LEVEL OF MILK PRODUCTION IN RANGE COWS: EFFECTS ON WINTER FEED REQUIREMENTS, FORAGE INTAKE AND DIGESTIBILITY IN COWS AND PREWEANING FORAGE INTAKE, DIGESTIBILITY AND POSTWEANING FEEDLOT PERFORMANCE OF THEIR CALVES

By

KEITH STEWART LUSBY

Bachelor of Science
in Agriculture
Kansas State University
Manhattan, Kansas
1970

Master of Science
Kansas State University
Manhattan, Kansas
1971

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF PHILOSOPHY
December, 1974

Thesis
1974D
L968l
Cop. 2

OKLAHOMA
STATE UNIVERSITY
LIBRARY

MAY 11 1976

LEVEL OF MILK PRODUCTION IN RANGE COWS: EFFECTS
ON WINTER FEED REQUIREMENTS, FORAGE INTAKE
AND DIGESTIBILITY IN COWS AND PREWEANING
FORAGE INTAKE, DIGESTIBILITY AND
POSTWEANING FEEDLOT PERFORMANCE
OF THEIR CALVES

Thesis Approved:

Robert Totusek
Thesis Adviser

Joe V Whiteman

George V. Odell

Donald G Wagner

Ronald R. Johnson

N N Durham
Dean of the Graduate College

938631

ACKNOWLEDGEMENTS

I wish to take this opportunity to express my sincere gratitude to my major professor, Dr. Robert Totusek, for his support and assistance during the course of this project.

Special thanks are extended to Dr. J. V. Whiteman, Dr. Donald R. Wagner, Dr. R. R. Johnson and Dr. George V. Odell for their suggestions and critical evaluation while serving on the guidance committee. Appreciation is also given to Dr. R. K. Johnson for assisting with statistical analysis of data.

Special recognition is extended to Leon Knori, herdsman at the Fort Reno Livestock Experiment Station. His excellent care of experimental animals, attention to records and suggestions made this project much more effective and enjoyable. Appreciation also goes to David Duffle, without whose assistance with records, preparation of this thesis would have been a great deal more difficult.

I would also like to thank Art Dean, Bill Holloway, Ivan Rush, Roger Wyatt, Rick Jones, Dennis Hallford and the other graduate students for their consideration and assistance with this study.

I especially thank my wife, Rosemary, for her patience and support during my years as a graduate student at Oklahoma State University.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

It has been shown that increasing the milking ability of beef cows results in increased weaning weight of calves. However, increased milk production leads to greater nutritive requirements for the cow and, hence, greater supplemental feed during winter. It is not known if the additional weaning weight from high producing cows can overcome the cost of additional feed required to maintain high milking beef females.

Further questions arise as to the efficiency of calves raised by high milking dams. Will high milk intake lower forage intake and digestibility in the calf? How will calves weaned at heavy weights perform in the feedlot and how will their carcass characteristics compare with calves weaned at lighter weights.

The purpose of this study was (1) to determine the influence of varying levels of winter supplementation on milk yield, calf performance (pre-weaning) and reproductive efficiency of beef, beef x dairy and dairy cows under range and drylot conditions, (2) investigate the effects of varying levels of milk intake on forage intake and digestibility of nursing calves and (3) compare the feedlot performance and carcass traits of calves with 0, 25 and 50% dairy breeding when fed to approximately equal slaughter weight.

CHAPTER II

REVIEW OF LITERATURE

This review will investigate: (1) the effects of forage intake on digestibility and feed efficiency in cows; (2) the effect of concentrate supplementation on milk production, forage intake, and feed efficiency in cows; and (3) the effects of level of milk consumption on feed efficiency and forage intake of nursing calves.

Influence of Forage Intake on Digestibility and Feed Efficiency in Cows

Early work by Hale et al. (1940) showed that digestibility of long or chopped dry forages commonly fed to sheep and cattle was not affected by level of intake. Reid (1956) noted that digestibility of mixed rations (concentrate and forage) by cows declined as the level of intake increased, but that the digestibility of all-forage rations was unaffected. Reid and Tyrrell (1964) in their review, stated that the effect of level of intake on digestibility by sheep and cattle depended upon the chemical and physical nature of the diet. In general, the digestibility of long or chopped forages (2.4-10 cm) was not affected, whereas the digestibility of finely ground forages fed as a meal, pellet or gruel usually decreased as the level of intake was increased. In other instances when pelleted or ground hay was fed at or slightly above maintenance, the digestibility was not different from long or chopped hay (Wright et al., 1963). A later study by Tyrrell (1964) showed that the physical form of long or chopped forages may prevent an intake sufficient to depress digestibility to any measurable extent.

Further evidence that digestibility of long roughages do not change with intake was given in a long term study by Wiktorsson (1970). No significant depression in digestibility using a wide range of hay: concentrate ratios could be found. It was postulated that the large depressions in digestibility reported in other literature might have been due to incomplete adaptation of animals to experimental rations before collections. This is in disagreement with Moe et al. (1965) who reported a decrease in digestibility with higher concentrate:hay ratios. A depression in digestibility of about 17% was found when the feed intake (75% concentrate) was increased from maintenance to four times maintenance.

In the first of two digestibility experiments, Wagner and Loosli (1967) found a decrease of about 6.5% when cows were fed rations similar to those in the trial by Moe et al. (1965). The fact that the 6.5% difference was not significant indicated a large variation in the digestibility coefficients. In the second of the two experiments, the depression in digestibility was greater and significant at a feeding level of four times maintenance with the concentrate:hay ratio at 75:25. At three times maintenance and 40% concentrate in the ration, very little or no decrease in digestibility was noted.

Campling, Freer and Balch (1962) observed that voluntary intakes of cows fed hay or straw were related to rates of disappearance of digesta and resulted in a constant amount of rumen digesta just before a meal. The results are supported by Freer and Campling (1962) who showed the amount of digesta in the rumens of cows fed grass hay to be almost constant after each meal.

McCullough and Russel (1962) reported that any influence of digestibility on intake declined when digestibility was above 65%. Conrad _et al_. (1966) suggested that the breaking point was at the digestible dry matter level of 66%. Beyond this point, body weight$^{0.75}$ seemed to be the most accurate indicator of feed intake (Baumgardt, 1969).

Blaxter, Wainman and Wilson (1961) reported a series of experiments with sheep in an attempt to place on a quantitative basis the theory that the voluntary intake of ruminants increases with the quality of fodder they are given. It was shown that voluntary intake varied with a fractional power of body weight close to 0.734. It was further found that voluntary intake of long fodders was related to the apparent digestibility of their energy; increasing rapidly as digestibility increased from 38% to 70% and thereafter more slowly. The feeding of concentrates resulted in a drop in voluntary intake of fodder.

Ward and Kelly (1969) reported differences in _ad libitum_ consumption of diets consisting of: 5.5:1, 2.2:1 and 1:1 weight ratios of alfalfa hay to concentrate mixtures by lactating cows. Total consumption increased consistently with each increase in concentrate:hay ratio. Their results support the conclusion that rumen fill limits feed intake in rations containing more than 40% forage.

Conrad (1964) summarized the relationship of forage intake and digestibility. He observed that physical and physiological factors regulating feed intake change in importance with increasing digestibility. At low digestibility they are body weight (reflecting forage capacity), rate of passage and dry matter digestibility. At higher digestibility, intake appears to be dependent on metabolic size, production and digestibility.

