Calf Weight Gain on 240-Day Milk Yield for Third-Calf Hereford, Crossbred and Holstein Females

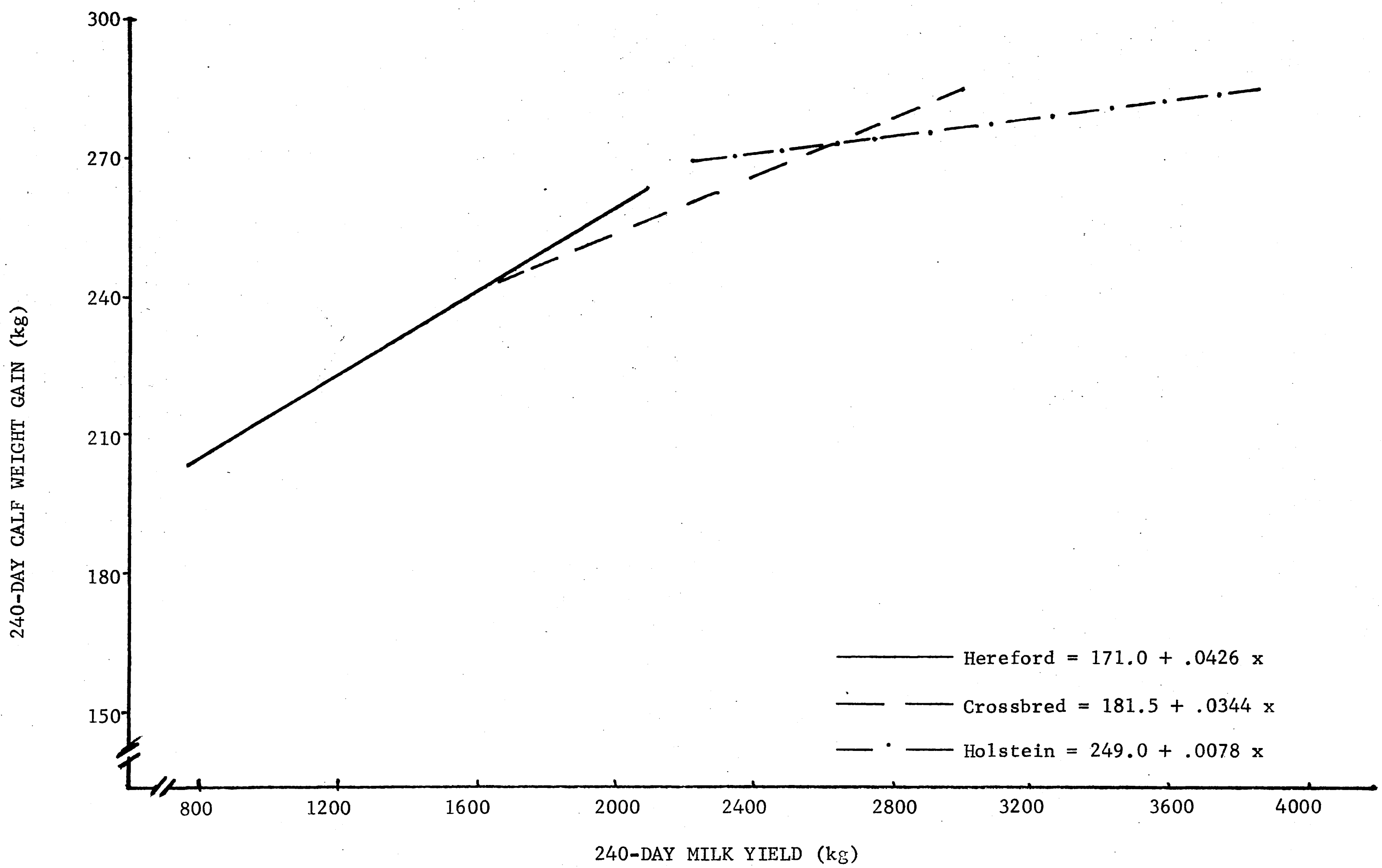

Figure 4.4. Regression of Calf Weight Gain on 240-Day Milk Yield for Fourth-Calf Hereford, Crossbred and Holstein Females

SELECTED BIBLIOGRAPHY

Armstrong, D.G. and K.L. Blaxter. 1965. Effects of acetic and propionic acids on energy retention and milk secretion in goats. Proc. 3rd Sympos. Energy Metabolism from Scotland, 1964. European Association of Animal Production Pub. No. 11:59; Academic Press, London.

