EFFICIENCY ON RANGE AND IN DRYLOT OF HEREFORD, HEREFORD x HOLSTEIN AND HOLSTEIN FEMALES AS INFLUENCED BY LEVEL OF WINTER SUPPLEMENTATION

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CHAPTER I

INTRODUCTION

Weaning weight is important to the beef industry because it affects all phases of the industry. A rapid method for increasing weaning weight of beef cattle progeny is infusion of dairy genes (Cundiff, 1970). This method increases not only the milk yield of the cow and the growing ability of the calf, but also the nutritive requirements of the cow. This latter factor may be important in determining the breeding performance and economic usefulness of these cattle. Thus, the question arises as to the relative performance for beef production of cows giving widely different levels of milk. A companion question is one of efficiency; what is the relative efficiency of milk or beef production of cows giving widely different amounts of milk? This problem of efficiency can be attacked from a different direction: what are the relative changes in preweaning calf weight gain with increment increases in milk yield over a wide range?

CHAPTER II

REVIEW OF LITERATURE

Effect of Nutrition and Level of Milk on Performance

Efficiency of milk production for range cows involves three distinct problems (1) effect of nutrition on milk production (2) effect of nutrition and milk production on reproduction and (3) effect of milk production on calf gain.

Effect of Nutrition on Milk Production

A large number of workers have indicated that relatively low milk producing cows (conventional beef breeds) experience a drop in production if fed either extremely high or low levels of winter nutrition (Harris, Anthony and Brown, 1962; Arnett, 1963; Furr and Nelson, 1964; Smithson *et al.*, 1964; Bond *et al.*, 1964; Hughes, 1971; Dunn *et al.*, 1965). An increase in milk production by infusion of dairy genes is often also accompanied by increased body size, and this factor must be considered as it affects feed requirements and milk yields. By regression analysis, Ludwig (1971) showed a very small change in TDN required per kg cow weight increase from 318 to 590 kg with the addition of lactation requirement to those of maintenance, weight gain and fetal growth. Similarly, Gillooly *et al.* (1967) reported that body size of

Angus x Holstein females was not associated with milk yield or percent solids-not-fat.

Thus, the major factor to consider is the relative increase in nutritional requirements for increased levels of milk production. Gillooly et al. (1967), Wilson et al. (1969) and McGinty and Frerichs (1971) reported increased milk yields of dairy x beef cattle with increased energy levels to 135% of recommended NRC requirement. Huber et al. (1964) and Huber and Bowen (1966) reported linear relationships between feed energy and milk for Holstein cows except those consuming all corn diets. They also found inverse relationships between energy density and butterfat percentages.

Graves et al. (1940) found reduced milk yield and butterfat when Holsteins were maintained on pasture. Baker and Tomhave (1944) found a peak in 4% fat corrected milk yield at 120% of the Haecker standard. Flux and Patchell (1954) found that underfeeding after parturition resulted in decreased milk yield, solids-not-fat and total protein, but increased percent butterfat.

Effect of Nutrition and Milk Production on Reproduction

Some workers have indicated that inherent high milk producing ability at adequate levels of nutrition is not associated with reproductive efficiency (Gaines, 1927; Boyd, Sheath and Olds, 1954; Olds and Sheath, 1953). Other workers have indicated small but inverse relationship between milk production and reproductive performance. Boyd (1967) reported that each additional 454 kg of milk during the first 120 days of lactation was associated with a 1.5 day delay in estrus. Carman (1955) studied 1646 Holstein lactations and found a positive association between postpartum interval and amount of milk given in previous lactations. This relationship probably exists, but the association between milk production at adequate levels of nutrition and reproductive efficiency is probably so small that it is not economically important.

The pertinent problem, therefore, is the breeding performance of high producing cows under conditions of low feed intake. Many workers have indicated that in relatively low milking Hereford and Angus females, a low plane of winter nutrition is associated with poor reproductive performance (Smithson et al., 1964; Turman et al., 1964; Wiltbank et al., 1962).

In addition, Deutscher and Whiteman (1971) reported a lower percent cows rebreeding for Angus x Holstein (13%) than Angus (63%) when fed similar but low levels of winter supplementation. This indicates that a higher level of nutrition may be necessary for higher milking cows to rebreed. McGinty and Frerichs (1971) also showed decreased rebreeding performance for dairy x beef crossbred females when fed similar levels as beef females (112 and 135% of NRC). Brown Swiss x Hereford females exhibited a 65% calf crop whereas Herefords exhibited 93 percent.

Effect of Milk Production on Calf Gain

Milk Production and Early Growth. Schwulst et al. (1966) found small (less than 0.40) and nonsignificant correlations between average daily gain (ADG) of calf and milk consumption during the first two weeks of lactation. Gifford (1949) and Gleddie and Berg (1968) found a correlation of 0.60 between first month ADG and total and average daily milk yield, respectively. The correlation between eight weeks ADG and milk yield was between 0.71 and 0.75 (Neville, 1962; Gifford, 1949; and Gleddie and Berg, 1968). Much variation exists in methods of measuring milk production and therefore the correlations between milk consumption and calf growth to three months are widely variable; from 0.23 to 0.96 (Serwanja, Welch and Kidder, 1969; Melton *et al*., 1967a; Brumby *et al*., 1963).

Milk Production and Growth to Weaning. Several researchers have found a decrease in correlation between milk production and weaning weight as lactation progresses (Gifford, 1949; Brumby *et al*., 1963; Gleddie and Berg, 1968; Neville, 1962). Evidently as the calf grows, a smaller percent of its diet is the dam's milk, and therefore the relationship between milk yield and weaning weight decreases. Many researchers with many methods of experimentation studying different types of cattle under widely differing management systems have found correlations from 0.40 to 0.82 between preweaning ADG and milk consumption (Velasco, 1962; Pinney, 1962; Christian, Hauser and Chapman, 1965; Furr and Nelson, 1964; Klett, Mason and Riggs, 1965; Melton *et al*., 1967a; Brumby *et al*., 1963; Neville, 1962).

Several workers have indicated that the relationship between milk composition and calf gain is near zero (Klett *et al*., 1965; Melton *et al*., 1967a; Wilson *et al*., 1969; and Gleddie and

Berg, 1968). Christian, Hauser and Chapman (1965), however, reported a significant correlation of 0.40 for percent butterfat to 60 days with weaning weight.

The question of importance, however, is: Will the amount of milk required per kg of calf gain change as level of milk produced increases? The amount of milk required per kg gain increases as the calf gets older if milk is a large proportion of the diet. Brumby et al. (1963) found that the amount of milk required per kg of calf gain increased linearly from 9.1 kg at six weeks to 50 kg at 24 weeks. When the calf is allowed pasture, however, the trend is different; Drewry, Brown and Honea (1959) found the requirements to be 12.5, 10.8 and 6.3 kg of milk per kg of gain during the first, third and sixth months of lactation in Angus cows. Researchers have reported a range from 4.0 to 23.5 kg of milk per kg of calf gain in beef cows (Montsma, 1960; Wistrand and Riggs, 1966; Neville, 1962; Melton et al., 1967a; Kress, Hauser and Chapman, 1968). Wilson et al. (1969) reported a less efficient conversion rate (11.2:1) for Angus x Holstein cows as compared to most of the work with beef cattle. Deutscher (1970) reported 6 kg milk/kg calf gain for Angus cows compared to 7.1 for Angus x Holstein cows. Plum and Harris (1971) indicated an even less efficient conversion rate for Holstein cows managed under range conditions (12 kg of milk per kg of gain for a 191 day lactation period). However, these figures for crossbred and dairy cattle are within the above range for beef cattle.

Nutrition of the dam may be a factor in conversion rate of milk to calf gain. Neville (1962) concluded that calves from dams on a higher plane of nutrition required more milk per kg gain than calves from dams on a lower plane of nutrition.

Efficiency of Energy Utilization for Lactation

This review will encompass the efficiency of energy utilization for lactation with regard to: (1) its relative efficiency as compared to other body functions, (2) its efficiency as level of milk production and feed intake increase and (3) its efficiency relative to type of diet.

Energetic Efficiency of Milk Yield Relative to Other Body Functions

Early work by Fries, Braman and Cochrane (1924) and Forbes et al. (1926a) indicated a 22% increased efficiency of energy utilization for milk production than for growth. Later work summarized by Reid (1961, 1962) and Blaxter (1962) similarly indicated that utilization of metabolizable energy (ME) for lipogenesis during lactation was 70.2% whereas the corresponding efficiency for nonlactating animals was 58.4 percent. Coppock et al. (1964) summarizing energy balance trials estimated efficiency of ME for lactation to be 75.5±.9%. Van Es (1961) indicated that efficiency of conversion of ME consumed to tissue deposited is 62% and conversion of tissue energy to milk energy is 70%. Bath et al. (1966) reported that NE_p values of feed increments of beef cattle were 86% of that for dairy cattle.

Moe, Tyrrell and Flatt (1971) have indicated that efficiency of ME to tissue depends on the physiological status of the cow. They found energetic efficiency of gain for non-lactating cows to be 58.7% compared to that of a lactating cow of 74.7%; efficiency of milk production was 82.4%. Much disagreement exists as to the reason for improved efficiency of gain during lactation. Armstrong and Blaxter (1965) hypothesized a removal of acetate by the mammary gland with the result that the metabolites available for lipogenesis are those most efficient for body fat synthesis. Ørskov and Allen (1966) and Bull, Johnson and Reid (1967), however, showed efficient utilization of acetate for lipogenesis of non-lactating sheep.

Energetic Efficiency as Level of Milk Yield and Feed Intake Increase

It is widely accepted that as milk yield increases, efficiency also increases (Mason, Robertson and Gjelstad, 1957). But Armsby (1971) was the first of many researchers to show the diminishing milk producing value of the diet as level of intake increases. This hyperbolic relationship between milk yield and efficiency is the result of the interaction of a series of opposing factors. Increasing yield increases efficiency because of dilution of the fixed maintenance cost (Mason, Robertson and Gjelstad, 1957; Wagner and Loosli, 1967). The diminishing-returns effect, however, may be explained by: (1) diminishing rate of digestibility, (2) increased proportion of energy being diverted to tissue synthesis and (3) decreased efficiency of tissue synthesis as compared to lactation (Flatt, 1964; Reid and Tyrrell, 1964; Blaxter, 1956; Reid, 1956; Reid, 1961). Flatt (1964) summarizing Cornell studies reported depressions of digestibility up to 23% when cows were fed 6x maintenance requirements. Although digestibility may be reduced at high levels of intake (and therefore DE reduced), Blaxter (1962) and Moe, Reid and Tyrrell (1965) have indicated that methane and urine losses decrease slightly with increasing intakes, somewhat stabilizing ME conversion to milk as intake increases. Similarly, Hashizume et al. (1965) and Flatt (1966) indicated apparent linearity between ME input and milk energy output up to intake of 3 to 4.5x maintenance indicating that differential mammary gland efficiency is not a factor. Also, Reid and Tyrrell (1964) indicated a constant proportion of ME is lost as heat when intakes of a diet constant in composition increases to 3x maintenance. In conclusion, the main factor for diminishing returns in efficiency of milk production with increased intake is reduced digestibility.

Wagner and Loosli (1967) studied the relationship between energetic efficiency of milk production, level of milk yield and level of feed intake. They showed an increase in conversion rate of total digestible nutrients (TDN) to 4% fat corrected milk (FCM) as level of FCM production increased. Acceleration of the rate of this increase occurred at higher levels of feed intake.

As level of milk yield increases, another phenomenon occurs that could possibly affect efficiency of production. Flatt (1964) reported that Holsteins at peak of lactation will mobilize body tissue rather than consume sufficient dietary energy. In light of the discussion in the previous section, a depressed efficiency from 82.4 to 61.6% (82.4 x 74.7% if body tissue is synthesized during lactation) would be expected; Flatt (1964), however, noted no depression in efficiency of ME utilization.

Energetic Efficiency Relative to Type of Diet

Baumgardt (1967) reviewing the effect of forage quality on the efficiency of milk production, concluded that increased forage nutritive value should improve milk production efficiency when limited amounts of concentrates are fed. Review articles of Van Soest (1963) and Baumgardt (1967) indicate that efficiency of milk production is not linearly associated with hay:grain ratio, but is maximum at the point milk production is depressed. Baumgardt (1967) suggested this point to be 40% forage 60% grain, but efficiency may increase further by further narrowing the acetate: propionate ratio. Blaxter (1962) postulated that the efficiency of utilization of ME for lactation is maximal when rations fed resulted in 50-60 molar percent acetate in the rumen.

Moe and Tyrrell (1972) found no changes in efficiency with which DE or ME was converted to milk when they compared diets containing 11.9 and 8.2% DP.

CHAPTER III

PERFORMANCE AS THREE-YEAR-OLDS OF HEREFORD, HEREFORD x HOLSTEIN AND HOLSTEIN FEMALES ON RANGE AND IN DRYLOT[1,2]

Summary

Performance of winter-calving, three-year-old Hereford, Hereford x Holstein (Crossbred) and Holstein females under tall-grass native range and drylot confinement conditions was compared. Two levels of winter supplementation (Moderate and High) were imposed on groups within each breed. A group of Holstein females was fed an additional level (Very High). The base breed-treatment groups (Moderate Herefords, High Crossbreds and Very High Holsteins) were fed precalving supplement levels of 0.4, 0.9 and 1.8

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(range) and 1.0, 1.6 and 2.5 (drylot) kg/day, respectively; post-calving levels were 1.4, 2.9, and 4.2 and 1.4, 3.0 and 4.1 kg/day, respectively. Drylot cows were also allowed roughage and concentrates in proportion necessary to approximate weight change patterns of range cows. Cow weight, calf weight and milk yield were estimated monthly. Calves were sired by Charolais bulls and were weaned at 240±7 days.

In drylot, estimated cow DE and DP intake during lactation was not affected by level of supplementation because Moderate level cows compensated by increasing roughage intake. Holsteins consumed significantly ($P<.05$) more estimated DE and DP than other females. As level of supplement increased, winter weight loss tended to decrease except for Herefords. All cows regained winter weight losses during the summer except Moderate and High Holsteins. Changes in condition score followed weight change patterns. Milk yield was 6.0, 9.1 and 13.4 kg for Hereford, Crossbred and Holstein range cows, respectively; yields of drylot cows were similar. Percentages of total solids, solids-not-fat and butterfat increased as level of supplementation increased. Sex-adjusted weaning weights for Herefords, Crossbreds and Holsteins were 269, 290 and 331 (range) and 237, 275 and 310 (drylot) kg, respectively. Increasing supplement levels were associated with decreased post-partum interval and days to apparent conception. Generally, conception rate increased as level of supplement increased.