Brown (1966) concluded that kinds of forages (grasses vs. legumes), grain mixtures (particularly protein source and level), hay-grain ratios, plane of nutrition of the animal, and other environmental factors may also account for some of the variation in reported results. McCullough (1959) pointed out that the cow contributes at least three sources of variation to forage intake: (1) individuality, (2) level of production and (3) body size.

The effect of body size can be adjusted by correcting intake figures to metabolic size. MacLusky (1955) found an average coefficient of variation in intake of 21% with free grazing cows. According to McCullough (1959) this difference in intake partially reflected differences in size and production, but primarily reflected inherent differences between cows of similar size and production.

In general, the depression in digestibility of fresh forages associated with feeding level has been small but variable. Woodman et al. (1937) reported that the amount of fresh grass fed to sheep may be varied within wide limits without significantly affecting digestibility. Andersen et al. (1959) fed green, first growth and green, aftermath forage to sheep at 700, 1000 and 1200 g per day and noted no change in dry matter digestibility associated with feeding level of the green, first growth forage. The green aftermath forage was approximately 2.4% more digestible at the low level than at the high level of feeding. However, since forage consumed at the high level of intake was less digestible than forage consumed at the medium level in only three of 13 trials, the authors concluded that any difference in digestibility due to intake was of little consequence.

Effect of Supplementation on Milk Production, Forage Intake and Feed Efficiency

The rate of digestion of forage is inhibited by anything which represses microflora activity. Rate of cellulose digestion can be related to voluntary forage intake through its effect on frequency of recurring appetite (Crampton, 1957). Retardation of cellulose digestion must mean that such material remains longer in the rumen. The more quickly ingesta moves out of the rumen the sooner hunger recurs and thus more feed may be consumed over a given time. Crampton (1957) further observed that rate of digestion may be retarded by any number of conditions which inhibit the numbers or activity of rumen microorganisms. The most common conditions include: excessive lignification of forages with advanced maturity, partial nitrogen starvation of microflora or specific mineral deficiency.

In an early experiment by Burroughs and Gerlaugh (1949a) the dry matter digestion of corn cobs and Timothy hay was increased by 14 and 17%, respectively by the inclusion of soybean oil mean in the ration. A subsequent study (Burroughs et al., 1949c) showed that addition of starch to roughage rations increased the protein requirement to maintain digestibility of the forage. Burroughs et al. (1950) added casein to low-protein cattle rations and observed increased dry matter digestibility of the roughage portion of the ration. Bacteriological findings of this study showed that protein aided roughage digestion by furnishing an essential nutrient for rumen bacteria concerned directly with roughage digestion.

Further evidence that addition of protein to low protein roughage diets brought about an increase in roughage intakes was given by Egan (1970). The addition of casein sufficient to raise the nitrogen content of the basal oaten chaff from 0.9 to 1.8% resulted in an increase of 23% in mean dry matter intake, with a significant increase in the apparent digestibility of dry matter. Further additions of casein resulted in increased intake although the apparent digestibility of dry matter was not significantly increased.

Balch and Campling (1962) in their review of feed intake in ruminants, reported that concentrates given in addition to roughages may increase voluntary intake to three or even four times the amount required for maintenance. Hawkins et al. (1964) observed that mean daily intakes of coastal bermudagrass hays were correlated positively with crude protein and ash and were correlated negatively with lignin content of the forages.

Effects of Level of Milk Consumption on Feed Efficiency and Forage Intake in Nursing Cows

Although much information is available on the effects of varying ratios of milk:solid feed on rumen development, very little has been done to investigate the effects of high levels of milk production on feed efficiency in nursing calves. Diet is known to have an important influence on rumen development, (Blaxter, 1952; Savage and McCay, 1942). Blaxter (1952) reported that animals given roughage in addition to milk, developed larger rumens than milk-fed calves growing at the same rate. Warner, Flatt and Loosli (1956) summarized early German work which demonstrated that although fore-stomach development was retarded by prolonged exclusive milk feeding, some growth was apparent, suggesting that diet was not the only factor responsible for rumen growth.

Otterby and Rust (1965) presented data suggesting that rumen fermentation was usually established by three or four weeks of age, and that the presence of hay in the diet had little effect on rumen fermentation until calves were seven to eight weeks of age. These workers concluded that roughage had no appreciable effect on rumen fermentation until calves consumed approximately 227 g per day. Ruminal volatile fatty acid (VFA) data by Ndumbe, Runcie and McDonald(1963) showed that fermentation in the rumen was developed more rapidly in early-weaned calves fed only concentrates after 28 days of age than control calves fed milk to provide 454 g/day gain plus maintenance.

McCarthy and Kesler (1956) reported that the most rapid increases in percent cellulose digestion and in the concentration of VFA in rumen fluid occur during the first six months of age. The data indicated that although rumen activity was not completely developed, it would be considered to be similar to that of the mature animal by 5 or 6 weeks of age. Conrad, Hibbs and Frank (1958) showed that total VFA in the rumen reached adult levels at about 6 weeks of age in high roughage diets. Other results have shown that calves given high concentrate diets reached adult VFA levels at 7-8 weeks of age (Langemann and Allen, 1953; McCarthy and Kesler, 1956).

Blaxter and Wood (1921) used two Ayrshire calves (5 days old) to determine digestibility of milk in calves. He obtained digestion coefficients of 94.4 to 98.2 for dry matter, 90.7 to 97.1 for protein, and 92.8 to 97.9 for fat. It was concluded that because different levels of milk were fed and fecal fat remained relatively constant, that fecal fat was of body origin and does not represent unabsorbed dietary milk fat. Blaxter and Wood (1951b) showed that fasting calves excreted an average of 4.2 g fat/day, a value close to the mean fat excretion observed by Blaxter and Wood (1952). Blaxter (1952) in a digestion study with a single Ayrshire calf (3 days of age) found coefficients of digestibility for gross energy of 94 to 97%. He concluded from this and previous data that a figure of 95% would be representative.

CHAPTER III

THE PERFORMANCE ON RANGE AND IN DRYLOT OF FOUR-YEAR-OLD HEREFORD, HEREFORD x HOLSTEIN AND HOLSTEIN FEMALES AS INFLUENCED BY LEVEL OF WINTER SUPPLEMENTATION[1,2]

Summary

The productivity of winter-calving four-year-old Hereford, Hereford x Holstein (Crossbred) and Holstein females under native range or dry-lot conditions was compared. Two levels of winter supplementation were imposed on each group throughout the winter. An additional group of Holsteins received a very high level. As level of supplementation increased, winter weight loss, days post-partum to first estrus and days post-partum to apparent conception decreased while rebreeding rate increased. Only 40% of Moderate Holsteins and 56% of High Holsteins rebred. Cows in each group regained their weight in summer except the Moderate Crossbreds and Moderate and High Holsteins. Daily milk yields were 6.1, 9.2 and 12.4 kg/day on range and 6.7, 9.0 and 10.9 in drylot,

---

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

[2]The authors wish to express appreciation to Leon Knori for his care of experimental animals.

respectively, for Herefords, Crossbreds and Holsteins, while weaning weights were 260, 288 and 318 on range and 259, 294 and 312 kg in drylot respectively.