Bath, D.L., M. Ronning, G.P. Lofgreen and J.H. Meyer. 1966. Comparative utilization of energy by cattle for growth and lactation. J. Anim. Sci. 25:1138.

Baumgardt, B.R. 1967. Efficiency of nutrient utilization for milk production: Nutritional and physiological aspects. J. Anim. Sci. 26:1186.

Blaxter, K.L. 1952. The utilization of the energy of whole milk. Brit. J. Nutr. 6:12.

Blaxter, K.L. 1956. The nutritive value of feeds as sources of energy. J. Dairy Sci. 29:1396.

Blaxter, K.L. 1962. The Energy Metabolism of Ruminants. Charles C. Thomas, Pub., Springfield, Ill.

Bond, James N., W. Hoover Jr., E.J. Warwick, R.L. Hines and G.V. Richardson. 1972. Influence of breed and plane of nutrition on performance of dairy, dual purpose and beef steers. II. From 180 days of age to slaughter. J. Anim. Sci. 34:1047.

Bond, J. and J.N. Wiltbank. 1970. Effect of energy and protein on estrus conception rate, growth and milk production of beef females. J. Anim. Sci. 30:438.

Bond, J., J.N. Wiltbank, E.J. Warwick, R.P. Lehmann and T.B. Kinney. 1975. Feed intake and milk production of beef cows. J. Anim. Sci. 23:901. (Abstr.).

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

Brown, L.D. 1966. Influence of intake on feed utilization. J. Dairy Sci. 49:223.

Brumby, P.T., D.E. Johnson and J.T. Reid. 1967. The utilization of volatile fatty acids by ruminants. Proc. 1967. Cornell Nutr. Conf.

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

Burroughs, Wise, W.T. Mealy, E.A. Kline and Frances Carlin. 1965. Summary of three experiments on feedlot performance, marketing considerations and carcass characteristics of Holstein vs. beef bred feeder steers. Iowa Agr. Exp. Sta. R70.

Burtening, P.J. 1974. Dairy-beef crossbreeding: I. Growth to weaning. J. Anim. Sci. 38:1219. (Abstr.).

Callow, E.H. 1961. Comparative studies of meat. VII. A comparison between Hereford, Dairy Shorthorn and Friesian steers on four levels of nutrition. J. Agri. Sci. 56:265.

Cartwright, T.C., R.C. Thomas and H.A. Fitzhugh, Jr. 1974. Productivity of Angus-Jersey vs. Hereford cows. J. Anim. Sci. 39:144. (Abstr.).

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

Cole, J.W., L.E. Orme and C.M. Kincaid. 1960. Relationship of loin-eye area, separable lean of various beef cuts and carcass measurements to total carcass lean in beef. J. Anim. Sci. 21:355.

Coppock, E.E., W.P. Flatt and L.A. Moore. 1964a. Effect of hay to grain ratio on utilization of metabolizable energy for milk production by dairy cows. J. Dairy Sci. 47:1330.

Coppock, C.E., W.P. Flatt and L.A. Moore. 1964b. Relationships between end products of rumen fermentation and utilization of metabolizable energy for milk production. J. Dairy Sci. 47:1359.

Crampton, E.W. and L.E. Harris. 1969. <u>Applied Animal Nutrition</u> (2nd Ed.). W.H. Freeman and Company, San Francisco, CA.

Dean, R.A., L.E. Walters, D.F. Stephens, K.S. Lusby, J.V. Whiteman and Robert Totusek. 1974. Feedlot performance and carcass merit of calves from Hereford, Hereford x Holstein and Holstein cows. Okla. Ag. Exp. Sta. Misc. Pub. 92:131.

Deutscher, Gene H. 1970. Productivity of Angus-Holstein crossbreds versus Angus heifers under tallgrass range conditions. M.S. Thesis. Oklahoma State University, Stillwater, Oklahoma.

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.

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.

Dunn, T.G., J.N. Wiltbank, D.R. Zimmerman and J.E. Ingalls. 1965. Dam's energy intake and milk production and calf gains. J. Anim. Sci. 24:586. (Abstr.).

Elliot, J.M. and J.K. Loosli. 1959a. Effect of dietary ratio of hay to concentrate on milk production, ration digestibility and urinary energy losses. J. Dairy Sci. 42:836.