Three-year-old Crossbred cows produced more milk and weaned heavier calves than Herefords at a comparable level of winter supplementation but exhibited poorer rebreeding performance. Holsteins produced still more milk and heavier calves but required from 26 to 31% more roughage (drylot) than Herefords and also exhibited poor rebreeding performance and delayed estrus at lower levels of supplement.

Introduction

One of the most important economic factors in the cow-calf industry is the weaning weight of the calves produced. Weaning weight may be increased by increasing the milk production of beef cows (Knapp and Black, 1941; Gifford, 1953; Pinney, 1962; Valesco, 1962). A rapid method for increasing milk production in beef cows is the introduction of genes from dairy animals (Cundiff, 1970). Several workers have shown increased milk production by Angus x Holstein cows as compared to Angus cows when managed under range conditions (Wilson et al., 1969; Deutscher and Whiteman, 1971; Hendrix, 1971). Maximum milk production may not be the most efficient under the nutritional environment of range conditions (Baker and Tomhave, 1944). Also, problems with poor reproductive performance have been reported for beef x dairy crossbreds when energy is limited (Deutscher and Whiteman, 1971; McGinty and Frerichs, 1971).

The purpose of this study was to determine the influence of level of winter supplement on milk yield, calf performance and reproduction of three-year-old range brood cows differing widely in milk production potential.

Materials and Methods

Hereford, Hereford x Holstein (Crossbred) and Holstein 3-year-old females were maintained under tallgrass native range and completely confined drylot conditions at the Fort Reno Livestock Research Station. A detailed description of management practices and data collected was reported by Kropp et al. (1973), who summarized the results for the production of these cows as 2-year-olds. This report summarizes their production as 3-year-olds; only deviations in management practices from those reported by Kropp et al. (1973) will be discussed in detail here.

Within each breed, according to initial calving date as 2-year-olds, females were assigned to two levels of winter supplementation designated as Moderate and High. An additional group of Holsteins was also fed a Very High level. The Moderate, High and Very High levels represented the amount of supplement estimated necessary to maintain a high level of reproduction in Hereford, Crossbred and Holstein females, respectively. These terms refer to the levels of supplementation adequate for Herefords (Pinney et al., 1962); Moderate level is optimum for Herefords. As 2-year-olds, Moderate Hereford, High Crossbred and Very High Holstein range females were fed post-calving supplement levels of 1.2, 2.5 and 3.5 kg/head/day (Kropp et al., 1973). The average daily supplement (30% crude protein) fed the 3-year-old females is shown in table I. The cows were fed supplement individually five days each week for a period of 157 days (November 9 to April 15).

Drylot cows were individually fed the same supplement for the same period of time as the range cows but on a daily basis. Their supplement was prorated so that the same amount was fed each week in both drylot and range phases. Drylot cows were also individually fed roughage and concentrates to simulate seasonal changes in the energy intake of range cows. The drylot feeding regime consisted of cottonseed hulls during the winter to April 18, then chopped alfalfa hay, ground milo and beef tallow in increasing increments until maximum caloric density was attained on July 3 (65% alfalfa, 30% milo, 5% tallow). Estimated DE and DP intakes were calculated from tabular data (Crampton and Harris, 1969). The females were drylotted in seven pens according to breed and treatment but were individually fed their roughage ration ad libitum during a 3-hour period each day. The calves were fed creep ad libitum daily in individual pens for the period of time their dams were being fed. Kropp et al. (1973) observed a depression in drylot calf gain when a high roughage creep ration was fed; therefore, a high energy creep ration consisted of (%): steam rolled corn, 57.5; molasses, 5.0; ground alfalfa hay, 15.0; cottonseed hulls, 10.0; soybean meal, 17.5.

The first calves produced by the females were sired by Angus bulls (Kropp et al., 1973); as 2-year-olds the females were artificially inseminated to one Charolais bull for 23 days, then hand mated for 22 days and pasture exposed for 45 days to three half-sib Charolais bulls.

Cow weights, cow condition scores, calf weights, milk production and milk composition estimates were collected in the manner reported by Kropp et al. (1973).

Because this study reports the second consecutive calf crop in a long range study, there is a disproportionality in numbers of cattle in each breed-treatment group for the range phase. Also, different numbers of cattle were available for analysis of different variables. For example, more cows were used to calculate reproductive performance than weaning data because some cows whose calves died raised a foster calf. Their reproductive data was valid but their weaning data was not. Therefore, a least squares analysis was employed using three breeds (Hereford, Crossbred and Holsteins) and two levels of supplementation (Moderate and High). An F test from this analysis was used to determine breed, treatment and breed x treatment effects; Very High Holsteins were excluded from this analysis and reference to breed and treatment means refer to these least square means. An analysis of variance was then calculated with Very High Holsteins included in a simple one-way classification; breed-treatment combination was the classification factor. The error mean square associated with this analysis was used to calculate a Least Significant Difference (Snedecor and Cochran, 1967) which was employed in comparing the Very High Holsteins to other breed-treatment groups.

Results and Discussion

Feed Intake

Drylot females consumed more winter supplement than range females because of the larger amount fed pre-calving; post-calving supplement level was similar for range and drylot (table I).

In drylot, level of supplement within breed did not significantly affect either estimated cow DE or DP intake. The Holsteins, however, did consume more ($P<.05$) DE and DP than either Crossbred or Hereford females. This increase was the result of increased ($P<.05$) roughage consumption by the Holstein females and was expected because of increased requirements of Holsteins for maintenance and lactation. The Crossbreds were similar in size to the Herefords (table II) but produced more milk (table III) and ingested slightly more roughage. Cows in all treatments received more than the estimated DE and DP requirements (Dairy NRC, 1966) for the total lactation period. As level of supplement increased within a breed, the amount of total yearly roughage intake tended to decrease (table I) indicating a tendency for cows on lower levels of supplementation to compensate by consuming more roughage, thereby increasing their DE intake.

As milk intake by drylot calves increased (table III), estimated calf DE and DP intake tended to increase; this trend was apparent even though calves of Holstein cows consumed less creep. It appears that the calves with the greatest growth potential (those out of Holstein cows) decreased their intake of creep when confronted with a plentiful supply of milk and did not gain to their potential. However, this was not a problem on the range where calves had access to grass and were not restricted to individual stalls.

Weight and Condition of Cows

Although drylot cows received sufficient DE (Dairy NRC, 1966) when averaged over the entire lactation, their winter ration of cottonseed hulls and supplement provided insufficient energy for lactation causing weight loss (table II).

Both on range and in drylot, cows on lower levels of supplementation tended to lose more winter weight, with the exception that High Herefords on range lost more weight during winter (14 kg) than Moderate Herefords. Apparently, under range conditions, the Moderate level provided adequate supplementation for Herefords, and increasing supplementation to the High level resulted in a decreased desire to graze low quality forage. This gave rise to a significant ($P < .05$) breed x treatment interaction for cows on range. In concurrence with this hypothesis, High Hereford cows in drylot consumed less roughage than Moderate Herefords (table I). Holsteins tended to lose more winter weight than other breeds ($P \approx .01$ and $\approx .68$ for range and drylot, respectively).

Within each breed, Moderate females tended to gain more summer weight in both range and drylot ($P \approx .50$ and $\approx .01$, respectively) except for the range Herefords. These results agree with those of Kropp <u>et al</u>. (1973), Joubert (1954), Nelson <u>et al</u>. (1954), Zimmerman (1960) and Hughes (1971) who reported that cows losing more winter weight, gain more weight during summer. For range cows at Moderate level of supplementation, both Hereford and Crossbred females made compensatory summer gains in contrast to the previous year when the Herefords were the only Moderate level range cows that compensated for winter losses. Moderate level drylot Herefords and Crossbreds also made compensatory summer gain. No breed differences were detected ($P \approx .22$) for range cow summer gains but in drylot, the Holsteins gained 36 and 53 kg more ($P < .05$ and .01) than the Crossbreds and Herefords, respectively. Moderate and High Holsteins (both range and drylot) did not increase in weight during the year as is normally observed between 3 and 4 years of age.

Generally, condition scores followed the trends of winter weight losses and summer weight gains. As 2-year-olds, a trend existed for groups that lost more condition during the winter to compensate by gaining more in the summer (Kropp et al., 1973). This trend, however, was not as distinct for the cows as 3-year-olds; all cows compensated for their winter condition loss during the summer except Moderate Holsteins on range and Moderate and High Holsteins in drylot. Range and drylot cows on higher levels of winter supplementation generally had higher ($P \approx .10$ and $\approx .01$, respectively) spring condition scores. Breed affected all condition scores ($P < .005$) with Holsteins having lowest scores followed by Crossbreds and Herefords, respectively.

Lactation

The three breeds employed in this experiment effectively produced three distinct levels of milk yield (table III). All differences between breeds were highly significant ($P < .01$) whereas treatment differences within breeds were not significant ($P \approx .56$). As would be expected, Herefords, Crossbreds and Holsteins produced 15, 10 and 22% (range) and 40, 8 and 30% (drylot) more milk as 3-year-olds than as 2-year-olds (Kropp et al., 1973). Average daily milk production for Herefords, Crossbreds and Holsteins was 6.0, 9.1 and 13.4 kg (least square means for the range); and 6.7, 9.0 and 13.9 kg (simple means for the drylot).

Although the trend was not as clear in the drylot phase, the three breed groups remained distinct for milk yield throughout the lactation period (figure 1). Similar to their lactation curves as 2-year-olds, the Hereford and Crossbred curves were very flat. Both on range and in drylot, the Holsteins actually increased in production during the latter part of lactation. The flatness of the Hereford and Crossbred curves as well as the latent increase in the Holstein curves may be explained by lush grazing conditions in the spring (months 3, 4 and 5 of lactation in figure 1 were March, April and May) for the range cattle and the transition to higher energy rations for the drylot cattle. The range lactation curves did decrease in the very last part of lactation corresponding with decreasing quality of summer grasses. The curves of the drylot cattle remained relatively high at the end of lactation because of the high caloric density of their ration at that time (65% alfalfa hay, 30% milo, 5% tallow). Another possible explanation for increased milk production, especially for the Holsteins, during latter stages of lactation is increased calf capacity. Plum and Harris (1971) reported that Holsteins under a system of beef cattle management produced a constant amount of milk throughout lactation but the calf could not consume the entire milk production until the fourth month. Both on range and in drylot, Holsteins on lower levels of winter supplementation tended to increase milk production more rapidly upon the availability of diets of higher nutritional value. This is in agreement with Bond ét al. (1964), Huber, Graf and Engel (1964), Gillooly et al. (1967) and Wilson et al. (1969).

Although treatment differences for milk yield were nonsignificant ($P \approx .56$), a trend existed for the Herefords and Crossbreds on higher levels of supplementation to produce more milk. This trend, however, was not apparent for Holsteins.

Milk Composition

All values for milk composition (drylot phase) in table III are extremely low, especially values for butterfat. Ten of the 35 original cows begun in drylot were removed for various reasons (hardware disease, failure to calve, death of calf) near the time of their second calving and were replaced by range cows. A least squares analysis on butterfat, total solids and total milk production including only the 4 treatments in which cattle had been removed (Moderate Holsteins, Moderate Crossbreds and Moderate and High Herefords) revealed a highly significant ($P < .001$) advantage in butterfat of 0.7% for cattle that had been on range the previous year as compared to those that had been in drylot. The butterfat values in table III were corrected to a drylot cow equivalent on the basis of this difference between least square means. Previous system of management did not affect ($P > .50$) total milk production or total solids. This radical decrease in butterfat for cattle previously under drylot conditions is difficult to explain, but a partial explanation might be an accumulative stress of frequent handling and total confinement. Low butterfat percentages in the drylot cows might also be attributed to feeding low energy roughages (Graves et al., 1940; Lamond et al., 1969).

Holsteins and Crossbreds produced milk with a significantly higher ($P<.05$) percent butterfat than Herefords, whereas Herefords and Crossbreds produced milk with a higher ($P<.01$) percent solids-not-fat. No breed effect ($P>.50$) on total solids was detected.

Treatment affected percent butterfat and percent solids-not-fat significantly ($P<.005$); treatment effect on total solids approached significance ($P<.10$). The percent of each component increased as supplement level within breed increased. Much disagreement exists in the literature for changes in butterfat as dietary energy and protein change, but there is agreement that as level of nutrition increases, percent solids-not-fat also increases (Flux and Patchell, 1954; Huber et al., 1964; and Wilson et al., 1969).

Performance of Offspring

Drylot calves of Holstein cows were significantly ($P<.05$) heavier at birth than calves of Hereford cows whereas range calves of Holstein cows were significantly ($P<.05$) heavier than all other calves (table IV). These breed differences correspond to differences in body size of the dams of these calves since the Holstein cows were significantly heavier ($P<.01$) in both phases. Previous treatment of the dam did not affect ($P>.50$) birth weights of the second calves of these cows. This is not in agreement with long-term experiments with beef cattle wintered at different levels (Pinney, 1962; Hight, 1966; Wiltbank et al., 1962; Furr, 1959) but is similar to work of Reid et al. (1957a) who reported an increase in birth weight of calves expressed as percent of cow weight as nutritional level of the dam decreased.

Weaning weight least square means for range calves of Hereford, Crossbred and Holstein dams were 269, 290 and 331 kg whereas for drylot calves the means were 237, 275 and 310 kg, respectively (table IV). The only treatment differences within breed was for drylot Crossbreds; High level cows produced calves that weighed 61 kg more at weaning. This reflects their calves' increased DE and DP intake (table I).

Even though the drylot calves were fed a high energy creep and milk yield was similar within breed-treatment group between phases, the limited feeding time and possibly increased stress of stall feeding and total confinement limited growth of the drylot calves so that considerable advantage in weaning weight for the range calves was evident.

Reproductive Performance

As shown in table V, breed and treatment affected days post-partum to first observed estrus and days post-partum to apparent conception on range ($P < .01$) but not in drylot ($P > .05$). Post-partum interval tended to decrease as level of winter supplementation increased with the greatest differences being between treatments of higher producing cows. Moderate Holsteins exhibited a significantly ($P < .05$) longer post-partum interval compared to all other treatments. These results agree with those of Wiltbank et al. (1964), Turman et al. (1964), Deutscher and Whiteman (1971) and McGinty and Frerichs (1971).