Introduction

Weaning weight is one of the most important factors in beef production. Selection for weaning weight automatically results in selection for milk production because of the high correlation between level of milk production in the beef cow and weaned weight of the calf (Knapp and Black, 1941; Pinney, 1963). A rapid method for increasing milk production is by infusing genes from dairy animals (Cundiff, 1970). However, the increased feed requirements of high milking range females may decrease the efficiency of beef production. The purpose of this study was to determine the influence of varying levels of winter supplementation on actual milk yield, calf performance and reproductive efficiency of beef, beef x dairy and dairy cows under range or drylot conditions.

Materials and Methods

Hereford, Hereford x Holstein (Crossbred) and Holstein four-year-old females were maintained under native tall grass range conditions or in drylot at the Fort Reno Livestock Research Station. A complete description of the management practices and experimental procedures was reported by Kropp et al. (1973) who summarized results for performance of these cows as two-year-olds bred to Angus bulls. Holloway et al. (1974) gave results for these cows as three-year-olds bred to Charolais bulls.

Since first calving, groups of the Hereford and Crossbred females were subjected to two levels of supplement (Moderate and High) while three levels were fed to groups of Holsteins (Moderate, High and Very High). The Moderate level of supplement was calculated to allow good rebreeding performance in mature Hereford females with a 10-15% weight loss from fall to spring. The High level of supplement was established by the Crossbred females and consisted of that amount of supplement estimated necessary to maintain a body condition and physiological condition comparable to the Moderate Herefords. Moderate and High levels of supplement were also fed to groups of Herefords, Crossbreds and Holsteins. An additional group of Holsteins received a Very High level of supplement, calculated to maintain Holstein cows in body condition similar to the High Crossbreds and Moderate Herefords. Cows on range were fed supplement individually five days each week for a period of 151 days from November 15 to April 16. Supplement in drylot was fed on a daily basis with both drylot and range cows within the same treatment receiving the same amount each week.

The drylot winter feeding regime consisted of cotton, seed hulls, (1) IRN 1-01-599, (cottonseed hulls) fed through the winter to February 28, baled winter range forage from a pasture grazed by cows on the range phase from February 20 to March 8 and cottonseed hulls from March 9 to April 16. The summer regime consisted of Alfalfa, hay, S-C, mature, (1) IRN 1-00-071 (baled alfalfa) fed through the summer (except a 2-week period in July when the hay was ground) until each cow weaned her calf at 240 days of age. At this time the drylot cows were returned to range. The females were drylotted in seven pens according to breed and level of winter supplementation, but were individually fed the roughage ration *ad libitum* from 8 a.m. until 1 p.m. each day. Drylot calves received creep *ad libitum* individually during a three hour period each day. A pelleted high energy creep ration consisting of (%): Corn, dent yellow, grain, gr 2 US mn 54 wt., (4), IRN 4-02-931, 49.5; Alfalfa, hay, S-C, ground, early blm (1), IRN 1-00-108, 15.0; Sugarcane, molasses, mn 48 invert sugar 79.5 degrees brix, (4), IRN 4-04-696, 5; Soybean, seed wo hulls, solv-extd grnd, mx 3 fbr, (5), IRN 5-04-612, 17.5; Cotton, seed hulls, (1) IRN 1-01-599, 10.0; Wheat, flour by-prod., mx 9.5 fbr, (4) IRN 4-05-205, 3.0, was fed.

The four-year-old females were artificially inseminated to one Charolais bull for 60 days and pasture exposed for 30 days to seven Charolais bulls. Individual cow weights were taken monthly from November, 1972 to November, 1973. Condition scores were taken prior to initiation (November, 1972) just after termination (April, 1973) and just before reinitiation (November, 1973) of winter supplementation.

Monthly estimates of 24-hour milk yield were made by weighing calves to the nearest 0.045 kg immediately before and after nursing following four consecutive 6-hour periods of separation from their dams. Milk composition of drylot cows was measured during the mean fourth, fifth and sixth months of lactation. Milk samples were taken with a portable milking machine.

Data were subjected to analyses of variance using three breeds (Hereford, Crossbred and Holstein) and two levels of supplement (Moderate and High) in a 3 x 2 factorial arrangement. Very High Holsteins were deleted from this analysis and reference to breed and supplement level effects and interactions in Results and Discussion are based only on the 3 x 2 factorial arrangement. Very High Holsteins were compared to all other groups by the procedure of Least Significant Difference (Snedecor and Cochran, 1967). Significance levels indicated by superscript letters in tables were calculated by the Least Significant Difference procedure.

Results and Discussion

Feed Intake

Cows allotted to drylot were generally the early calvers resulting in a longer supplemental feeding period and higher supplement consumption (Table I) in drylot than on range. High level females consumed more ($P<.03$) total roughage during the lactation period than the Moderates, a trend not seen by Kropp et al. (1973) and Holloway et al. (1974) who reported that drylot cows on lower levels of winter supplement compensated by consuming more roughage in summer. Intake of the baled alfalfa fed in this trial was lower than intake of chopped alfalfa fed by Kropp et al. (1973) and Holloway et al. (1974). Apparently the quality and form of the baled alfalfa limited the Moderate level females in compensating for their lower level of winter nutrition. Detailed data on the influence of winter supplementation on roughage intake by these females was presented by Lusby, Stephens and Totusek (1974).

Drylot Holsteins consumed more ($P<.05$) total roughage, total DE and DP than the Herefords or Crossbreds, reflecting their increased requirements due to body weight (Table II) and milk production (Table III). Crossbred females were smiliar in body weight to the Herefords, but due to higher requirements for milk production, consumed slightly more DE and DP during lactation than the High Herefords and significantly ($P<.05$) more than the Moderate Herefords.

In order for the drylot phase to represent the influence of breed and level of supplement on year-round forage intake on range, a less palatable roughage (one more representative of winter range forage) than cottonseed hulls may be necessary. To evaluate the effect of roughage quality on intake in drylot, baled winter forage from a pasture used by range cows was substituted for cottonseed hulls for 16 days in drylot (Table I). Intakes of the winter forage were smaller than seen with cottonseed hulls and intake differences between supplement levels were small ($P<.25$). High level females in drylot apparently did not eat to capacity when confronted with a low quality unpalatable roughage such as found on winter range. Winter weight losses for High level cows on range (Table III) were 18 to 42 kg greater than for High level cows in drylot, further suggesting that range forage was of lower quality than cottonseed hulls fed in drylot.

Holstein progeny consumed less ($P<.05$) creep than Crossbred or Hereford progeny, a trend also noted by Holloway et al. (1974). As a result, total DE intakes (milk + creep) were not significantly different between calves of the three breeds.

Weight and Condition of Cows

The amount of winter weight loss on range and in drylot (Table II) decreased ($P<.001$) as level of supplemental feeding increased, in agreement with Kropp et al. (1973) and Holloway et al. (1974). The moderate and High Herefords, High Crossbreds and Very High Holsteins on range regained their winter weight loss during the summer months but the Moderate Crossbred, and Moderate and High level Holsteins did not.

This suggests that supplement levels for the base breed-supplement level groups (Moderate Hereford, High Crossbred and Very High Holstein) were adequate, but that lower levels were inadequate for heavy milking breeds. Breed influenced ($P<.001$) winter weight change and condition score change on range, but not in drylot ($P<.58$) due to the high weight loss among Moderate Herefords in drylot. Within each breed Moderates gained more weight in summer on range ($P<.16$) and drylot ($P<.01$) than High level coes.