Elliot, J.M. and J.K. Loosli. 1959b. Relationship of milk production efficiency to the relative proportions of the rumen volatile fatty acids. J. Dairy Sci. 42:843.

Ferrell, C.L., W.N. Garrett, N. Hinman and Genevieve Grichting. 1976. Energy utilization by pregnant and non-pregnant heifers. J. Anim. Sci. 42:937.

Flatt, W.P. 1964. Efficiency of utilization of energy by lactating dairy cows. Cornell Nutr. Conf. Proc., p. 71.

Flatt, W.P. 1966. Energy metabolism results with lactating dairy cows. J. Dairy Sci. 49:230.

Flatt, W.P., C.E. Coppock, L.A. Moore and R.W. Henaken. 1965. Energy balance studies with lactating, non-pregnant dairy cows consuming rations with varying hay to grain ratios. 3rd Symp. on Energy Metabolisms. K.L. Blaxter (Ed.) Academic Press, Inc., London.

Forbes, E.P., J.A. Frigs, W.W. Braman and M. Kriss. 1926a. The relative utilization of feed energy for maintenance, body increase and milk production of cattle. J. Agr. Res. 33:483.

Fries, J.A., W.W. Braman and D.C. Cochrane. 1924. Relative utilization of energy in milk production and body increase of dairy cows. U.S.D.A. Bul. 1281.

Furr, R.D. 1962. Part I. Grazing behavior of range beef cows. Part II. Effect of different levels of supplemental winter feed upon the production of fall-calving beef cows. Ph.D. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Garrett, W.M. 1969. Energetic efficiency of beef and dairy steers. J. Anim. Sci. 32:451.

Gifford, W. 1949. Importance of high milk production in beef cows found overestimated. J. Anim. Sci. 8:504. (Abstr.).

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

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

Hashizume, T., H. Morimoto, T. Masubuchi, M. Abe and T. Hamada. 1965. Some aspects of energy utilization by cows during gestation and lactation 3rd Symp. on Energy Metabolism. K.L. Blaxter (Ed.) Academic Press, Inc., London.

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.

Huber, J.T., G.C. Graf and R.W. Engel. 1964. Effect of supplemental feeding of cows on pasture on milk consumption and yield. J. Dairy Sci. 47:63.

Hughes, Joe H., Jr. 1971. The influence of winter nutrition on the growth and milk production of Hereford females and birth date and growth of their calves. Ph.D. Thesis. Oklahoma State University, Stillwater, Oklahoma.

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. Anim. Sci. 16:VI.

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

Knott, J.C., R.E. Hodgson and E.V. Ellington. 1934. Methods of measuring pasture yields with dairy cattle. Washington Agr. Exp. Sta. Bul. 295.

Kraybill, H.F., H.L. Bitter and O.G. Hankins. 1952. Body composition of cattle. II. Determination of fat and water content from measurement of body specific gravity. J. Appl. Physiol. 4:575.

Kress, D.P., E.R. Hauser and A.B. Chapman. 1968. Factors affecting weaning weight in beef cattle. J. Anim. Sci. 27:1128. (Abstr.).

Kropp, J.R., J.W. Holloway, D.F. Stephens, Leon Knori, R.D. Morrison and Robert Totusek. 1973a. Range behavior of Hereford, Hereford x Holstein and Holstein non-lactating heifers. J. Anim. Sci. 36:797.

Kropp, J.R., D.F. Stephens. J.W. Holloway, J.V. Whiteman, Leon Knori and Robert Totusek. 1973b. 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. 1974. Level of milk production in range cows: Effects on winter feed requirements, forage intake, digestibility and post weaning feedlot performance of their calves. Ph.D. Thesis, Oklahoma State University, Stillwater, Okla.

Mason, I.L., Alan Robertson and B. Gjelstad. 1957. The genetic connection between body size, milk production and efficiency in dairy cattle. J. Dairy Res. 24:135.

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

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

Minish, G.L., H.A. Newland and H.E. Henderson. 1966. Varying levels of corn silage and shelled corn for finishing two grades of cattle. Mich. Agr. Exp. Sta. AH-BC-655.

Moe, P.W., W.P. Flatt and H.F. Tyrrell. 1972. Net energy value of feeds for lactation. J. Dairy Sci. 55:945.

Moe, P.W., J.T. Reid and H.F. Tyrrell. 1965. Effect of level of intake on digestbility of dietary energy by high-producing cows. J. Dairy Sci. 48:1053.