As 2-year-olds, all Herefords, High Crossbreds and High and Very High Holsteins rebred (Kropp et al., 1973). A possible accumulative effect on reproduction occurred for the Moderate Crossbreds since (when range and drylot were combined) only 75% rebred. It is difficult to appraise the reproductive performance of the Holstein females because of the disproportionality of numbers resulting from poor reproduction of the Moderates the previous year, but when range and drylot were combined, the conception rates were 89, 93 and 100% for Moderate, High and Very High, respectively.

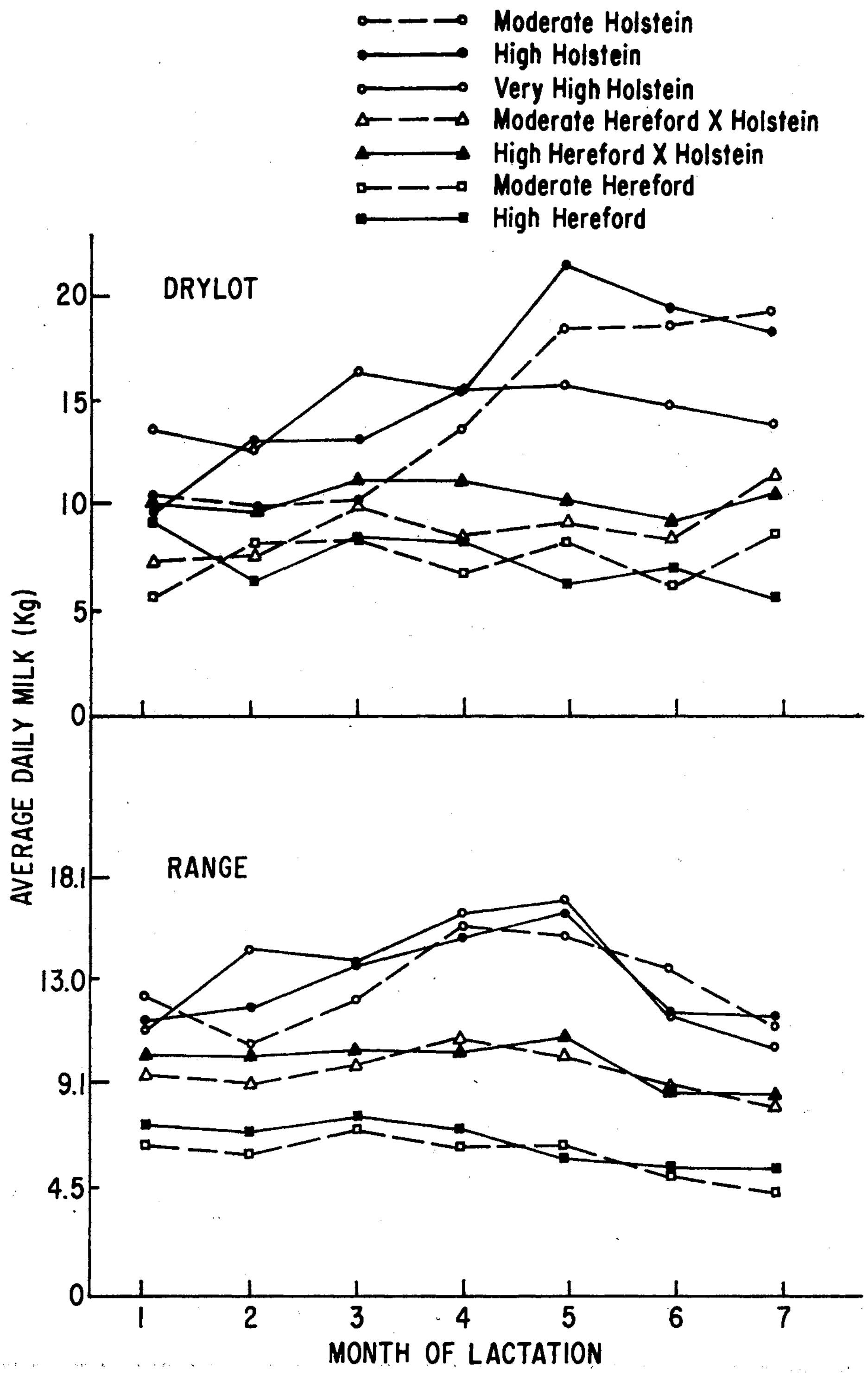

Figure 1. Lactation Curve of Hereford, Hereford x Holstein and Holstein Range and Drylot Cows

TABLE I

ROUGHAGE AND ESTIMATED DE AND DP INTAKE

Item	Breed and level of winter supplementation							SE[a]
	Hereford		Hereford x Holstein		Holstein			
	Moderate	High	Moderate	High	Moderate	High	Very High	
Range cows								
Supplement, kg								
Total winter[b]	160	313	156	346	177	354	539	
Daily, pre-calving	0.4	0.7	0.4	0.9	0.4	1.0	1.8	
Daily, post-calving	1.4	2.8	1.3	2.9	1.5	2.9	4.2	
Drylot cows								
Supplement, kg								
Total winter[b]	192	395	188	403	230	387	565	
Daily, pre-calving	1.0	1.6	1.0	1.6	1.2	1.5	2.5	
Daily, post-calving	1.4	2.9	1.3	3.0	1.6	3.0	4.1	
Roughage, drylot cows								
Total roughage intake, kg[c]	4055[fg]	3681[g]	4321[fg]	4189[fg]	5379[f]	5241[f]	4956[fg]	
Total roughage intake, %[d]	100	91	107	103	133	129	127	
Estimated daily DE intake during lactation, Mcal	26.30[g]	27.76[gh]	26.77[g]	31.02[h]	36.74[f]	36.16[f]	36.79[f]	1.37
Estimated daily DP intake during lactation, kg	0.99[h]	1.01[h]	1.01[h]	1.11	1.27[f]	1.31[fg]	1.40[g]	0.04
Creep feed, drylot calves								
Total creep intake, kg	336.18[f]	299.65[fg]	277.05[fg]	309.12[fg]	230.55[g]	253.17[g]	252.71[g]	71.80
Estimated daily DE intake, Mcal[e]	8.13[g]	7.65[g]	8.45[g]	9.77[g]	10.39[f]	12.19[f]	11.22[f]	0.51
Estimated daily DP intake, kg[e]	0.37[h]	0.35[h]	0.39[fg]	0.45[f]	0.52[h]	0.56[h]	0.54[h]	0.03

[a]Standard Error: Drylot, n = 5.
[b]November 9, 1971 - April 15, 1972, 157 days.
[c]Intake during pregnancy and lactation.
[d]Expressed as % of Moderate Herefords.
[e]Creep + milk.
[f,g,h,i]Means on the same line with the same superscript letter are not significantly different (P>.05).

TABLE II

WEIGHT, WEIGHT CHANGE, CONDITION AND CONDITION CHANGE

Item	Breed and level of winter supplementation							
	Hereford		Hereford x Holstein		Holstein			
	Moderate	High	Moderate	High	Moderate	High	Very High	SE[a]
Range								
Weight, kg								
Fall (pre-calving)	459^{de}	464^{de}	451^{d}	485^{cd}	538^{bce}	534^{bc}	549^{b}	15
Spring (mid-lactation)	386^{de}	377^{de}	369^{d}	407^{cd}	414^{bc}	433^{bc}	459^{b}	14
Fall (post-lactation)	469^{bd}	475^{d}	458^{d}	495^{cd}	530^{bc}	534^{b}	563^{b}	
Weight change, kg								
Winter	-72^{c}	-86^{bcd}	-83^{cd}	-79^{cd}	-125^{e}	-101^{be}	-90^{bd}	6.0
Summer	84^{b}	97^{b}	90^{b}	89^{b}	116^{b}	101^{b}	104^{b}	11.3
Year	11^{b}	11^{b}	7^{b}	10^{b}	-8^{b}	0^{b}	14^{b}	8.5
Weight change, %								
Winter	-16	-19	-18	-16	-23	-19	-16	
Summer	22	26	24	22	28	23	23	
Year	2	2	2	2	-2	0	3	
Condition score								
Fall (pre-calving	5.5^{de}	6.1^{d}	4.3^{bf}	4.9^{ef}	3.3^{bc}	3.0^{c}	3.8^{bc}	0.30
Spring (mid-lactation)	4.4^{b}	4.4^{b}	2.3^{ce}	3.2^{d}	1.3^{cd}	1.8^{ce}	2.4^{de}	0.31
Fall (post-lactation)	6.4^{b}	6.5^{b}	4.9^{c}	4.9^{c}	3.0^{d}	4.0^{cd}	3.8^{d}	0.38
Condition score change								
Winter	-1.1^{b}	-1.7^{bc}	-2.0^{c}	-1.7^{bc}	-2.0^{bc}	-1.3^{b}	-1.4^{bc}	0.25
Summer	2.0	2.0	2.6	1.7	1.7	2.2	1.4	0.40
Drylot								
Weight, kg								
Fall (pre-calving)	445^{d}	457^{d}	460^{d}	474^{cd}	556^{b}	530^{bc}	529^{bc}	22
Spring (mid-lactation)	371^{e}	427^{ce}	385^{e}	446^{cd}	466^{bcd}	496^{bd}	512^{b}	20
Fall (post-lactation)	507^{bcd}	500^{cd}	466^{d}	504^{cd}	540^{bc}	525^{bcd}	567^{b}	22

TABLE II (Continued)

Item	Hereford: Moderate	Hereford: High	Hereford x Holstein: Moderate	Hereford x Holstein: High	Holstein: Moderate	Holstein: High	Holstein: Very High	SE
	Breed and level of winter supplementation							
Weight change, kg								
Winter	-74^{c}	-30^{b}	-74^{c}	-27^{b}	-91^{c}	-34^{b}	-17^{b}	14
Summer	136	73^{b}	80^{b}	58^{bc}	74^{b}	29^{c}	56^{bc}	12
Year	62^{b}	43^{bc}	6^{ce}	31^{bcd}	-16^{e}	-5^{cde}	18^{bcde}	16
Weight change, %								
Winter	-17	-7	-16	-6	-16	-6	-3	
Summer	37	17	21	13	16	6	11	
Year	14	9	1	7	-3	-1	0	
Condition score								
Fall (pre-calving)	5.6^{b}	6.0^{b}	5.2^{bc}	4.6^{cd}	3.8^{d}	4.4^{cd}	4.4^{cd}	0.34
Spring (mid-lactation)	3.6^{b}	5.2	2.4^{c}	3.8^{b}	1.0	2.4^{c}	3.6^{b}	0.40
Fall (post-lactation)	6.6^{b}	6.8^{b}	5.6^{bc}	5.6^{bc}	3.4^{d}	3.6^{d}	5.2^{cd}	0.44
Condition score change								
Winter	-2.0^{c}	-0.8^{b}	-2.8^{d}	-0.8^{bc}	-2.8^{d}	-2.0^{c}	-0.8^{b}	0.34
Summer	3.0^{b}	1.6^{d}	3.2^{b}	1.8^{c}	2.4^{c}	1.2^{e}	1.6^{cde}	0.32

[a]Standard errors for range cows are approximate; those for Moderate Holsteins are approximately twice those of other groups. Standard errors for drylot cows are exact.

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

TABLE III

MILK PRODUCTION AND MILK COMPOSITION

Item	Hereford Moderate	Hereford High	Hereford x Holstein Moderate	Hereford x Holstein High	Holstein Moderate	Holstein High	Holstein Very High	SE[e]
	Breed and level of winter supplementation							
Range								
Total lactation yield, kg	1462[c]	1432[c]	1926[b]	2440[b]	3472[a]	3030[a]	3378[a]	189
Daily yield, kg	6.1[c]	6.0[c]	8.1[b]	10.2[b]	14.5[a]	12.6[a]	14.1[a]	2.00
Drylot								
Total lactation yield, kg	1595[c]	1625[c]	1975[ab]	2328[b]	3227[a]	3431[a]	3241[a]	162
Daily yield, kg	6.7[c]	6.8[c]	8.2[ac]	9.7[a]	13.4[b]	14.3[b]	13.5[b]	1.5
Butterfát, %	1.90[d]	1.98[cd]	2.06[bd]	2.54[abc]	2.02[b]	3.04[a]	2.54[abc]	0.22
Solids-not-fat, %	8.56[a]	8.58[a]	8.32[a]	8.65[a]	7.84[b]	8.24[a]	8.33[a]	0.14
Total solids, %	10.46[abc]	10.56[ac]	10.38[bc]	11.19[a]	9.86[c]	11.28[a]	10.87[ab]	0.26

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

[e]Standard errors for range cows are approximate; those for Moderate Holsteins are approximately twice those of other groups. Standard errors for drylot cows are exact.

TABLE IV

CALVING AND WEANING PERFORMANCE

Item	Breed and level of winter supplementation							SE[e]
	Hereford		Hereford x Holstein		Holstein			
	Moderate	High	Moderate	High	Moderate	High	Very High	
Range								
No. of calves	12	8	9	12	3	8	8	
Male	7	7	1	4	1	3	5	
Female	5	1	8	8	2	5	3	
Birth weight, kg	38^{d}	39^{d}	39^{abd}	39^{ad}	45^{abc}	44^{bc}	44^{c}	1.7
Adj. weaning weight, kg	273^{bc}	268^{c}	286^{bc}	292^{b}	328^{a}	334^{a}	329^{a}	7.6
Drylot								
No. of calves	5	5	5	5	5	5	5	
Male	3	1	4	3	2	3	3	
Female	2	4	1	2	3	2	2	
Birth weight, kg	38^{abc}	35^{c}	36^{bc}	41^{abc}	43^{abc}	44^{a}	41^{abc}	5.2
Adj. weaning weight, kg	238^{b}	237^{b}	244^{b}	305^{a}	302^{a}	317^{a}	307^{a}	13.5

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

[e]Standard errors for range cows are approximate; those for Moderate Holsteins are approximately twice those of other groups. Standard errors for drylot cows are exact.