Lactation

Milk yields (Table III) for Hereford, Crossbred and Holstein females were 6.1, 9.2 and 12.3 kg/day on range and 6.7, 9.0 and 10.9 kg/day in drylot, respectively. These values are similar to those reported by Holloway et al. (1974) except for drylot Holsteins which produced 2.2 kg less per day as four-year-olds than as three-year-olds.

Lactation curves (Figure 1) show that three distinct milk production levels were established by the three breeds on range, but not in drylot, although breed differences for milk production here highly significant (P .001) in both phases. Range lactation curves obtained for the first and second calf crops (Kropp et al., 1973; Holloway et al., 1974) were relatively flat, while the curves for four-year-olds exhibited a more typical decline during the last three months of lactation. The drylot curve showed the same trend, but was more erratic.

In drylot, High supplemented females produced more ($P<.11$) milk per day than Moderates. On range, High Holsteins yielded 1.9 kg more milk per day than Moderate Holsteins while no supplement level influence on milk production was noted among Herefords or Crossbreds. Most of the treatment influence was achieved in the first three months of lactation (Figure 1) and ceased with the onset of lush grazing on range and the feeding of alfalfa hay in drylot during the fourth and fifth months of lactation.

Milk Composition

Butterfat, total solids and solids-not-fat (Table III) were similar to those reported for these females as two-year-olds (Kropp et al., 1973) while butterfat values were higher and total solids and solids-not-fat lower than found by Holloway et al. (1974).

Significant treatment effects were noted for butterfat (P<.01), but not for total solids (P>.57) or solids-not-fat (P>.27). These results are not consistant with data of Flux and Patchell (1954), Huber et al. (1964) and Gillooly et al. (1967) who reported increased percents of solids-not-fat as well as butterfat with higher energy intakes. No breed effects on any of these components were noted.

Performance of Offspring

Breed effects on birthweight (Table IV) were highly significant on range (P<.001) and approached significance (P<.15) in drylot. No supplement level influence was noted. The birthweight differences between Herefords and Crossbreds on range were not noted in the previous two calf crops.

At weaning, calves from Hereford, Crossbred and Holstein cows weighed 260, 289 and 318 kg on range, and 259, 293 and 319 kg in drylot.

In previous years drylot calves failed to gain as rapidly to weaning as range calves, but higher creep intakes by drylot calves of four-year-olds resulted in comparable weaning weight by drylot and range calves. In drylot, calves of High level females tended to weigh more ($P<.14$) at weaning than calves of Moderates, probably the result of higher milk production and greater butterfat content noted in High level dams. Level of winter supplementation had little ($P>.47$) influence on range weaning weights.

Drylot weaning weights compared favorably with estimated calf DE intakes (Table I) and milk production estimates (Table III).

Reproductive Performance

Hereford, Crossbred and Very High Holstein females showed good rebreeding rates (Table V). The low numbers of Moderate and High Holsteins rebreeding on range (50 and 64%) respectively, and in drylot (20 and 40%) indicated that high milking females on range cannot maintain rebreeding performance without large amounts of supplemental feed. Generally those cows which did not rebreed never showed estrus. Moderate Holsteins showed poor rebreeding performance as two-year-olds (Kropp et al., 1973) and three-year-olds (Holloway et al., 1974) but High Level Holsteins rebred well as two and three-year-olds. The lower rebreeding performance of High Holsteins as four-year-olds may indicate an accumulative effect of range conditions and low winter nutrition on high milking cows.

Breed effects on days post-partum to first observed estrus and on days post-partum to apparent conception were significant ($P<.01$) on range, but not in drylot ($P>.50$). The drylot rebreeding data are difficult to appraise since only one Moderate and two High level Holsteins rebred. Days post-partum to first estrus and apparent conception on range were similar between Moderate and High Herefords and between Moderate and High Holsteins, suggesting that the Moderate level of supplement was adequate for Herefords while even the High level was inadequate for Holsteins.

Discussion

Data from these cows as two, three and four-year-olds have clearly shown that high levels of milk production and subsequent heavy calf weaning weights are possible under range conditions. However, the poor rebreeding performance and long post-partum interval of both Moderate and High Holsteins demonstrated that additional milk production must be accompanied by additional feed input.

The true measure of the efficiency of beef production is the weight of beef produced per unit of land. Drylot data showed that Crossbreds and Holsteins (Moderate and High) consumed 15 and 28% more roughage, respectively (in addition to more supplement) to produce 13 and 18% more weaned calf weight than Herefords. The increased roughage intakes for high milking females translates to lower carrying capacity for range. If land or forage calculations also include the requirements for open cows or replacement heifers to maintain herd numbers, the desirability of increasing weaning weights through the use of high milking females may be questioned, at least under similar range and climatic conditions to those encountered under this experiment.

TABLE I

ROUGHAGE AND ESTIMATED DE AND DP INTAKE

Item	Breed and Level of Winter Supplementation							
	Hereford		Hereford x Holstein		Holstein			
	Moderate	High	Moderate	High	Moderate	High	Very High	SE[a]
Range cows								
Supplement, kg								
Total winter[b]	100	256	119	256	142	284	404	
Daily, pre-calving	0.4	0.9	0.4	0.9	0.4	0.9	1.4	
Daily, post-calving	1.2	2.6	1.2	2.6	1.4	2.8	3.8	
Drylot cows								
Supplement, kg								
Total winter[b]	139	311	137	328	149	327	583	
Daily, pre-calving	0.4	0.9	0.4	0.9	0.4	0.9	1.4	
Daily, post-calving	1.2	2.6	1.1	2.8	1.7	2.9	4.4	
Roughage ration, kg								
Total roughage intake[c]	2220^{i}	2569^{hi}	2687^{h}	2800^{gh}	2934^{fgh}	3226^{f}	3109^{fg}	131
Total roughage intake, %[d]	100	116	121	126	132	145	140	
Cottonseed hulls, daily	8.5^{i}	12.0^{gh}	11.3^{h}	13.5^{fgh}	12.5^{gh}	15.3^{f}	14.2^{fg}	0.77
Range hay, daily	6.9^{h}	6.9^{h}	7.0^{gh}	8.0^{fgh}	8.7^{fg}	9.5^{f}	9.5^{f}	0.63
Alfalfa hay, daily	12.6^{h}	12.4^{h}	14.2^{fgh}	14.4^{fgh}	15.6^{fg}	16.2^{fg}	16.7^{f}	0.78
Estimated daily DE intake during lactation, Mcal	24.6^{j}	28.7^{i}	29.3^{hi}	32.6^{gh}	33.3^{g}	36.3^{fg}	38.5^{f}	1.33
Estimated daily DP intake during lactation, kg	0.91^{j}	1.07^{hi}	1.09^{hi}	1.21^{gh}	1.32^{g}	1.35^{g}	1.49^{f}	0.06
Drylot calves								
Creep, total, kg	489.5^{f}	420.1^{fgh}	425.6^{fgh}	458.6^{fg}	406.7^{fgh}	368.4^{gh}	339.9^{h}	36.1
Estimated daily DE intake, Mcal[e]	12.7^{fg}	12.3^{g}	12.7^{fg}	14.8^{f}	12.9^{fg}	13.8^{fg}	14.9^{f}	0.72
Estimated daily DP intake, kg[e]	0.54^{g}	0.52^{g}	0.54^{g}	0.64^{f}	0.56^{fg}	0.61^{fg}	0.63^{f}	0.03

[a]Standard Error: Drylot, n=5
[b]November 15, 1972 - April 15, 1973.
[c]Dates fed: Cottonseed hulls, Calving - Feb. 28; Range Hay, Feb. 20 - Mar. 8; Cottonseed hulls, Mar. 9 - Apr. 16; Alfalfa hay, Apr. 16 - Weaning.
[d]Expressed as % of Moderate Herefords.
[e]Creep + milk.
[f,g,h,i,j]Means on same line with the same superscript letter are not significantly different (P<.05).