Moe, P.W. and H.F. Tyrrell. 1975. Efficiency of conversion of digested energy to milk. J. Dairy Sci. 58:602.

Moe, P.W., H.F. Tyrrell and W.P. Flatt. 1971. Loss of fat from dairy cows; Energetics of body tissue mobilization. J. Dairy Sci. 54:548.

Montsoma, G. 1960. Observations of milk yield, calf growth and conversion rate on three types of cattle in Ghana. Biol. Abstr. 36:7820.

Murphey, C.E., D.K. Hallet, W.B. Tyler and J.C. Pierce, Jr. 1960. Estimating yields of retail cuts from beef carcasses. J. Anim. Sci. 29:1240. (Abstr.).

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

Neville, W.E., Jr. 1974. Comparison of energy requirements of non-lactating and lactating Hereford cows and estimates of energetic efficiency of milk production. J. Anim. Sci. 38:681.

Neville, W.E., Jr., D.M. Baird and O.E. Sell. 1960. Influence of sire, dam's milk production, three levels of nutrition and other factors on 120- and 240-day weight of Hereford calves. J. Anim. Sci. 19:1223. (Abstr.).

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.).

Orskov, E.R. and D.M. Allen. 1966. Utilization of salts of volatile fatty acids by growing sheep. I. Acetate and butyrate as sources of energy for young growing lambs. Brit. J. Nutr. 20:295.

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

Pinney, D.O. 1962. Performance of range beef cows as affected by supplemental winter feed and age at first calving. M.S. Thesis. Oklahoma State University, Stillwater, Okla.

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

Reid, J.T. 1956. Some nutritional effects of varying concentrate-roughage ratios in relation to feed input-milk output by dairy cows. Cornell U. Agr. Exp. Sta. Memoir 344.

Reid, J.T. 1961. Problems of feed evaluation related to feeding of dairy cows. J. Dairy Sci. 44:2122.

Reid, J.T. 1962. Symposium papers on animal nutrition's contributions to modern animal agriculture. Cornell Univ. Exp. Sta. Spec. Bul., pp. 54-93.

Reid, J.T., P.W. Moe and H.F. Tyrrell. 1966. Energy and protein requirements of milk production. J. Dairy Sci. 49:215.

Reid, J.T. and H.F. Tyrrell. 1964. Effect of level of intake on energetic efficiency of animals. Cornell Nutr. Conf. Proceedings.

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

Schake, L.M. and J.K. Riggs. 1975. Caloric efficiency of beef production. J. Anim. Sci. 40:54.

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.

Steel, Robert G.D. and James H. Torie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Company, Inc.

Swift, R.W. 1957. The caloric value of TDN. J. Anim. Sci. 16:753.

Totusek, Robert and Dudley Arnett. 1965. Estimates of milk production in beef cows. J. Anim. Sci. 24:906. (Abstr.).

Tyrrell, H.F. and J.T. Reid. 1966. Prediction of the energy value of cow's milk. J. Dairy Sci. 48:1215.

Van Soest, P.J. 1963. Ruminant fat metabolism with particular reference to factors affecting low milk fat and feed efficiency. A review. J. Dairy Sci. 46:204.

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

Wagner, D.G. and J.K. Loosli. 1967. Studies on the energy requirements of high-producing dairy cows. Cornell Agr. Exp. Sta. Memoir 400.

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 preweaning 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, Roger D. 1976. Effects of milk level, calf type and twin rearing on cow and calf performance. Ph.D. Thesis. Oklahoma State University, Stillwater, Oklahoma.

VITA

Larry Dale Ridenour

Candidate for the Degree of

Master of Science

Thesis: EFFICIENCY ON RANGE AND IN DRYLOT OF HEREFORD, HEREFORD X HOLSTEIN AND HOLSTEIN FEMALES AND THEIR PROGENY

Major Field: Animal Science

Biographical:

Personal Data: Born in Lovington, New Mexico, September 14, 1953, the son of Dale and Bea Ridenour; married Melanie Lee Bridgforth August 9, 1975.

Education: Graduated from Lovington High School, Lovington, New Mexico, 1971; received the Bachelor of Science in Agriculture degree from New Mexico State University, Las Cruces, New Mexico, with a major in Animal Science in May, 1975; completed the requirements for Master of Science degree in December, 1977.

Professional Organizations: Blue Key National Honor Fraternity and Alpha Zeta Honorary Agricultural Fraternity.