TABLE V

REPRODUCTIVE PERFORMANCE

	Breed and level of winter supplementation							
	Hereford		Hereford x Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE[f]
Range								
No. of cows	12	10	11	13	4	9	8	
No. of cows exhibiting estrus	12	10	9	13	4	8	8	
Days post-partum to first observed estrus[a]	73[e]	68[e]	79[e]	64[e]	127[d]	79[e]	57[e]	8.9
No. of cows which conceived[b]	12	9	8	12	4	8	8	
Days post-partum to apparent conception[c]	94[e]	90[e]	94[e]	90[e]	140[d]	94[e]	85[e]	8.9
Drylot								
No. of cows	5	5	5	5	5	5	5	
No. of cows exhibiting estrus	4	5	5	5	5	5	5	
Days post-partum to first observed estrus[a]	101[de]	90[de]	79[de]	72[e]	109[d]	83[de]	65[e]	11.4
No. of cows which conceived[b]	4	5	4	5	4	5	5	
Days post-partum to apparent conception[c]	106[d]	99[d]	77[d]	89[d]	109[d]	90[d]	103[d]	11.1

[a]Only data from cows exhibiting estrus were analyzed.
[b]Based on palpation and verified by calving records the following season.
[c]Analysis on those cows which conceived.
[d,e]Means on the same line with the same superscript letter are not significantly different ($P<.05$).
[f]Standard errors for range cows are approximate; those for Moderate Holsteins are approximately twice those of other groups. Standard errors for drylot cows are exact.

CHAPTER IV

EFFICIENCY OF BEEF PRODUCTION OF TWO AND THREE-YEAR-OLD HEREFORD, HEREFORD x HOLSTEIN AND HOLSTEIN FEMALES ON RANGE AND IN DRYLOT[1,2]

Summary

Efficiency of production of first and second calf Hereford, Hereford x Holstein (Crossbred) and Holstein cows was compared under both range and drylot conditions. Within breed, cows were fed either a Moderate or High level of winter supplementation. A group of Holsteins was also fed a Very High level. Moderate, High and Very High treatments were the theoretical amounts of winter supplement needed in addition to dry winter range grass to

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[1]Journal Article 2735 of the Agricultural Experiment Station, Oklahoma State University, Stillwater. This research was conducted by the Department of Animal Sciences and Industry in cooperation with the U.S.D.A., Agricultural Research Service, Southern Region.

[2]J.W. Holloway[3], Leon Knori[4], R.A. Dean[5], J.R. Kropp[5], K.S. Lusby[5], J.V. Whiteman[5], D.F. Stephens[4] and Robert Totusek[5].

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sustain good reproduction of Hereford, Crossbred and Holstein cows, respectively. Estimated digestible energy (DE) intakes were calculated from individual feed intakes of drylot cows and from theoretical requirements of range cows (efficiencies were calculated from these estimated values). Drylot cows were fed roughage and concentrates to simulate seasonal changes in energy intake of range cows. Drylot calves were individually fed a creep ration before weaning and were individually fed post-weaning until they were deemed fat enough to grade choice. Calves were sired by Angus bulls the first year and Charolias bulls the second. Gross efficiency of production was calculated on the basis of conversion of estimated DE intake to (1) milk, (2) weaned calf and (3) carcass beef.

Holstein cows consumed more ($P<.005$) DE, produced more ($P<.01$) milk gross energy (GE) and converted estimated DE to milk GE more ($P<.01$) efficiently than other breeds, followed by Crossbreds and Herefords, respectively.

Although calves from Holsteins grew faster ($P<.01$) to time of weaning and were heavier ($P<.01$) at weaning, they converted both milk GE and total (creep and milk) DE intake to weaning weight less efficiently ($P<.05$) than calves from Crossbreds or Herefords. Herefords were superior in this respect, but Crossbreds were slightly superior ($P<.25$) in converting total feed DE intake of cow and calf to weaning weight because of greater efficiency in conversion of DE to milk GE.

Herefords and Crossbreds were more efficient ($P<.10$) than Holsteins for conversion of DE intake of cow, calf, or cow and calf to kilograms of high-priced cuts. Herefords, however, held the advantage ($P \sim .001$ to $\sim .16$ for six comparisons) in converting DE intake of cow, calf or cow and calf to gross energy of carcass followed respectively by Crossbreds and Holsteins. Generally, treatment of dam did not affect ($P > .10$) the calculated efficiencies.

Introduction

Weaning weight is of considerable importance in beef production since it either directly or indirectly affects all phases of the industry. Currently, much pressure is being exerted to increase weaning weight by increasing milk yield of the dam. Milk yield of beef cows can be increased most rapidly by introducing genes from dairy animals. Increasing level of milk yield in dairy cows increases efficiency of lactation (Reid, Moe and Tyrrell, 1966; Baumgardt, 1967), but Holsteins do not grow as efficiently in the feedlot as Herefords (Garrett, 1969). A comparison of the gross efficiencies of beef, beef x dairy and dairy breeds during the entire production cycle has not been reported previously.

The objective of the research reported herein was to determine the efficiency of utilization of digestible energy by Hereford, Hereford x Holstein and Holstein cattle, considering energy consumed by the cow and calf to slaughter.

Materials and Methods

Hereford, Hereford x Holstein (Crossbred) and Holstein females were assembled at the Fort Reno Livestock Research Station at approximately one year of age and managed under either tallgrass native range or completely confined drylot conditions during their first two productive years. Detailed descriptions of management practices and data collected were reported by Kropp et al. (1973) and Holloway et al. (1974) who summarized the production of these cattle as 2- and 3-year-olds, respectively. Only a general review of management practices will be outlined here but other techniques specifically utilized in the research reported herein will be described in detail.

Both range and drylot cows were bred for winter (December, January, February) calving to Angus and Charolais bulls their first and second calves, respectively. Cows of each breed were assigned on the basis of initial calving date to two levels of winter supplement (30% natural protein) designated as Moderate and High. An additional Very High level was fed to another group of Holsteins. The Moderate, High and Very High levels represented the amount of supplement estimated necessary to maintain satisfactory reproductive performance in Hereford, Crossbred and Holstein females, respectively. Moderate Hereford, High Crossbred and Very High Holstein cows were considered the base groups and in drylot were fed an average of 1.2, 2.3 and 3.6 and 1.4, 3.0 and 4.1 kg/head/day post-calving, respectively, as 2-year-olds (Kropp et al., 1973) and as 3-year-olds (Holloway et al., 1974). Individual cows within level of supplement both on range and in drylot were fed supplement according to metabolic size ($Wt._{lb}^{.75}$) in accordance with their deviation from the mean weight of the base group. Drylot cows were also fed roughage and concentrates to simulate seasonal changes in energy consumption of range cows. The winter drylot cow ration was primarily cottonseed hulls with gradually increasing increments of chopped alfalfa hay, milo, molasses and beef tallow during spring. The first calves of drylot cows received a creep ration of 60% chopped alfalfa hay, 20% cottonseed hulls, 15% whole oats and 5% liquid cane molasses; the second year the ration consisted of 52.5% steam rolled corn, 17.5% soybean meal, 15% ground alfalfa hay, 10% cottonseed hulls and 5% molasses. Estimated DE intakes were calculated from tabular data (Crampton and Harris, 1969) and were employed in calculation of all estimates of efficiency. Digestibility coefficients were determined for cows in both winter and summer by the chromic oxide technique (Lusby et al., 1973), but these data were used in this study to aid in interpretation.

Drylot cattle were maintained in seven pens according to breed and treatment, but both cows and calves were individually fed their diet ad libitum during a 3-hour period each day. After weaning, drylot calves were allowed one large loafing pen but were individually fed ad libitum for a 15-hour period each night. The feedlot rations in tables VI and VII were fed to drylot calves the first and second years, respectively. The drylot feedlot ration as well as drylot creep and cow roughage rations were increased in caloric density the second year to improve weight gains over those noted in drylot the first year (Kropp et al., 1973). Each calf was slaughtered when judged fat enough to grade choice.

Cow weights, calf weights and milk yield estimates were obtained at monthly intervals and milk composition of drylot cows was estimated during the fourth, fifth and sixth months of lactation in the manner reported by Kropp et al. (1973), employing the standard Babcock and total solids procedures. These milk composition data were used to calculate energy density of milk by the equation of Tyrrell and Reid (1966). At slaughter, warm carcass weight, chilled carcass weight, ribeye area, and fat thickness over the 12th rib were obtained, and percent kidney, heart and pelvic fat was estimated; the equation of Murphy et al. (1960) was employed to calculate percent retail cuts. Gross energy of the carcass of drylot calves was determined by specific gravity as explained by Kraybill, Bitter and Hankins (1952).

Individual feed intake was obtained for drylot cows during first lactation, second lactation and the "dry" period between the two lactations; efficiency calculations were made both with and without estimated DE intake of this "dry" period. When estimating efficiency of conversion of DE intake by the cows to GE in milk, the "dry" period was considered a recovery period for the first period. In estimating efficiency of DE intake of cow to output variables concerning the calf, DE intake of the "dry" period was considered a part of the DE requirement of the second calf (requirement of the cow during gestation) and was included in these calculations.

Statistical analysis was appropriate only for the drylot phase. Variables concerning only the cows were analyzed by analyses of variance in a 3 x 2 factorial using three breeds (Hereford, Crossbred and Holstein) and two levels of supplementation

(Moderate and High) as the 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 excluded from this analysis but were compared to all other groups by the least significant difference (LSD) procedure (Snedecor and Cochran, 1967). Since the females were initially allotted according to date of calving and not re-allotted for the second calf crop, a disproportionate calf sex distribution within breed-treatment group resulted. Since sex was a potential factor in the growth and feed intake of the calf, all variables concerning the calf were analyzed by least squares analyses including three breeds (Hereford, Crossbred and Holstein), two levels of supplementation (Moderate and High) and two sexes (steers and heifers). Including sex in the model resulted in empty cells for the data of the first year's production causing the $(X'X)^{-1}$ matrix not to be of full rank. Therefore, these estimates of means and variances are not the best linear unbiased estimates but are unbiased. None of the interactions tested were significant ($P > .05$). Very High Holsteins were excluded from this analysis and 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. The breed-treatment means refer to these least square sex adjusted means. An analysis of variance was then calculated including sex of calf, breed-treatment group adjusted for sex of calf and breed-treatment group. The mean square associated with this error term (cow adjusted for sex of calf and breed-treatment group) was used in calculation of LSD to compare the Very High Holsteins to other breed-treatment groups.

For comparison of drylot and range cows, estimates were made of the energy input-outgo relationships of the range cows based on averages of breed-treatment groups; thus no statistical analysis could be performed. DE intake of range cows during lactation was calculated by:

DE requirement = DE required for maintenance + DE required for weight gain - DE available from weight loss + DE required for milk production.

DE required for maintenance was calculated by the method of Garrett, Meyer and Lofgreen (1959). DE required for weight gain and DE available from weight loss were derived 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 20 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 calculated by the equation 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 for drylot cows.

DE intake during "dry" period was calculated by:

DE requirement = DE required for maintenance - DE available from tissue loss + DE required for gestation.

DE requirement for maintenance was calculated as for the lactation period. DE available from tissue loss was calculated by:

DE tissue loss (gain) = 2.73 Mcal/lb (weight gain (lb) - (2 x birth weight (lb) of calf)),

which considers the proportion of weight gain prior to calving that is fetal growth. DE requirement for gestation was calculated by:

DE gestation = 1.15/0.15 x 0.85 (birth weight (kg)),

according to Widdowson (1950) and Moe, Tyrrell and Flatt (1971).

Results and Discussion

Efficiency of cows can be classified according to end-points of production, and this discussion will be organized in that manner with the end-points being milk yield, weaning weight and carcass beef. Efficiency of milk yield was measured most precisely; precision decreased as estimates of efficiency progressed to carcass beef production. The following discussion will mainly concern the drylot phase, but range data will be discussed for comparison purposes.

Efficiency of Milk Yield

The efficiencies presented in this section are gross efficiencies by definition (Brody, 1945) and suffer from several faults from a theoretical standpoint. First, females in different breed and level of supplementation groups may lose different amounts of body tissue during lactation. 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 of milk yield may be affected but not detected by the gross efficiency calculation. Tissue energy change could not be monitored in this trial because of the unknown composition of body weight change (Flatt _et al_., 1965). Second, the gross efficiencies are based on calculated DE values from tabular material and fail to consider potential differences in cow or calf digestibility due to breed and level of supplementation. Third, the gross efficiencies are based on estimated GE of milk employing the regression equation developed by Tyrrell and Reid (1966). Although this equation is precise in predicting energy content of low butterfat milk, a few of the butterfat and solids-not-fat values observed in this research were outside the population employed in formulating the prediction equation.

The redeeming characteristic of the GE efficiency calculation used in this study, however, is its pragmatic nature; the most important measure of efficiency to producers is the overall conversion of "potential" DE intake to milk GE or some other measure of output. The differences in gross efficiencies between breed-level of supplementation groups consist of many factors including the first two mentioned above; further characterization of these factors is beyond the scope of this study.

Breed affected ($P<.005$) drylot DE intake for both lactations with Herefords, Crossbreds and Holsteins consuming 4808, 5602 and 6733 (first lactation) and 6492, 6935 and 8749 (second lactation) Mcal, respectively (table VIII). The increased DE intake of the second lactation was due to increased cow maintenance requirement, increased energy density of roughage rations and changes in management practices to allow increased consumption of roughages. Level of winter supplement also affected DE intake for both lactations ($P<.025$ and .10) with High level cows consuming 437 and 408 Mcal more DE than Moderates in the first and second lactations, respectively. High Holsteins, however, consumed slightly less DE than the Moderates in the second lactation. Neither breed nor level of winter supplementation significantly ($P>.25$) affected DE intake during the "dry" period, but on range and in drylot Holsteins tended to consume more DE during the "dry" period. Generally, theoretical intakes of the range cows followed the same trends and were comparable in magnitude to those of drylot cows (table VIII); DE intake during "dry" period of drylot cows was greater than that estimated for range cows because of higher level of pre-calving supplement for drylot cows (Holloway et al., 1974).

As level of supplementation increased (drylot, table VIII), caloric density of milk also increased ($P<.005$), reflecting increased ($P<.05$) butterfat and SNF percentages. All values for milk composition were low (table VIII), especially butterfat in the second lactation, possibly due to drylot stresses and low energy diets. Ten of the 35 original drylot cows were removed from drylot for various reasons (hardware disease, failure to calve, death of calf) before second lactation and were replaced by range cows. A least squares analysis for second lactation butterfat, solids-not-fat and total milk yield on the four treatments in which cattle had been removed (Moderate Holstein, Moderate Crossbred and Moderate and High Hereford) revealed a highly significant ($P<.001$) advantage in butterfat of 0.7% for cows on range the previous year. Previous system of management did not affect ($P>.50$) total milk yield or SNF. Butterfat values were corrected to a drylot cow equivalent on the basis of this difference between least square means.