TABLE II

WEIGHT, WEIGHT CHANGE, CONDITION AND CONDITION CHANGE

	Breed and Level of Winter Supplementation							
	Hereford		Hereford x Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE[a]
Range								
Weight, kg								
Fall (pre-calving)	449^{d}	468^{cd}	498^{bcd}	477^{cd}	577^{b}	537^{bcd}	550^{bc}	19
Spring (mid-lactation)	361^{d}	404^{cd}	389^{cd}	393^{cd}	439^{bc}	439^{bc}	479^{b}	14
Fall (post-calving)	459^{d}	484^{bcd}	469^{cd}	479^{bcd}	553^{bc}	520^{bcd}	564^{b}	18
Weight change, kg								
Winter	-88^{cd}	-65^{d}	-109^{bc}	-84^{cd}	-139^{b}	-98^{bc}	-71^{cd}	14
Summer	98^{b}	79^{b}	80^{b}	86^{b}	113^{b}	81^{b}	86^{b}	15
Year	10^{bc}	16^{b}	-28^{c}	2^{bc}	-26^{bc}	-17^{bc}	14^{bc}	8
Weight change, %								
Winter	-19.6	-13.8	-21.8	-17.7	-24.0	-18.1	-12.8	
Summer	21.2	16.4	17.1	+18.0	20.5	15.5	15.1	
Year	2.0	3.0	-5.6	0.0	-4.4	-3.1	2.5	
Condition score								
Fall (pre-calving)	6.5^{b}	6.4^{b}	4.9^{bc}	4.9^{bc}	3.0^{d}	4.0^{cd}	4.5^{cd}	0.33
Spring (mid-lactation)	3.9^{bc}	4.6^{b}	3.0^{cd}	3.6^{bc}	1.7^{d}	2.0^{d}	3.6^{bc}	0.27
Fall (post-lactation)	7.1	6.9^{b}	5.8^{b}	5.6^{b}	3.4^{c}	3.5^{c}	5.2^{bc}	0.35
Condition score change								
Winter	-2.6^{b}	-1.8^{bc}	-1.9^{bc}	-1.3^{bc}	-1.3^{bc}	-1.9^{bc}	-0.8^{c}	0.28
Summer	3.2^{b}	2.3^{bc}	2.8^{bc}	2.0^{bc}	1.7^{c}	1.5^{c}	1.6^{c}	0.27
Drylot								
Weight, kg								
Fall (pre-calving)	455^{d}	456^{d}	464^{d}	477^{cd}	543^{bc}	541^{bc}	564^{b}	20
Spring (mid-lactation)	358^{e}	432^{cde}	393de	411de	452^{cd}	484^{bc}	526^{b}	26
Fall (post-lactation)	473^{c}	481^{c}	469^{c}	471^{c}	502^{c}	533^{bc}	591^{b}	24

TABLE II (Continued)

Item	Hereford		Hereford x Holstein		Holstein			SE[a]
	Moderate	High	Moderate	High	Moderate	High	Very High	
Weight change, kg								
Winter	-98^{b}	-24^{d}	-72^{bcd}	-66^{bcd}	-90^{bc}	-56^{bcd}	-38^{cd}	19
Summer	116^{b}	49^{c}	76^{bc}	60^{bc}	49^{c}	48^{c}	65^{bc}	25
Year	18^{b}	24^{b}	5^{b}	-5^{b}	-38^{b}	8^{b}	27^{b}	14
Weight change, %								
Winter	-21	-6	-15	-14	-17	-10	-7	
Summer	32	11	19	15	11	10	12	
Year	4	5	1	-1	-8	-1	5	
Condition score								
Fall (pre-calving)	5.8^{b}	6.0^{b}	6.0^{b}	5.0^{bc}	4.3^{cd}	3.4^{d}	5.2^{bc}	0.47
Spring (mid-lactation)	3.6^{cd}	5.4^{b}	3.0^{de}	4.0^{cd}	2.0^{e}	2.2^{e}	4.6^{bc}	0.46
Fall (post-lactation)	7.0^{b}	7.0^{b}	5.8^{bc}	5.4^{cd}	4.3^{de}	3.8^{e}	6.2^{bc}	0.50
Condition score change								
Winter	-2.2^{b}	-0.6^{c}	-3.0^{b}	-1.0^{c}	-2.3^{b}	-1.2^{c}	0.6^{c}	0.33
Summer	3.4^{b}	1.6^{c}	2.8^{bc}	1.4^{c}	2.3^{bc}	1.6^{c}	1.6^{c}	0.49

Breed and Level of Winter Supplementation (column heading spanning all breed columns)

[a]Standard errors for range cows are approximate, n=12; standard errors for drylot cows are exact, n=5.
[b,c,d,e]Means on the same line with the same superscript letter are not significantly different (P<.05).

TABLE III

MILK PRODUCTION AND COMPOSITION

	Breed and Level of Winter Supplement							
	Hereford		Hereford x Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE[e]
Range								
Total lactation yield, kg	1457^{d}	1465^{d}	2216^{c}	2206^{bc}	2775^{ab}	3242^{a}	2849^{a}	113
Daily yield, kg	6.1^{c}	6.1^{c}	9.3^{b}	9.2^{bc}	11.6^{ba}	13.5^{a}	11.9^{a}	1.13
Drylot								
Total lactation yield, kg	1502^{c}	1586^{c}	2057^{b}	2254^{b}	2483^{a}	2675^{a}	2670^{a}	186
Daily yield, kg	6.2^{c}	7.2^{c}	8.6^{b}	9.4^{b}	10.4^{a}	11.1^{a}	11.1^{a}	1.22
Butterfat, %	2.30^{c}	2.64^{abc}	2.72^{abc}	2.83^{ab}	2.40^{c}	2.90^{a}	2.45^{bc}	0.14
Solids-not-fat, %	7.14^{a}	6.91^{a}	7.64^{a}	7.03^{a}	6.86^{a}	6.87^{a}	6.98^{a}	0.38
Total solids, %	9.44^{a}	9.55^{a}	10.36^{a}	9.86^{a}	9.26^{a}	9.77^{a}	9.43^{a}	0.43

[a,b,c,d] Means on the same line with the same superscript letters are not significantly different (P<.05).
[e] Standard errors for range cows are approximate, n=12; standard errors for drylot cows are exact, n=5.