Drylot Holsteins produced 578 and 356 Mcal more ($P<.01$) milk GE than Crossbreds which in turn produced 350 and 679 Mcal more ($P<.01$) than Herefords for first and second lactations, respectively. Also, cows on higher levels of winter supplement produced more ($P<.01$) milk GE than Moderate level cows; this is a reflection of increased energy density of milk since level of winter supplementation did not affect ($P>.05$) milk yield.

In drylot as supplement level increased within breed, gross efficiency of conversion of cow feed DE to milk GE also tended to increase (table VIII). This increase was detected from the theoretical estimates of range cows only the first year and perhaps can be explained by differences in digestibility. Results from a chromic oxide digestibility trial conducted on second lactation winter cottonseed hull ration indicated an increase ($P<.01$) in digestibility of; dry matter (17.2 and 8.4%), acid detergent fiber (26.8 and 14.7%) and crude protein (15.7 and 6.2%) for the

Very High and High levels as compared to Moderates (Lusby et al., 1973). These digestibility results do not concur with work of Brown (1966) and Tyrrell, Reid and Moe (1966) who reported decreased digestibilities as intake increased, but can be explained on basis of availability of a more balanced nutrient supply to rumen microbes for cattle receiving higher levels of winter supplement. Breed significantly ($P<.01$) affected efficiency of conversion of DE consumed by cow to milk GE both when the "dry" period was included and excluded (table VIII, drylot). Excluding the dry period, Holsteins were 1.4 and 9.3 percent more efficient than Crossbreds and Herefords the first lactation and 4.2 and 8.3 percent the second lactation. The same trends were noted for range cows. Lusby et al. (1973) found decreased digestibility of acid detergent fiber for Herefords consuming the summer alfalfa ration during their second lactation. This indicates that the values for Hereford DE intake in table VIII may be slightly high thus increasing actual gross efficiency of lactation and decreasing the actual difference between Herefords and other breeds slightly. The gross efficiency values in table VIII are low compared to values of 25.0 to 37.4% reported for dairy cattle by Coppock, Flatt and Moore (1964a), Elliot and Loosli (1959ab), Flatt et al. (1966) and Putnam and Loosli (1959), probably because both DE intake and milk yield were much lower in this study.

DE intake and milk yield were higher the second lactation than the first but gross efficiency decreased. This can be explained by the abnormally low butterfat and solids-not-fat levels in the second lactation resulting in abnormally low caloric density of milk (table VIII). In calculating caloric density of milk for range cows, the first lactation drylot composition data were used for both range lactations since there was no apparent reason for decreased composition for the second lactation of range cows. Therefore, increased theoretical DE intake and increased milk yield for the second lactation resulted generally in increased gross efficiencies.

Efficiency of Weaned Calf Production

Breed of dam significantly ($P<.0001$) affected both first and second calf DE consumption (creep and milk). Daily sex-adjusted DE consumption for calves of Hereford, Crossbred and Holstein dams was 5.33, 8.42 and 9.86 (first calves) and 7.82, 9.09 and 11.09 (second calves) Mcal/day (table IX). Level of winter supplementation of dam did not significantly ($P\approx.51$ and $\approx.10$ for first and second calves, respectively) affect DE or DP intake of the calf possibly because calves of Moderate cows tended to compensate for limited milk intake by increasing creep intake (table IX). Breed of dam did not affect ($P\approx.61$) creep DE intake of the first calves, but the second calves of Hereford and Crossbred cows partially compensated for their limited milk DE intake by increasing ($P<.05$) creep intake as compared to Holsteins.

Although Holstein cows were more efficient ($P<.01$) in converting feed DE to milk GE, Hereford calves were more efficient ($P<.005$) in converting milk GE to weaning weight (table IX). These efficiencies for Herefords, Crossbreds and Holsteins were 0.253, 0.175 and 0.147 (first calves) and 0.266, 0.223 and 0.163

(second calves) kg calf/Mcal GE; similar trends were noted for range cows. Gifford (1953) reported decreased efficiency of calf gain from milk of high producing cows ostensibly because of increased maintenance requirement of heavier calves. This cannot completely explain the large differences in efficiency noted in this study since heavier calves also grew faster (preweaning daily gain of calves from Herefords, Crossbreds and Holsteins was 0.69, 0.81 and 0.90, and 0.84, 0.98 and 1.11 kg/day for first and second calves, respectively), resulting in a dilution of maintenance requirements. Increased efficiency of calves from Herefords for converting milk to weaning weight may be due to inherent metabolic differences resulting from years of selection pressure for progeny performance. Increased efficiency of second calves of Hereford cows can also be explained by the increased proportion of total consumed DE contributed by creep.

Also, when efficiency was calculated on the basis of conversion of total DE intake of calf (creep and milk) to weaning weight, calves of Hereford cows were most efficient; 0.023 and 0.035 (first calves $P<.0001$), and 0.004 and 0.012 (second calves $P\approx.20$) kg calf/Mcal DE more efficient than calves from Crossbred and Holstein cows, respectively.

In drylot, when efficiency was calculated as conversion of feed DE intake of both cow or cow and calf (including and excluding cow "dry" period), no breed differences ($P>.05$) were detected. Crossbreds, however, tended to be most efficient for all measurements of efficiency (table IX, drylot), but only slightly superior to Herefords. From theoretical calculations of the range cows, however, the Herefords were more efficient than Crossbreds (table IX, range). This discrepancy between range and drylot might be explained by a more severe calf weaning weight depression in response to drylot stress for calves of Hereford cows as compared to those of Crossbreds. Weaning weight of calves from Hereford cows in drylot was 81.5 and 86.3% that of first and second calves of Crossbred cows whereas on range, the corresponding values were 90.3 and 92.8 percent. Thus, it is possible that the advantage in efficiency of Crossbreds over Herefords in drylot for conversion of calf or cow and calf DE intake to weaning weight may not apply to cattle on range conditions.

Level of winter supplementation did not affect any of the calculated efficiencies ($P>.53$) except conversion of DE intake by cow when dry period was included ($P\approx.02$). For this expression of efficiency as well as all other efficiencies including cow DE intake, the High level cows tended to be more efficient. As mentioned above, however, Lusby et al. (1973) indicated increased digestibilities for winter ration of High level cows as compared to Moderates. Thus, the tabular DE intakes used in calculating efficiencies here tended to underestimate actual DE intakes of High level cows as compared to Moderates. If the efficiencies were calculated on actual DE intakes, the difference between Moderate and High level cows would be small or non-existent.

Efficiency of Slaughtered Beef Production

Breed of dam significantly influenced feedlot DE intake of drylot calves ($P \approx .0001$ and $\approx .003$ for the first and second calves, respectively). Calves from Hereford, Crossbred and Holstein dams consumed 4927, 6324 and 7544, and 5370, 5684 and 7167 Mcal the first and second calves, respectively. Although level of dam supplementation did not affect ($P > .76$) first calf feedlot DE intake or carcass weight, the second calves of High level cows consumed 1037 Mcal more ($P \approx .07$) and had 76 kg heavier ($P \approx .04$) carcass weights than calves from Moderate cows (table X). No reason for this is apparent except chance allottment of cattle to treatment. Combining years, calves from Holstein cows had 8 and 30 kg more ($P < .10$) high priced cuts than calves of Crossbreds and Herefords, respectively. This difference was not due to breed effect ($P > .25$) on percent high priced cuts but to the breed effect ($P \approx .0006$ and $\approx .12$ for first and second calves) on carcass weight (table X). Because carcass weight of the second calves was influenced ($P \approx .04$) by level of dam supplementation, second calves of High level cows had more ($P \approx .03$) high priced cuts.

Neither breed nor treatment of dam affected ($P > .3$) carcass energy density of calf, probably because the calves were slaughtered at similar fatness. A possibility exists, however, that in using the specific gravity method for determining carcass energy density, a bias was introduced decreasing apparent differences between treatments. According to Reid and Robb (1971), the equation used in this study progressively underestimates percent fat as carcass density decreases below 1.075. This bias was minimized in this study because the end-point for slaughter was fatness; no breed or treatment differences (P>.10) were noted for either fat over the 12th rib or percent kidney, heart and pelvic fat. Another bias possibly introduced by employment of specific gravity technique arises from the difference in percent bone of dairy and beef breeds. Estimates of differences between Hereford and Holstein carcass for percent bone on a fat-free basis vary from 0.2 to 2.4 percent (Callow, 1961; Cole, Orme and Kincaid, 1960 and Bond et al., 1972). Since within calf crop, most calves in this study were sired by the same bull, the biases in carcass density due to breed differences in bone were judged to be small.

Another result of using fatness as the criterion for slaughter was the breed of dam effect (P≈.07) on carcass weight resulting in a breed difference in total carcass energy (P≈.06 and ≈.15 for first and second calves). Total carcass energy of first and second calves was largest for Holsteins (901 and 1009 Mcal) followed by Crossbreds (908 and 891 Mcal) and Herefords (727 and 880 Mcal), respectively.

Breed of dam affected (P≈.0006 to ≈.06) efficiency of conversion of calf or cow and calf DE intake to high priced cuts. Although Holsteins produced calves that yielded more kilograms of high priced cuts, they did so with less efficiency than Crossbreds or Herefords (table X); calves of Hereford cows (considering lifetime DE intake) were 18 and 29 (first calves) and 2 and 19 (second calves) percent more efficient than calves of Crossbreds and Holsteins, respectively. Generally, Herefords tended to be most efficient producers of high priced cuts except for second calf efficiency of conversion of feed DE intake of both cow (including and excluding "dry" period) and calf to high priced cuts. For these estimates, Herefords and Crossbreds were similar but were 13 (first calf) and 16 (second calf) percent more ($P \approx .02$) efficient than Holsteins.

Holsteins were also the least efficient producers of carcass GE ($P \approx .0001$ to $\approx .16$ for all estimates). Herefords were consistently more efficient than Crossbreds and Holsteins respectively for conversion of calf or cow and calf DE intake to carcass GE. For efficiency of conversion of cow and calf feed DE intake, Herefords were 3 and 17 (first calf) and 5 and 13 (second calf) percent more efficient than Crossbreds and Holsteins, respectively. When efficiency was calculated as conversion of calf lifetime DE intake to carcass GE, the efficiency of first calves of Hereford, Crossbred and Holstein dams was 0.1193, 0.1053 and 0.0915 Mcal carcass GE/Mcal feed DE, whereas the efficiency of second calves was 0.1207, 0.1121 and 0.1022 Mcal GE/Mcal DE, respectively. This indicates that Angus and Charolais crossbred calves of Hereford cows were 18 and 30 percent more ($P < .04$) efficient in converting lifetime estimated DE intake to carcass GE than corresponding calves of Holstein cows.

Garrett (1969) indicated that in feedlot, Herefords are 20 percent more efficient in conversion of feed energy to protein and fat than Holsteins, in agreement with results of this trial. He suggests that the difference between breeds is not due to differential efficiency of fat and protein synthesis but to differences in metabolism resulting from different selection pressures for the two breeds. Another possible explanation would be differences in digestibility (and nutritive value) between breeds due to inherent differences in level of feed intake. This, however, could not account for the magnitude of differences in this study since Moe and Tyrrell (1973) have found maximum decreases in nutritive value of only 4% for each increased intake of 1x maintenance; the maximum differences in cow intake between breed-treatment groups in this experiment was 0.7x maintenance.

Level of winter supplementation did not affect efficiencies of high priced cuts or carcass gross energy production.

TABLE VI

FEEDLOT RATION FOR FIRST DRYLOT CALVES

Ingredient	
Milo, dry rolled, %	65.5
Cottonseed hulls, %	10.0
Chopped alfalfa hay, %	10.0
Soybean meal (44% CP), %	7.5
Urea (45% N), %	1.0
Liquid cane molasses, %	5.0
Dicalcium phosphate	0.5
NaCl	0.5
Vitamin A, IU/kg	10.0
Chlorotetracycline, mg/kg	1.5
Stilbesterol, mg/kg	0.1

TABLE VII

FEEDLOT RATION FOR SECOND DRYLOT CALVES

Ingredient	
Whole corn, %	87.0
Cottonseed hulls, %	5.0
Supplement (pelleted), %	8.0
Composition of supplement	
Soybean meal (44% CP), %	50.000
Urea (45% N), %	10.000
NaCl, %	4.500
KCl, %	3.250
$CaCO_3$ (38% Ca), %	7.500
Trace minderal mix, %	0.350
Chlorotetracycline, g/kg	10.582
Vitamin A, %	0.300
Cottonseed meal (41% CP), %	19.785
Wheat mids (15.5% CP), %	3.500