TABLE IV

CALVING AND WEANING PERFORMANCE

	Breed and Level of Winter Supplementation							
	Hereford		Hereford x Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE[e]
Range								
No. of calves	14	13	12	14	10	11	11	
Male	9	7	7	11	3	6	6	
Female	5	6	5	3	7	5	5	
Birth weight, kg	39^{a}	40^{ab}	41^{abc}	42^{abc}	47^{d}	46^{cd}	44^{bcd}	1.72
Adj. weaning weight, kg	260^{c}	260^{c}	277^{bc}	300^{abc}	326^{a}	315^{ab}	314^{ab}	8.17
Drylot								
No. of calves	5	5	5	5	5	5	5	
Male	3	3	3	3	3	3	3	
Female	2	2	2	2	2	2	2	
Birth weight, kg	42^{ab}	36^{a}	41^{ab}	41^{ab}	43^{ab}	44^{b}	43^{ab}	2.5
Adj. weaning weight, kg	259^{a}	259^{a}	282^{ab}	305^{bc}	300^{bc}	316^{c}	319^{c}	10.9

[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, n=12; standard errors for drylot are exact, n=5.

TABLE V

REPRODUCTIVE PERFORMANCE

Item	Breed and Level of Winter Supplementation							
	Hereford		Hereford x Holstein		Holstein			
	Moderate	High	Moderate	High	Moderate	High	Very High	SE[g]
Range								
No. of cows	14	13	12	14	10	11	11	
No. of cows exhibiting estrus	12	13	11	12	5	6	11	
Days post-partum to first observed estrus[a]	47[d]	50[d]	69[de]	50[d]	89[e]	94[e]	50[d]	5.8
No. of cows which conceived[b]	12	13	11	12	5	7	10	
Days post-partum to apparent conception[c]	61[de]	67[def]	82[def]	55[d]	95[ef]	105[f]	59[d]	6.3
Drylot								
No. of cows	5	5	5	5	5	5	5	
No. of cows exhibiting estrus	5	5	4	5	2	3	4	
Days post-partum to first observed estrus[a]	83[de]	51[d]	79[de]	74[de]	74[de]	93[e]	87[e]	12.7
No. of cows which conceived[b]	5	5	4	5	1	2	4	
Days post-partum to apparent conception[c]	86[ef]	57[de]	80[def]	75[def]	40[d]	101[f]	94[ef]	13.3

[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,f] Means on same line with same superscript letter are not significantly different (P<.05).
[g] Standard errors for range and drylot cows are approximate: range, n=12; drylot n=5.

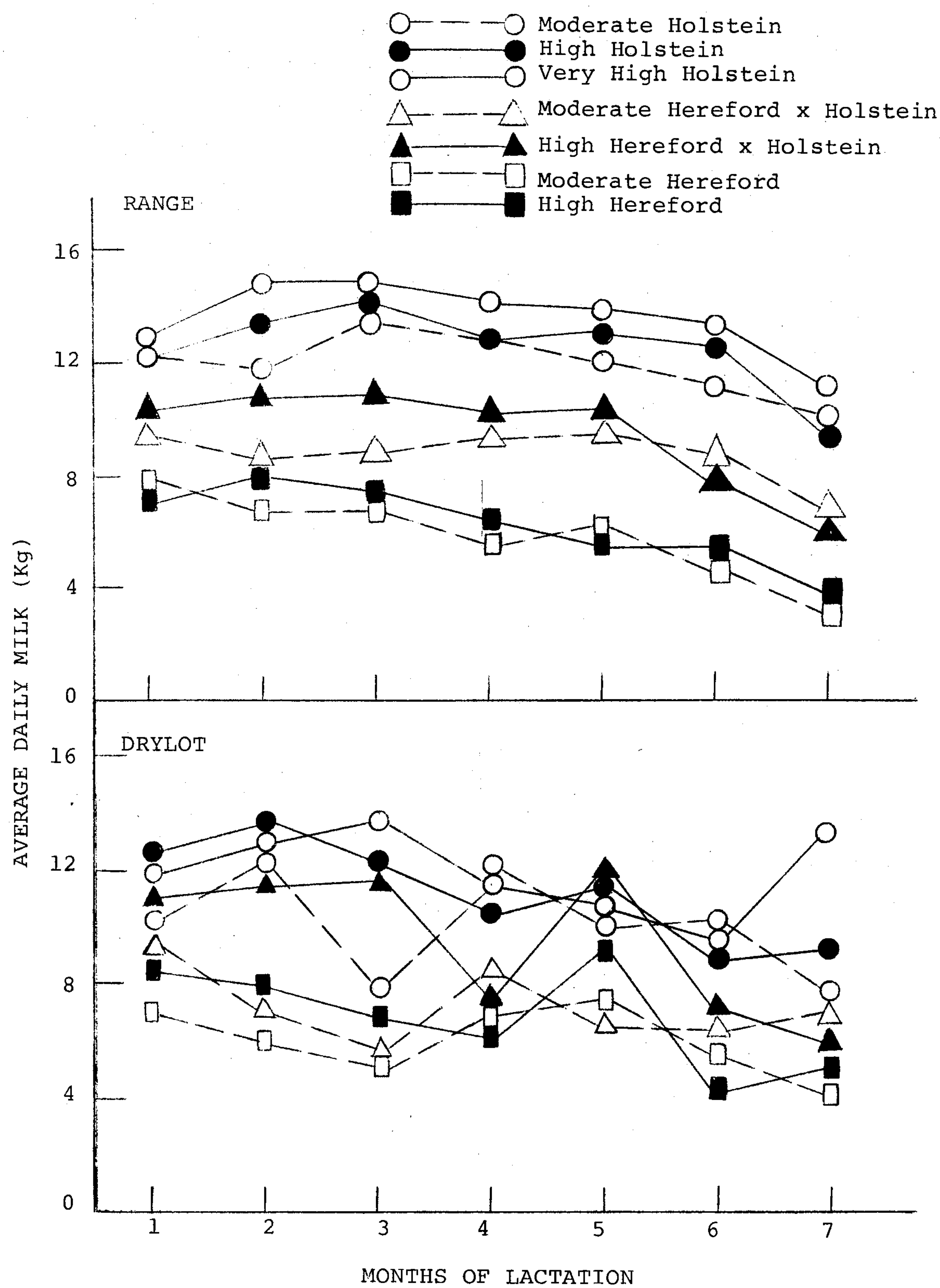

Figure 1. Average Daily Milk Yield

CHAPTER IV

INFLUENCE OF BREED AND LEVEL OF WINTER SUPPLEMENT ON ROUGHAGE INTAKE AND DIGESTIBILITY IN DRYLOT COWS[1,2]

Summary

Thirty-five lactating 4-year-old Hereford, Hereford x Holstein (Crossbred) and Holstein cows were maintained in drylot to study the influence of breed and level of winter supplement (Moderate, High or Very High) on winter and subsequent summer roughage intake. Cottonseed hulls were fed *ad libitum* individually in two winter trials and alfalfa hay in three summer trials to simulate range forage. Cows fed a high level of winter supplement consumed more ($P<.001$) cottonseed hulls in winter and had higher digestibility coefficients for acid detergent fiber and dry matter than cows fed a Moderate level. In summer, with *ad libitum* alfalfa hay and no supplement, cows previously wintered on the Moderate supplement level tended to consume

---

[1]Journal Article of the Oklahoma Agricultural Experiment Station, 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]The authors wish to express appreciation to Leon Knori for his care of experimental animals and R. K. Johnson for assistance with statistical analysis.

more alfalfa hay than cows wintered on the High or Very High levels of supplement. Groups with the highest alfalfa intakes generally had the highest digestion coefficients for acid detergent fiber, dry matter and crude protein. Holsteins consumed more ($P<.05$) roughage than Crossbreds, and Crossbreds more than Herefords in both winter and summer.

Introduction

High milking females produced heavier calves at weaning but required more forage and higher levels of winter supplementation to maintain body condition and rebreeding performance similar to that found in conventional beef cows (Kropp et al., 1973; Holloway et al., 1973). Any influence of increased forage intake or high winter supplementation levels on forage digestibility will be reflected in altered efficiency of the cow. Results have been conflicting with some workers (Moe, Reid and Tyrell, 1965) reporting decreased digestibility with increased intake while others (Lassiter, Huffman and Duncan, 1958) showed increased digestibility as intake increased. Burroughs and Gerlaugh (1949) and Egan (1970) reported increased digestion of low quality hays when protein was added to the ration.

The experiments reported herein were designed to study the influence of breed, reflecting level of milk production, and level of winter supplement on winter and subsequent summer roughage intake and digestibility by drylot cows.

Materials and Methods

Thirty-five Hereford, Hereford x Holstein (Crossbred) and Holstein females were confined in drylot from the time they calved in December, January and February until their calves were weaned at 240 days of age. Trials discussed here were conducted when the cows were three and four-year-olds raising their second and third calves, respectively.

From the date of calving until April 15, all cows were individually fed *ad libitum* cottonseed hulls daily to simulate winter range forage. In addition, each cow was fed 227 g alfalfa pellets per day. Two levels of a 30% natural protein supplement, Moderate and High, were fed to five cows of each breed from calving to April 15. The Moderate level was calculated to allow good rebreeding performance in mature Hereford females with a 10-15% weight loss from fall to spring. The high level was established for the Crossbred females and consisted of that amount of supplement estimated necessary to maintain a physiological condition and rebreeding performance similar to that of the Moderate Herefords. A Very High level was fed only to five Holsteins and consisted of that amount of supplement estimated necessary to maintain a body condition similar to that of the Moderate Herefords and High Crossbreds. Within each supplement level the quantity of supplement fed to each female was adjusted for differences in body size. Supplement intake by breed and level of supplement is shown in Table VII.

From April 15 until calves were weaned, all cows received *ad libitum* chopped or baled alfalfa hay fed individually to simulate summer range forage. Chemical analyses of feeds are shown in Table VI. Complete reviews of management procedures used with these cows have been reported by Kropp *et al.* (1973) and Lusby *et al.* (1974).

Two digestion trials were conducted in March of 1972 (Trial I) and 1973 (Trial II) when all cows were fed cottonseed hulls and three levels of supplement. Three trials were conducted in June of 1972

(Trial III) and June and July of 1973 (Trials IV and V, respectively) when ad libitum alfalfa hay was fed. The alfalfa was chopped through a hammer mill for Trials III and V while Baled alfalfa was fed in Trial IV. Feeding schedules during digestion trials were altered from once daily (8 a.m. to 1 p.m.) to twice daily feeding periods from 6 a.m. to 10 a.m. and from 4 p.m. to 6 p.m. Chromic oxide (20 g/head/day) was fed twice daily (7 a.m. and 5 p.m.) to each cow for 7 days prior to collection of fecal grab samples and for 7 succeeding days during which rectal grab samples (110 g) were taken at the time of each chromic oxide administration. Chromic oxide was fed via the supplement in Trials I and II and with 227 g ground corn as a carrier in Trials III, IV and V when no supplement was fed.

Fecal grab samples were composited over the 7 day collection periods for each cow, dried at 100° C for 48 hours and analyzed for chromic oxide content (Williams, David and Iismaa, 1962). Samples of feed were taken daily, composited for the trial period, and analyzed for crude protein A. O. A. C., 1965), dry matter and acid detergent fiber (Van Soest, 1963). Nutrient digestion coefficients were calculated using the nutrient concentration of the feed and feces and chromic oxide concentration of the feces.

Data were subjected to analysis of variance using three breeds (Hereford, Crossbred and Holstein) and two levels of supplement (Moderate and High) in a 3 x 2 factorial arrangement. Very High Holsteins were deleted from this analysis and reference to breed and treatment effects and interactions in Results and Discussion are based only on the 3 x 2 factorial arrangement. Very High Holsteins were compared to all other groups by the procedure of Least Significant

Difference (Snedecor and Cochran, 1967). Significance levels indicated by superscript letters in tables were calculated by the Least Significant Difference procedure.

Results and Discussion

In Trials I and II (Table VII) with three levels of supplement fed, cottonseed hull intake within each breed was higher (P<.001) for cows receiving the High supplement level than for cows fed the Moderate level. Very High Holsteins consumed more cottonseed hulls in Trial I (P<.05) and Trial II (nonsignificant) than High Holsteins. Holsteins consumed more (P<.05) cottonseed hulls than Crossbreds while Crossbreds consumed more than Herefords in both Trials I and II.

Dry matter digestibility coefficients for High supplemented females were greater than for Moderates in both Trial I (P<.001) and Trial II (P<.02). Since digestion coefficients were determined on the total diet of each cow, a part of the increased dry matter digestibility observed in High and Very High females was due to a greater proportion of highly digestible supplement in the total diet of cows fed the High or Very High supplement levels. Dry matter digestibility differences between the Moderate and High level Herefords and Holsteins in Trial II could be explained on this basis. However, differences in dry matter digestibility between Moderate and High Crossbreds in Trial II and between Moderate and High level cows of all breeds in Trial I are too large to have resulted from the additional supplement fed to High level cows.

A better estimate of the influence of supplement on roughage digestibility was obtained from the acid detergent fiber (ADF) digestibility values. The supplement contained only 12.9% ADF and hence contributed little of this fraction to the total diet. High level females had higher (P<.01) ADF digestibility in Trial I than the Moderates. Differences in ADF digestibility in Trial II, while as high in magnitude as found in Trial I, were not statistically significant (P<.10) due to greater variability in Trial II. An explanation for the higher variation in digestibility coefficients incurred in Trial II compared to Trial I is not readily apparent. Results from these trials concur with the work of Crabtree and Williams (1971) and Egan (1970) who reported increased intake and digestibility of low quality roughages in sheep when additional protein was added to the ration.

Protein digestibility was not measured in Trials I and II since cottonseed hulls contained little digestible protein and any digestion coefficient would only reflect the contribution of supplement protein.

Interpretation of results from Trials III, IV and V was made more difficult by factors which prohibited the feeding of alfalfa hay identical in quality and method of preparation in all summer trials. An attempt at the time of Trial III to equalize weights between the drylot cows used in this experiment and similar groups of the same breeds and supplement levels on range (Holloway, 1974) forced the inclusion of 10% ground sorghum grain in the chopped alfalfa ration and led to higher digestion coefficients in Trial III than found in Trials IV and V. The alfalfa hay fed in Trials IV and V was poorer in quality than that used in Trial III, as Table VI indicates. Further, difficulties with the feed mill forced the feeding of baled alfalfa in Trial IV.

Trial x supplement level interactions for ADF, dry matter and crude protein digestion coefficients were nonsignificant (P>.18) while the trial x supplement interaction for roughage intake approached significance (P<.12).

Results of the three summer trials are shown in Table VIII. A general trend existed for cows previously wintered on the Moderate supplement level to consume more alfalfa in summer than cows wintered on the High level in Trial III (P<.07) and Trial V (P<.15) but not in Trial IV. While this study was not designed to compare long and chopped forages, the lowered intake and overall greater digestibility of the long (baled) hay when compared to chopped hay has been noted (Reynolds and Lindhal, 1960; Campling, Freer and Balch, 1961). Adjustment of alfalfa intakes (kg/kg wt.$^{0.75}$) showed a significant influence of previous plane of winter supplement on summer roughage intake in Trial III (P<.02) and Trial V (P<.02) but not in Trial IV (P>.64).