TABLE VIII

LACTATION EFFICIENCY OF TWO AND THREE-YEAR-OLD COWS

Item	Breed and level of winter supplement							S.E.
	Hereford		Crossbred		Holstein			
	Moderate	High	Moderate	High	Moderate	High	Very High	
Drylot first lactation								
n	5	5	5	5	5	5	5	
DE intake during lactation, Mcal	4555^{a}	5061^{ab}	5533^{bc}	5671^{c}	6399	7067^{d}	7418^{d}	201.3
DE intake during "dry" period, Mcal	3033^{ab}	2568^{b}	3526^{ab}	2843^{ab}	3393^{ab}	3826^{a}	3330^{ab}	353.9
Butterfat, %	2.56^{a}	2.78^{ab}	3.00^{bc}	3.14^{c}	2.84^{ab}	3.22^{c}	3.24^{c}	0.103
Solids-not-fat, %	8.84^{b}	8.86^{b}	8.53^{a}	8.80^{b}	8.52^{a}	8.59^{a}	8.54^{a}	0.072
Total milk produced, kg	1132^{a}	1159^{a}	1980^{b}	1993^{b}	2390	2717	2804	89.7
Milk GE density, kcal/kg	614.0^{a}	635.6^{ab}	639.6^{ab}	665.5^{b}	624.1^{a}	662.9^{b}	662.3^{b}	10.25
Total milk GE produced, Mcal	697^{a}	737^{a}	1264^{b}	1325^{b}	1491	1799^{c}	1857^{c}	56.8
Efficiency of conversion of DE consumed by cow (including "dry" period) to milk GE, %	9.2^{a}	9.6^{a}	14.1^{b}	15.6^{c}	15.4^{bc}	17.4^{d}	17.6^{d}	0.96
Efficiency of conversion of DE consumed by cow (excluding "dry" period) to milk GE, %	15.6^{a}	14.6^{a}	22.7^{a}	23.3^{a}	23.5^{ab}	27.2	25.0^{b}	1.18
Drylot second lactation								
n	5	5	5	5	5	5	5	
DE intake during lactation, %	6320^{a}	6663^{ab}	6424^{a}	7445^{b}	8819^{c}	8680^{c}	8830^{c}	322.5
Butterfat, %	1.90^{a}	1.98^{ab}	2.06^{ab}	2.54^{bc}	2.02^{ab}	3.04^{c}	2.54^{bc}	0.220
Solids-not-fat, %	8.56^{a}	8.58^{a}	8.32^{a}	8.65^{a}	7.84	8.24^{a}	8.33^{a}	
Total milk produced, kg	1595^{a}	1625^{a}	1975^{ab}	2328^{b}	3227^{c}	3431^{c}	3241^{c}	162.3
Milk GE density, kcal/kg	554.7^{ab}	561.7^{ab}	562.2^{ab}	602.7^{c}	536.2^{a}	629.0^{c}	587.0^{abc}	22.27
Total milk GE produced, Mcal	891^{a}	914^{a}	1117^{ab}	1400^{b}	1734^{d}	2140^{c}	1907^{cd}	105.5
Efficiency of conversion of DE consumed by cow (excluding "dry" period) to milk GE, %	14.4^{a}	14.1^{a}	17.8^{b}	18.9^{bc}	20.3^{cd}	24.8	21.6^{d}	0.37

TABLE VIII (Continued)

Item	Hereford Moderate	Hereford High	Crossbred Moderate	Crossbred High	Holstein Moderate	Holstein High	Holstein Very High	S.E.
	Breed and level of winter supplement							
Range first lactation								
n	12	12	13	13	11	11	11	
Energy requirement during lactation (Mcal DE)	4693	4784	5850	5844	6922	7784	7365	
Energy requirement during "dry" period (Mcal DE)	2268	2303	2372	2444	2666	2710	2688	
Calculated energy produced in milk (Mcal GE)	805	891	1207	1405	1602	1775	1790	
Efficiency of conversion of DE intake (including "dry" period) to milk GE, %	11.53	12.57	14.68	16.95	16.71	16.91	17.81	
Efficiency of conversion of DE intake (excluding "dry" period) to milk GE, %	17.15	18.62	20.63	24.03	23.14	24.37	24.30	
Range second lactation								
n	12	8	7	12	3	8	8	
Energy requirement during lactation (Mcal DE)	5026	5441	5407	6240	8082	8037	7952	
Calculated energy produced in milk (Mcal GE)	900	910	1234	1627	2168	2012	2240	
Efficiency of conversion of DE intake (excluding "dry" period) to milk GE, %	17.90	16.72	22.84	26.07	26.82	25.04	28.17	

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

TABLE IX

EFFICIENCY OF TWO AND THREE-YEAR-OLD COWS TO TIME OF WEANING OF PROGENY

Item	Breed and level of winter supplement							S.E.
	Hereford		Crossbred		Holstein			
	Moderate	High	Moderate	High	Moderate	High	Very High	
Efficiency of conversion of feed DE intake by cow (including "dry" period) and calf to weaning weight of calf, kg/Mcal	0.0226^{a}	0.0243^{a}	0.0223^{a}	0.0279	0.0237^{a}	0.0240^{a}	0.0242^{a}	0.00108
Efficiency of conversion of DE intake by cow (excluding "dry" period) to weaning weight of calf, kg/Mcal	0.0379^{ab}	0.0355^{ab}	0.0383^{ab}	0.0409^{b}	0.0346^{a}	0.0366^{ab}	0.0351^{ab}	0.00217
Efficiency of conversion of feed DE intake by cow (excluding "dry" period) and calf to weaning weight of calf, kg/Mcal	0.0320^{ab}	0.0324^{ab}	0.0324^{ab}	0.0367^{a}	0.0324^{ab}	0.0331^{ab}	0.0317^{b}	0.00167
Efficiency of conversion of DE intake by calf to weaning weight, kg/Mcal	0.1213^{ab}	0.1322^{b}	0.1180^{ab}	0.1323^{b}	0.1235^{ab}	0.1083^{a}	0.1136^{a}	0.0061
Range first lactation								
Weaning weight, kg	230^{a}	227^{a}	250^{b}	256^{b}	275^{c}	282^{c}	288^{c}	6.6
Efficiency of conversion of milk DE to weaning weight, kg/Mcal	0.2857	0.2548	0.2071	0.1822	0.1717	0.1589	0.1609	
Efficiency of conversion of DE intake by cow (excluding "dry" period) to weaning weight of calf, kg/Mcal	0.0490	0.0474	0.0427	0.0438	0.0397	0.0387	0.0391	
Range second lactation								
Weaning weight, kg	273^{bc}	268^{c}	286^{bc}	292^{b}	328^{a}	334^{a}	329^{a}	8.3

TABLE IX (Continued)

Item	Hereford: Moderate	Hereford: High	Crossbred: Moderate	Crossbred: High	Holstein: Moderate	Holstein: High	Holstein: Very High	S.E.
Drylot first lactation								
Creep DE intake by calf, Mcal/day	2.71^{abd}	2.52^{ad}	3.15^{bc}	2.75^{ab}	2.91^{bd}	2.44^{a}	3.47^{c}	0.372
Daily total DE intake by calf, Mcal/day	5.58^{a}	5.56^{a}	8.47^{d}	8.28^{d}	9.09^{cd}	9.93^{bc}	11.24^{b}	0.477
Weaning weight, kg	179^{a}	196^{a}	230^{b}	229^{b}	249^{bc}	253^{bc}	261^{c}	8.8
Efficiency of conversion of milk DE to weaning weight, kg/Mcal	0.2480^{d}	0.2583^{d}	0.1806^{bc}	0.1684^{bc}	0.1577^{abc}	0.1365^{a}	0.1384^{ab}	0.01060
Efficiency of conversion of DE intake by cow to weaning weight of calf, kg/Mcal	0.0376^{ab}	0.0365^{ab}	0.0410^{b}	0.0393^{ab}	0.0368^{ab}	0.0349^{a}	0.0348^{a}	0.00163
Efficiency of conversion of feed DE intake by cow and calf to weaning weight of calf, kg/Mcal	0.0331^{ab}	0.0328^{ab}	0.0357^{b}	0.0352^{b}	0.0334^{ab}	0.0339^{ab}	0.0310^{a}	0.00135
Efficiency of conversion of DE intake by calf to weaning weight, kg/Mcal	0.1280	0.1408	0.1110^{b}	0.1125^{b}	0.1090^{b}	0.1034^{ab}	0.0956^{a}	0.0042
Drylot second lactation								
Creep DE intake by calf, Mcal/day	4.31^{b}	3.84^{b}	3.55^{b}	3.96^{b}	2.96^{a}	3.25^{a}	3.24^{a}	0.418
Daily total DE intake by calf, Mcal/day	8.13^{a}	7.65^{a}	8.45^{ae}	9.77^{ce}	10.39^{d}	12.19^{b}	11.22^{bcd}	0.518
Weaning weight, kg	238^{b}	237^{b}	244^{b}	305^{a}	302^{a}	317^{a}	307^{a}	13.5
Efficiency of conversion of milk DE to weaning weight, kg/Mcal	0.2675^{b}	0.2643^{b}	0.2261^{b}	0.2201^{b}	0.1766^{a}	0.1483^{a}	0.1672^{a}	0.01702
Efficiency of conversion of DE intake by cow (including "dry" period) to weaning weight of calf, kg/Mcal	0.0251^{a}	0.0268^{a}	0.0243^{a}	0.0305	0.0251^{a}	0.0255^{a}	0.0258^{a}	0.00127

TABLE IX (Continued)

Item	Hereford Moderate	Hereford High	Crossbred Moderate	Crossbred High	Holstein Moderate	Holstein High	Holstein Very High	S.E.
	Breed and level of winter supplement							
Efficiency of conversion of milk DE to weaning weight, kg/Mcal	0.3033	0.2945	0.2318	0.1795	0.1513	0.1660	0.1469	
Efficiency of conversion of DE intake by cow (including "dry" period) to weaning weight of calf, kg/Mcal	0.0392	0.0378	0.0348	0.0352	0.0342	0.0318	0.0327	
Efficiency of conversion of DE intake by cow (excluding "dry" period) to weaning weight of calf, kg/Mcal	0.0543	0.0493	0.0529	0.0468	0.0406	0.0416	0.0414	

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

TABLE X

EFFICIENCY OF TWO AND THREE-YEAR-OLD COWS TO TIME OF SLAUGHTER OF PROGENY

Item	Hereford Moderate	Hereford High	Crossbred Moderate	Crossbred High	Holstein Moderate	Holstein High	Holstein Very High	S.E.	S.E.
Drylot first calf									
n	5	4	4	5	4	5	5	4	5
Feedlot DE intake, Mcal	5066^{d}	4789^{d}	6479^{e}	6170^{de}	7089^{e}	8000	7128^{e}	507.2	453.6
High priced cuts, %[a]	50.0^{hi}	49.7^{fgi}	50.1^{hi}	48.6^{ef}	49.3^{eh}	48.7^{deg}	47.7^{d}	0.92	0.82
Chilled carcass weight, kg	239.7^{d}	237.5^{d}	278.2^{ef}	266.3^{df}	284.4^{efg}	307.8^{eg}	305.6^{g}	13.20	11.80
High priced cuts, kg[b]	119.9^{d}	118.1^{d}	140.2^{ef}	129.5^{de}	140.1^{ef}	149.7^{f}	145.8^{ef}	6.97	6.24
Efficiency of conversion of DE intake by calf to high priced cuts, kg/Mcal	0.0189^{e}	0.0190^{e}	0.0163^{de}	0.0160^{de}	0.0154^{d}	0.0144^{d}	0.0148^{f}	0.00108	0.00097
Efficiency of conversion of feed DE intake by cow (excluding "dry" period) and calf to high priced cuts, kg/Mcal	0.0118^{f}	0.0113^{ef}	0.0107^{def}	0.0103^{de}	0.101^{de}	0.0098^{d}	0.0094^{d}	0.00046	0.00041
Carcass water, %[c]	54.7^{de}	54.6^{d}	55.0^{def}	54.7^{de}	56.7^{f}	56.4^{ef}	56.2^{def}	1.37	1.22
Carcass fat, %[c]	22.8^{e}	22.9^{e}	22.5^{de}	22.8^{e}	20.4^{d}	20.7^{de}	20.9^{de}	1.68	1.50
Carcass protein, %[c]	18.1^{d}	18.1^{de}	18.1^{d}	18.1^{d}	18.4^{de}	18.5^{e}	18.4^{de}	0.26	0.23
Carcass GE, Mcal[c]	755.9^{d}	746.7^{d}	868.8^{de}	843.3^{de}	842.0^{de}	923.2^{e}	920.9^{e}	58.60	52.41
Efficiency of conversion of DE intake by calf to carcass GE, Mcal/Mcal	0.1194^{e}	0.1214^{e}	0.1023^{de}	0.1043^{de}	0.0930^{d}	0.0885^{d}	0.0937^{d}	0.00758	0.00678
Efficiency of conversion of DE intake by cow (excluding "dry" period) and calf to carcass GE, Mcal/Mcal	0.0743^{e}	0.0717^{de}	0.0670^{de}	0.0674^{de}	0.0611^{de}	0.0605^{d}	0.0594^{d}	0.00451	0.00403
Drylot second calf									
n	5	5	5	5	5	4	5	4	5
Feedlot DE intake, Mcal	5141^{de}	5751^{df}	4761^{d}	6390^{ef}	6834^{ef}	7338^{f}	7303^{f}	586.1	524.2
High priced cuts, %[a]	48.1^{df}	48.9^{ef}	48.8^{ef}	49.6^{e}	49.1^{d}	47.1^{d}	48.9^{ef}	2.57	2.90
Chilled carcass weight, kg	259.4^{d}	282.0^{de}	253.1^{d}	322.5^{e}	314.1^{e}	326.6^{e}	320.6^{e}	19.22	17.19
High priced cuts, kg[b]	124.5^{d}	138.0^{de}	123.1^{d}	159.9^{e}	153.9^{e}	153.8^{e}	157.1^{e}	8.99	8.04

TABLE X (Continued)

Item	Hereford Moderate	Hereford High	Crossbred Moderate	Crossbred High	Holstein Moderate	Holstein High	Holstein Very High	S.E.	S.E.
	Breed and level of winter supplement								
Efficiency of conversion of DE intake by calf to high priced cuts, kg/Mcal	0.0178^{e}	0.0180^{e}	0.0182^{e}	0.0183^{e}	0.0162^{de}	0.0151^{d}	0.0159^{de}	0.00095	0.00085
Efficiency of conversion of DE intake by cow (including "dry" period) and calf to high priced cuts, kg/Mcal	0.0081^{de}	0.0086^{de}	0.0080^{de}	0.0091^{e}	0.0078^{d}	0.0074^{d}	0.0078^{d}	0.00045	0.00040
Efficiency of conversion of DE intake by cow (excluding "dry" period) and calf to high priced cuts, kg/Mcal	0.0100^{de}	0.0103^{de}	0.0102^{de}	0.0108^{e}	0.0094^{d}	0.0091^{d}	0.0093^{d}	0.00048	0.00043
Carcass water, %[c]	53.2^{d}	56.1^{e}	56.4^{e}	55.8^{e}	55.9^{e}	53.7^{d}	55.1^{de}	1.21	1.08
Carcass fat, %[c]	24.7^{f}	21.0^{d}	20.8^{d}	22.4^{de}	21.3^{d}	24.0^{ef}	21.3^{d}	1.52	1.36
Carcass protein, %[c]	17.8^{d}	18.5^{f}	18.4^{f}	18.3^{f}	18.4^{f}	17.9^{de}	18.2^{ef}	0.25	0.23
Carcass GE, Mcal[c]	866.5^{def}	850.5^{df}	761.3^{d}	975.2^{ef}	951.7^{def}	1066.3^{e}	999.8^{ef}	72.86	65.17
Efficiency of conversion of DE intake by calf to carcass GE, Mcal/Mcal	0.1228^{e}	0.1114^{de}	0.1116^{de}	0.1121^{de}	0.1003^{d}	0.1045^{d}	0.1012^{d}	0.00633	0.00800
Efficiency of conversion of DE intake by cow (including "dry" period) and calf to carcass GE, Mcal/Mcal	0.0559^{d}	0.0530^{d}	0.0491^{d}	0.0553^{d}	0.0480^{d}	0.0513^{d}	0.0496^{d}	0.00313	0.00280
Efficiency of conversion of DE intake by cow (excluding "dry" period) and calf to carcass GE, Mcal/Mcal	0.0695^{e}	0.0638^{de}	0.0626^{de}	0.0662^{de}	0.0579^{d}	0.0631^{de}	0.0592^{d}	0.00378	0.00338

[a]Determined by equation of Murphy et al. (1966).
[b]High priced cuts = percent high priced cuts x chilled carcass weight.
[c]Determined by specific gravity method of Kraybill et al. (1952).
[defghi]Means on the same line with the same superscript are not significantly different (P>.05).

CHAPTER V

EFFICIENCY OF MILK YIELD CONVERSION TO CALF PREWEANING GAIN OF HEREFORD, HEREFORD x HOLSTEIN AND HOLSTEIN FEMALES[1, 2]

Summary

Regressions of preweaning calf weight gain on 240-day milk yield and on 240-day milk yield per unit of metabolic weight ($W^{.75}$) were calculated within breed and lactation for winter-calving 2- and 3-year-old Hereford, Hereford x Holstein and Holstein females. All cows were bred for winter calving to Angus bulls their first year and to Charolais bulls their second. Coefficient of determination and regression coefficient for first calf Herefords (Angus x Hereford calves) were 0.5951 and 0.0924 kg

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[1]Journal Article 2733 of the Agricultural Experiment Station, Oklahoma State University, Stillwater. This research was conducted by the Department of Animal Sciences and Industry in cooperation with the U.S.D.A., Agricultural Research Service, Southern Region.

[2]J.W. Holloway[3], Leon Knori[4], R.A. Dean[5], J.R. Kropp[5], K.S. Lusby[5], J.V. Whiteman[5], D.F. Stephens[4] and Robert Totusek[5].

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calf weight gain per kg 240-day milk yield, respectively. Coefficient of determination and linear regression coefficients tended to be largest for Herefords followed respectively by Crossbreds and Holsteins. Considering both Angus and Charolais crossbred calves, calf weight gain per unit of milk yield tended to be proportional to amount of calf weight gain and not proportional to milk yield. Similar trends were noted when calf preweaning weight gain was regressed on 240-day milk yield per unit of metabolic weight.

Introduction

Milk yield of beef cows is an important economic trait because increased milk yield is associated with increased weaning weight of calf (Gifford, 1949; Gleddie and Berg, 1968; Neville, 1962) and is also associated with increased feed requirements and reproductive problems (Deutscher and Whiteman, 1971; Kropp *et al.*, 1973; and Holloway *et al.*, 1974). These opposing factors endow economic importance on the level of milk required for maximum weaning weight. There is indication that as milk yield increases, more milk is required per unit of gain (Wilson *et al.*, 1969).

This report explores the relationship between milk yield and preweaning calf weight gain over a wide range in milk yield accomplished with Hereford, Hereford x Holstein and Holstein cows.

Materials and Methods

Hereford, Hereford x Holstein (Crossbred) and Holstein heifers were assembled at the Fort Reno Livestock Research Station and maintained under native tallgrass range conditions for their first two calf crops. Their performance as two and three-year-olds was reported by Kropp et al. (1973) and Holloway et al. (1974) who described specific management practices; only a general review of these practices will be presented here.

Females in each breed were allotted to two levels of winter supplement and a third level was fed to another group of Holsteins. By simple analysis of variance the first year and least squares analysis of variance the second, level of winter supplement fed was determined not to affect ($P>.05$) either milk yield or weaning weight and therefore will not be considered in this paper. By similar analyses, sex of calf was found not to influence ($P>.10$) level of milk yield.

First and second calves produced by the females were sired by Angus and Charolais bulls, respectively, and were born during winter (December, January and February).

Seven 24-hour milk yield estimates were made at monthly intervals by the calf suckle method (Kropp et al., 1973). Calves were weighed within 24 hours of birth (birth weight) and within 7 days of 240 days of age (weaning weight). Bull calves were castrated within 42 days of birth and heifer calves' weaning weights were corrected to a steer equivalent by multiplying actual weaning weight by 1.059 (Smithson, 1966).

Within each calf crop for each breed, calf weight gain from birth to 240-day weaning was regressed on total milk yield and total milk yield per unit of metabolic weight (June weight$^{.75}$).

June weight was used because all cows had recovered from weight losses of calving and lactation. Level of winter supplementation did not affect ($P<.10$) June cow weight.

Results and Discussion

Within breed of cow regression of calf weight gain from birth to 240-day weaning on 240-day milk yield of dam is shown in figure 2 and table XI (Angus crossbred calves, first year), and figure 3 and table XI (Charolais crossbred calves, second year). For the first year, the correlation between Hereford cow milk yield and calf gain was .77 which agrees with the previous beef cow estimates of Christian, Hauser and Chapman (1965), Furr and Nelson (1964), Melton et al. (1967), Brumby, Walker and Gallagher (1963) and Neville (1962), whose estimates range from .40 to .81. All correlation values in this experiment were in this range except those for Angus and Charolais calves of Holstein cows; milk yield accounted for only 14.58 and 0.13% of the variation in calf preweaning weight for these calves, respectively. This indicates that calves of Holstein cows, especially second lactation Charolais calves, were approaching maximal milk intakes and their weight gain depended on factors other than dam milk yield (genetic growth capacity, non-milk nutrient intake). Non-milk nutrient intake was measured in a similarly designed study under drylot conditions (Holloway et al., 1974); calves of Holstein cows consumed a lower proportion of total nutrient intake from non-milk sources than calves from Crossbreds and Herefords, indicating that genetic differences may be more important than non-milk nutrient intake in accounting for the unexplained variation. Perhaps there is more genetic variation in growth of calves from Holstein cows because of inbreeding with selection pressure in this breed has long emphasized milk yield whereas for the Hereford breed, selection pressure has indirectly emphasized growth rate. The R^2 values for the Charolais calves tended to be lower than those for Angus calves (table XI) probably due to different environments the two years. Another possible explanation for the decreased R^2 values for Charolais calves of Herefords and Crossbreds is increased proportion of calf diet contributed by non-milk nutrient intake. In the drylot phase, Charolais calves of Herefords and Crossbreds consumed 5 and 7% more non-milk DE than Angus calves. Charolais calves of Holstein cows, however, consumed consistently lower percentages (10% lower) of diet as non-milk DE than Angus calves. Although the R^2 values of the equations for Hereford and Crossbred calves were similar to those found in the literature, the large standard error of estimates (34.75 to 43.36 kg) decreases their worth for prediction purposes. All equations were significantly ($P<.01$) linear and no lack of fit was detected ($P>.10$).

The regression coefficient (9.24 ± 1.62 kg calf gain per 100 kg milk produced) for first calf Hereford females was similar to ratios found in literature for beef breeds (Drewry, Brown and Honea, 1959; Kress, Hauser and Chapman, 1968). Within each year, calves from Hereford cows responded more to increases in milk yield than calves of Crossbreds and Holsteins, respectively (figures 2 and 3); Charolais x Holstein calves did not respond to increases in milk yield (0.14 ± 0.99 kg loss in weaning weight per 100 kg increased milk yield).

In comparing the regression coefficients of the two calf crops, the range in milk yield of the second calf crop was wider than and included the range of the first calf crop; the lowest gaining calves the second year (Charolais x Hereford) gained approximately the same as the fastest gaining calves the first year (Angus x Holstein). Previous work (Wilson et al., 1969) has indicated that as level of milk yield increases, the increase in calf weight gain per unit of milk yield decreases. This trend was detected in this experiment within each calf crop, but across calf crops a trend was evident for the increase in calf weight gain per unit of milk yield to decrease as calf weight gain increased (table XI). Although Angus x Holstein and Charolais x Hereford calves were born in different years, consumed different quantities of milk, had access to different quality pasture and possibly differed in growth potential, they gained the same amount of weight during preweaning period and the rate of increase in weight gain per unit of milk yield was the same. It is possible that rate of conversion of milk to preweaning weight gain is the same for calves gaining at the same rate regardless of level of dam milk yield.

If preweaning weight gain is regressed on total milk yield per unit of metabolic weight, observed trends were the same as those discussed above (figures 4 and 5 and table XII). Relationship between milk yield and preweaning weight gain evidently does not depend on metabolic body size.

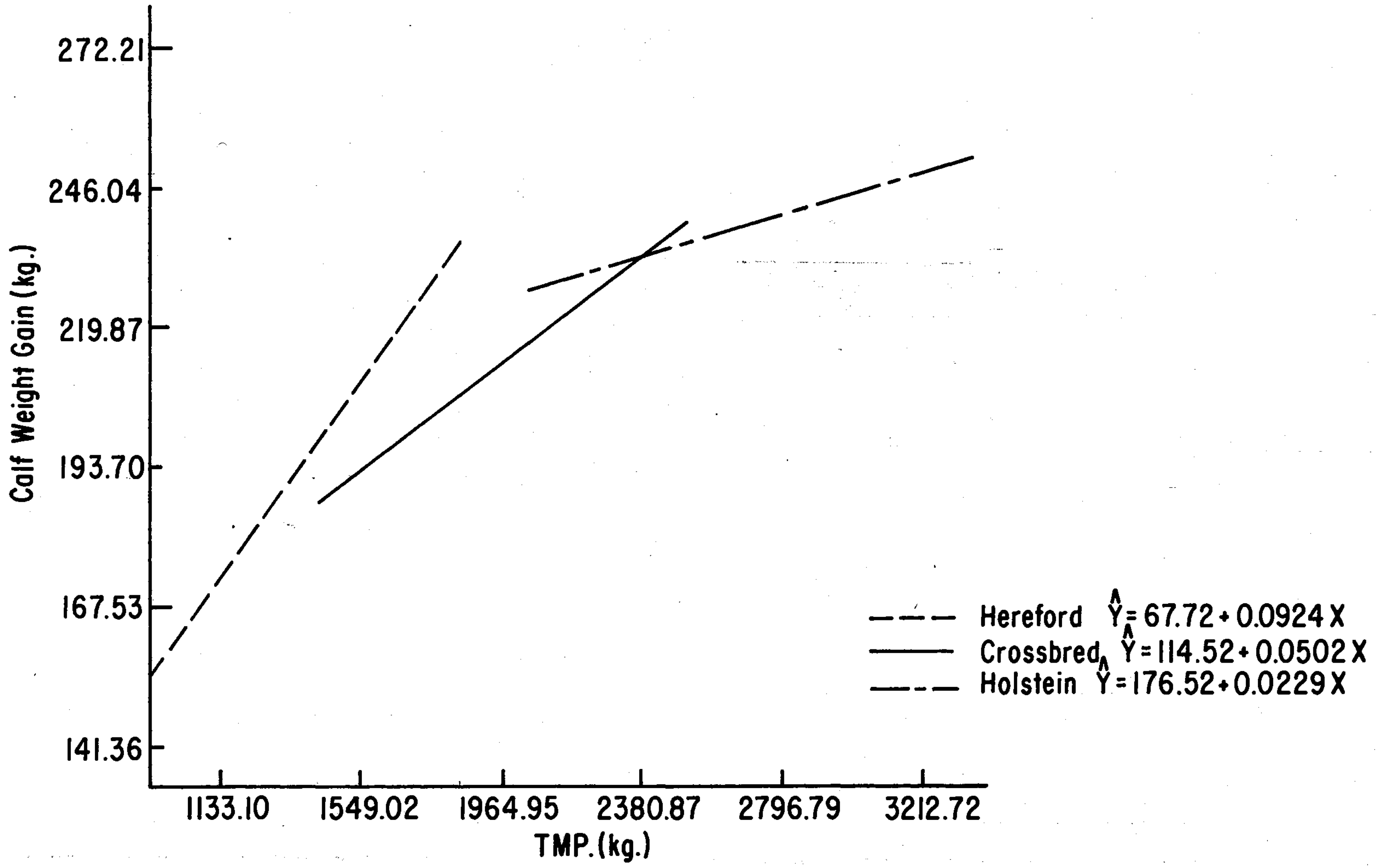

Figure 2. Regression of Calf Weight Gain on 240-Day Milk Yield for First-Calf Hereford, Crossbred and Holstein Females

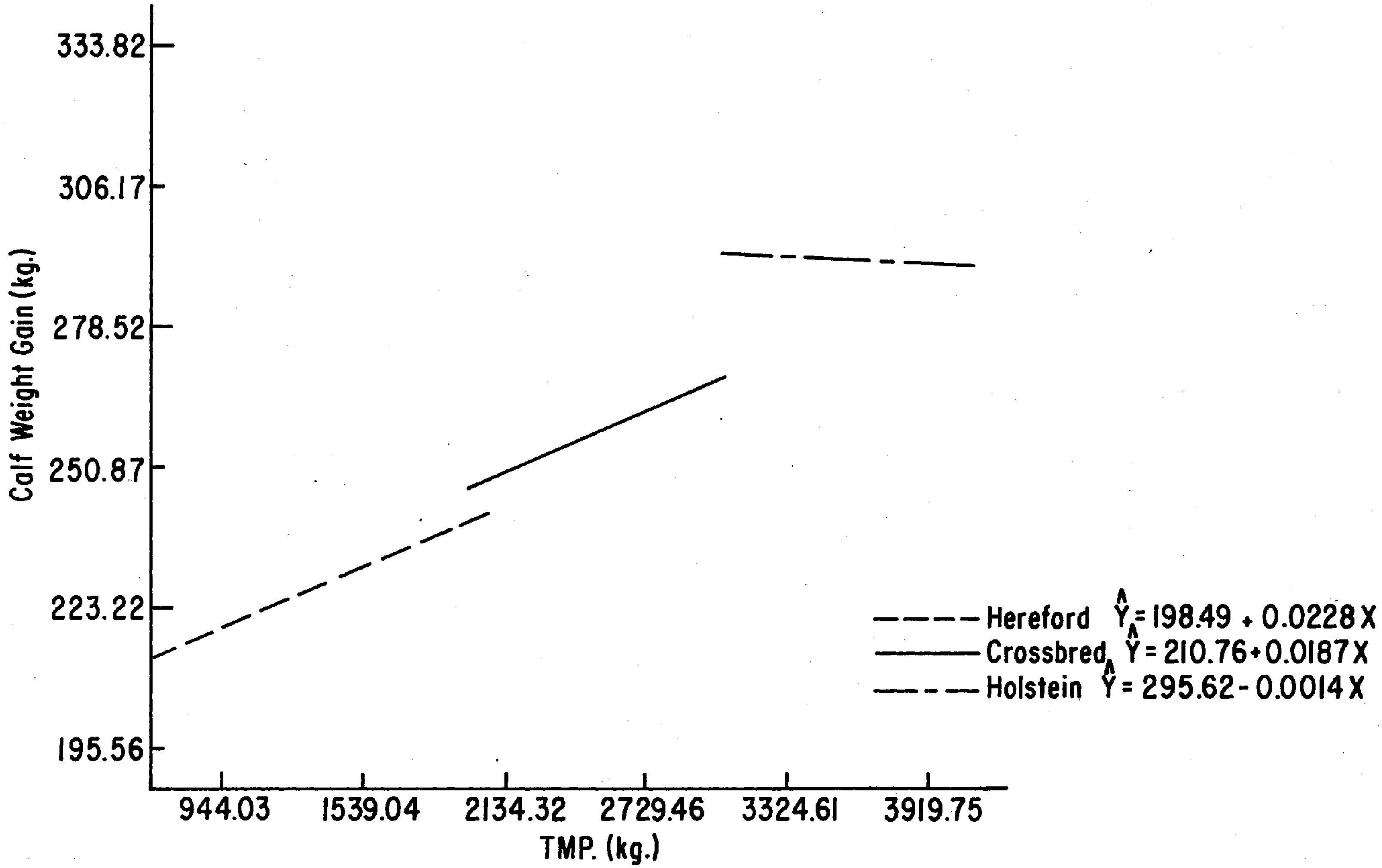

Figure 3. Regression of Calf Weight Gain on 240-Day Milk Yield for Second-Calf Hereford, Crossbred and Holstein Females

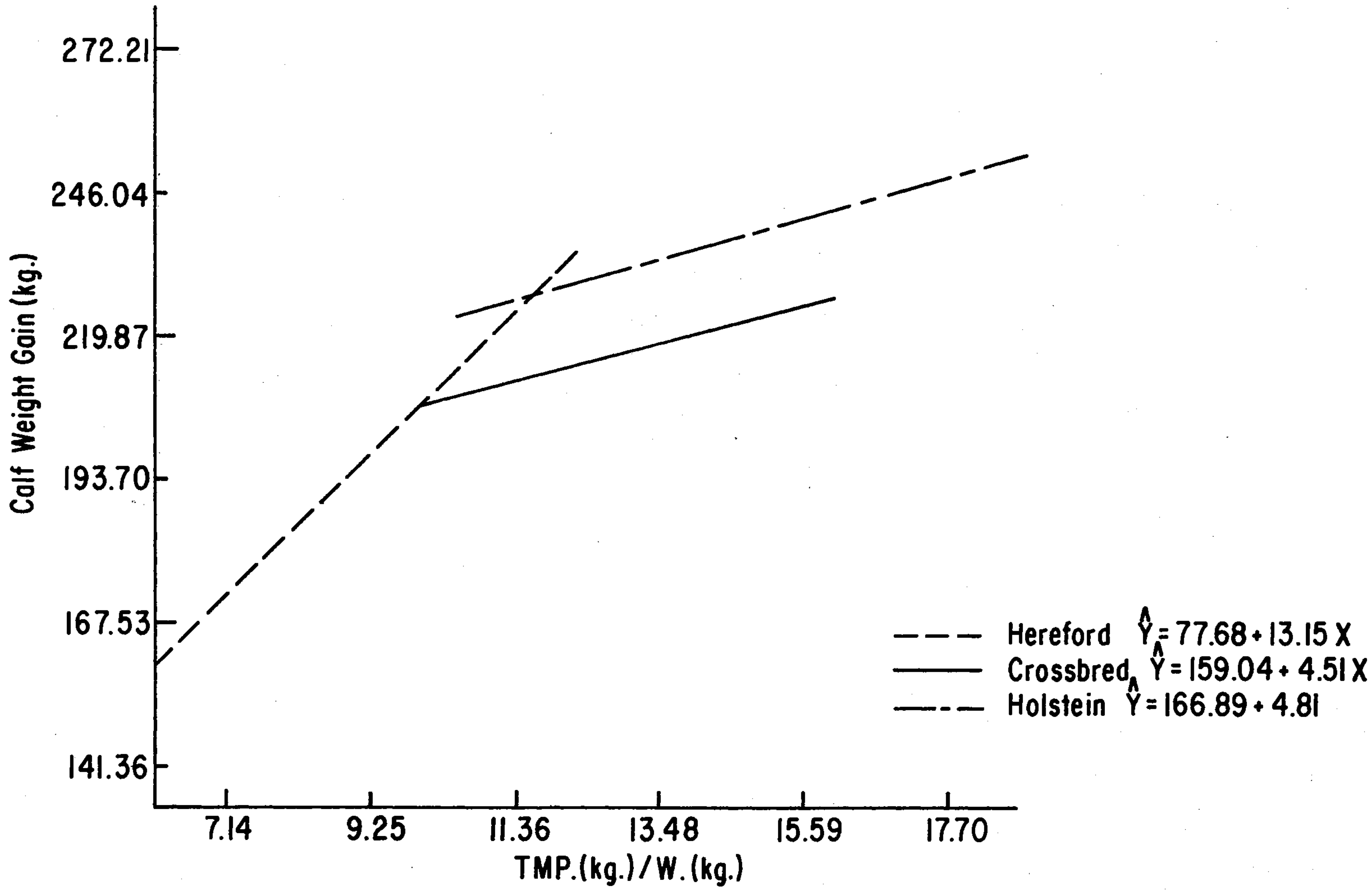

Figure 4. Regression of Calf Weight Gain on 240-Day Milk Yield Per $W_{kg}^{.75}$ for First-Calf Hereford, Crossbred and Holstein Females

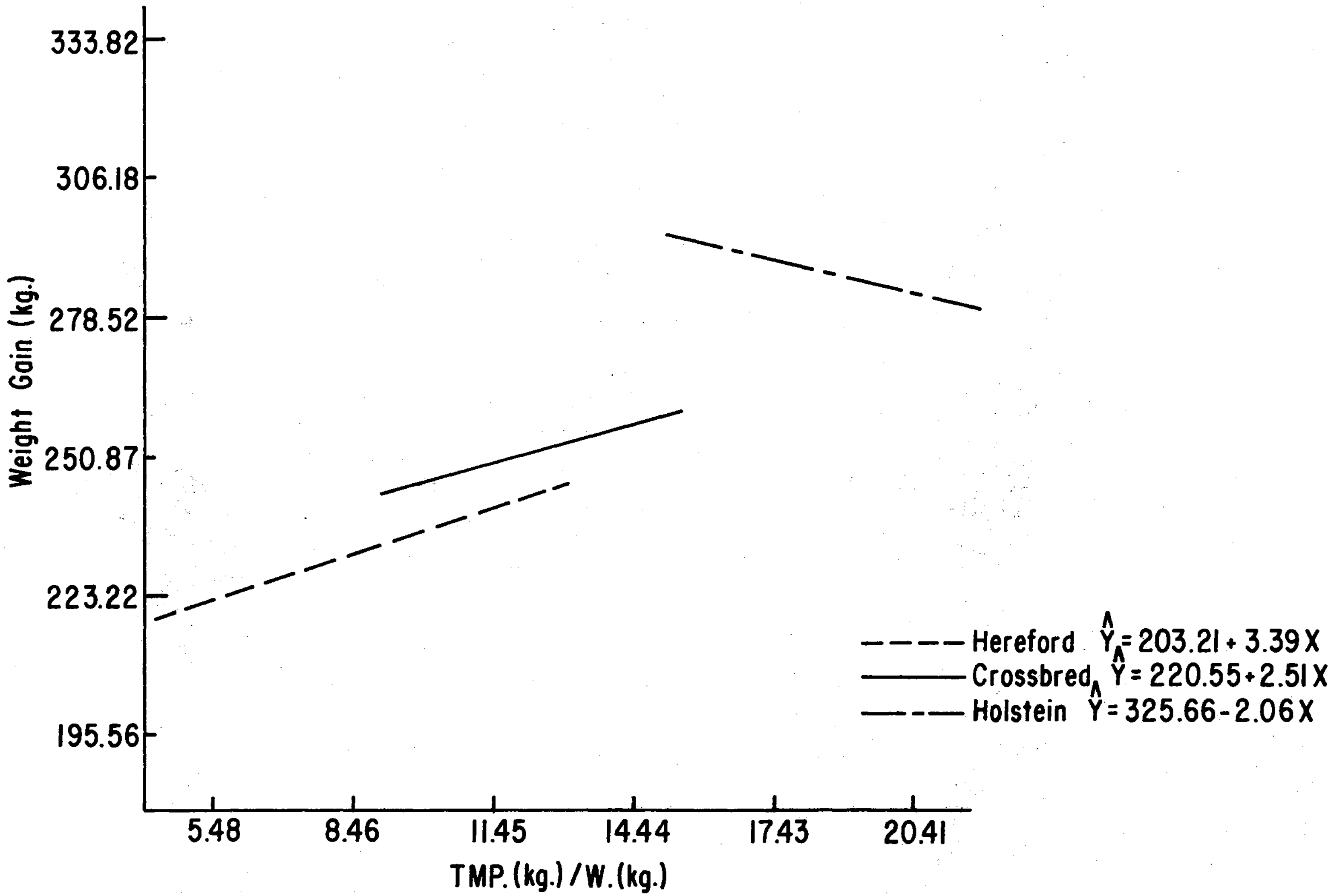

Figure 5. Regression of Calf Weight Gain on 240-Day Milk Yield Per $W_{kg}^{.75}$ for Second-Calf Hereford, Crossbred and Holstein Females

TABLE XI

REGRESSION EQUATIONS FOR PREDICTING CALF WEIGHT GAIN FROM BIRTH TO 240-DAY WEANING MILK PRODUCTION

Breed of sire of calf	Breed of dam of calf	Intercept	S.E.	Milk[1,2]	S.E.	R^2	$S_{y \cdot x}$	Calf weight gain $\bar{Y}$	Milk[1] $\bar{X}$	n
Angus	Hereford	67.72**	22.216	0.0924***	0.01624	0.5951	35.38	193	1355	24
	Crossbred	114.52***	24.206	0.0502***	0.01203	0.4208	37.15	215	1996	26
	Holstein	176.52***	26.446	0.0229*	0.00994	0.1458	40.77	237	2646	33
Charolais	Hereford	198.49***	15.913	0.0228*	0.01040	0.1940	34.75	233	1429	22
	Crossbred	210.76***	15.291	0.0187*	0.00682	0.2829	44.89	251	2180	21
	Holstein	295.19***	33.619	-0.0014	0.00992	0.0013	43.36	291	3207	17

[1]Total 240-day milk yield.
[2]Regression coefficient.
*Probability of a larger $|T|$ = 0.05, $H_o = b = 0$.
**Probability of a larger $|T|$ = 0.01, $H_o = b = 0$.
***Probability of a larger $|T|$ = 0.001, $H_o = b = 0$.

TABLE XII

REGRESSION EQUATIONS FOR PREDICTING CALF WEIGHT GAIN FROM BIRTH TO 240-DAY WEANING PER UNIT OF METABOLIC WEIGHT

Breed of sire of calf	Breed of dam of calf	Intercept	S.E.	$Milk/W^{.75}$ [1,2]	S.E.	R^2	$S_{y \cdot x}$	Calf weight gain $\bar{Y}$	$Milk/W^{.75}$ (kg/kg) [1] $\bar{X}$	$W^{.75}$ $\bar{X}$	n
Angus	Hereford	77.68***	24.254	13.15*	2.740	0.5109	38.88	192.67	16.7	81	24
	Crossbred	159.04***	27.261	4.51*	2.190	0.1505	45.00	214.64	22.9	87	26
	Holstein	166.89**	29.620	4.81***	2.020	0.1543	40.57	236.92	28.2	94	33
Charolais	Hereford	203.21***	15.277	3.39	1.720	0.1632	35.41	232.62	16.6	86	22
	Crossbred	220.55***	18.226	2.51	1.460	0.1352	49.30	250.82	25.1	87	21
	Holstein	325.66***	35.032	-2.06	2.040	0.0636	41.99	290.60	34.5	93	17

[1]Total 240-day milk yield per unit of metabolic weight $W^{.75}$.
[2]Regression coefficient.
*Probability of a larger $|T| = 0.05$, $H_o = b = 0$.
**Probability of a larger $|T| = 0.01$, $H_o = b = 0$.
***Probability of a larger $|T| = 0.001$, $H_o = b = 0$.

CHAPTER VI

SUMMARY

Holstein cows were larger ($P<.005$), consumed more ($P<.005$) DE, produced more ($P<.01$) milk gross energy (GE) and converted estimated DE to milk GE more ($P<.01$) efficiently than other breeds, followed by Crossbreds and Herefords, respectively.

Although calves from Holsteins grew faster ($P<.01$) to time of weaning and were heavier ($P<.01$) at weaning, they converted both milk GE and total (creep and milk) DE intake to weaning weight less efficiently ($P<.05$) than calves of Crossbreds or Herefords. Herefords were superior in this respect, but Crossbreds were slightly superior ($P<.25$) in converting total feed DE intake of cow and calf to weaning weight because of greater efficiency in conversion of DE to milk GE. Considering both Angus and Charolais crossbred calves, calf weight gain per unit of milk yield tended to be proportional to amount of calf weight gain and not proportional to milk yield.

Herefords and Crossbreds were more efficient ($P<.10$) than Holsteins for conversion of DE intake of cow, calf or cow and calf to kilograms of high-priced cuts. Herefords, however, held the advantage ($P\approx.001$ to .16 for six comparisons) in converting DE intake of cow, calf or cow and calf to gross energy of carcass followed respectively by Crossbreds and Holsteins. Generally, treatment of dam did not affect ($P > .10$) the calculated efficiencies.

Increasing supplement levels within breed, however, was associated with decreased post-partum interval and days to apparent conception. Generally, conception rate increased as level of supplement increased.

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