Breed effects on intake were significant in Trial III (P<.001), Trial IV (P<.003) and Trial V (P<.001). Adjusted intakes were similar though differences were not as great in Trial IV (P<.06) and Trial V (P<.01).

The effect of previous winter feeding level on digestibility of dry matter, protein and ADF was erratic but a nonsignificant trend was noted for groups with the greatest roughage intakes to also have higher digestion coefficients. These results agree with data from Conrad, Pratt and Hibbs (1964) and Blaxter, Wainman and Wilson (1961).

It is interesting to note that the High Herefords were generally the least efficient in digesting ADF, dry matter and protein in each summer trial. The greater degree of body condition of the High Herefords compared to that of the other breed-treatment groups suggests some influence of body condition on digestion as well as feed intake in agreement with Bines (1959) and, Suzuki and Balch (1969). These results clearly indicate that adding protein supplement to a low quality, readily consumed roughage such as cottonseed hulls will result in increased consumption of the roughage. The higher dry matter and ADF digestibilities noted with increased supplement suggest that the greater intake was the result of a faster removal of digesta from the rumen.

However, questions arise about the applicability of these results to cows under winter range conditions where forage is less palatable than the cottonseed hulls fed in these drylot trials. Kropp et al. (1973), reporting data from cows of these same breeds and winter supplement levels as 2-year-olds on range, reported that Moderate level Herefords and Holsteins on range lost only 2% more body weight in winter than High level Herefords and Holsteins; Very High Holsteins lost only 1% less weight in winter than High Holsteins. As 3-year-olds on range (Holloway et al., 1974) High level Herefords lost more (2.6%) weight in winter than Moderate Herefords. Lusby, Stephens and Totusek (1974) using these same breeds and treatments on range, found lower forage intake for High level cows than for Moderates. These findings suggest that the influence of supplementation on roughage intake may depend on palatability and availability of the roughage. Beef cows offered low quality winter range forage may respond to increased supplementation by reduced forage intake rather than increased intake seen with readily consumed and available cottonseed hulls in drylot.

TABLE VI

CHEMICAL COMPOSITION OF FEEDS

Feed	IRN no.	Trial no.	As % of dry matter: Crude protein	As % of dry matter: Acid detergent fiber
Cotton, seed hulls, (1) (Cottonseed hulls)	1-01-599	I	4.70	73.05
		II	4.55	72.76
Alfalfa, hay, s-c pltd, (1), (alfalfa pellets)	1-00-128	I	18.35	31.00
		II	18.60	31.50
Supplement[a]		I	31.20	12.93
		II	30.60	12.90
Alfalfa, hay, s-c mid blm, (1), (alfalfa hay)	1-00-063			
chopped		III	17.60	42.80
baled		IV	15.85	44.40
chopped		V	15.70	44.80
Sorghum, grain variety, grain, grnd, (4) (sorghum grain)	4-04-379	III	10.60	1.95

[a]Supplement composition: Soybean, seed, solv-extd grnd, mx 7 fbr, (5), IRN 5-04-604 (soybean meal) 60.1%; sorghum grain, ground, 30.3%; Alfalfa, leaves, dehy, grnd, (1), IRN 1-00-137 (dehydrated alfalfa meal) 5.0%; dicalcium phosphate, 2.9%; Masonex, 1.2%; salt, 0.5%; Vitamin A, 2000 IU/kg.

TABLE VII

FEED INTAKE AND DIGESTIBILITY, WINTER

Item	Breed and Level of Winter Supplement							
	Hereford		Hereford x Holstein		Holstein			
	Moderate	High	Moderate	High	Moderate	High	Very High	SE
Trial I, March, 1972								
Daily intake								
Alfalfa pellets, kg	.45	.45	.45	.45	.45	.45	.45	
Supplement, kg	1.23	2.59	1.22	2.66	1.45	2.89	4.09	
Cottonseed hulls, kg	11.67^{a}	15.22^{b}	11.91^{a}	16.61^{b}	16.15^{b}	20.10^{c}	22.57^{d}	0.66
Cottonseed hulls (adjusted)[h]	0.94^{a}	1.08^{bc}	1.01^{ab}	1.16^{c}	1.19^{c}	1.34^{d}	1.41^{d}	0.046
Supplement: roughage ratio[g]	0.10	.16	0.10	.16	0.08	.14	.18	
Digestibility %								
Dry matter	52.18^{a}	58.98^{b}	50.21^{a}	58.45^{b}	48.83^{a}	58.69^{b}	67.61^{c}	1.41
Acid detergent fiber	51.39^{abc}	55.28^{cd}	48.23^{a}	54.91^{bcd}	49.97^{ab}	58.07^{d}	56.38^{cd}	1.76
Trial II, March, 1973								
Daily intake								
Alfalfa pellets, kg	.45	.45	.45	.45	.45	.45	.45	
Supplement, kg	1.23	2.90	1.24	3.11	1.44	3.27	4.85	

TABLE VII (Continued)

	Breed and Level of Winter Supplement							
	Hereford		Hereford x Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE
Cottonseed hulls, kg	8.43^{a}	15.43^{c}	11.24^{b}	17.53^{d}	14.53^{c}	22.11^{e}	23.31^{e}	0.68
Cottonseed hulls (adjusted)[h]	0.69^{a}	1.06^{bc}	0.93^{b}	1.26^{de}	1.13^{cd}	1.52^{f}	1.39^{ef}	0.051
Supplement: roughage ratio[g]	.14	.18	.11	.17	.10	.14	.20	
Digestibility %								
Dry matter	59.12^{abc}	62.64^{bc}	49.70^{a}	64.11^{c}	52.84^{ab}	56.14^{abc}	63.23^{c}	3.47
Acid detergent fiber	53.50^{ab}	59.59^{ab}	50.08^{a}	62.05^{ab}	55.04^{ab}	55.97^{ab}	64.31^{b}	4.63

a,b,c,d,e,f Numbers with same superscript letter do not differ significantly ($P < .05$).

g Roughage calculated as cottonseed hulls and alfalfa pellets.

h Kg/kg wt$^{0.75}$.

TABLE VIII

FEED INTAKE AND DIGESTIBILITY, SUMMER

	Breed and Previous Level of Winter Supplement							
	Hereford		Hereford x Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE
Trial III, June, 1972								
Alfalfa intake (kg)[e]	11.52[ab]	9.36[a]	12.46[bc]	12.62[bc]	16.99[d]	15.38[d]	14.92[cd]	1.65
Alfalfa intake (adjusted)[h]	1.03[b]	0.81[a]	1.19[bc]	1.11[bc]	1.41[d]	1.26[cd]	1.18[bc]	0.70
Digestibility %								
Dry matter	57.41[ab]	51.37[a]	59.38[ab]	60.25[ab]	63.59[b]	59.35[ab]	59.59[ab]	3.16
Protein	68.60[ab]	65.20[a]	70.45[ab]	70.71[ab]	72.38[b]	70.28[ab]	70.20[ab]	2.21
Acid detergent fiber	56.01[ab]	53.80[a]	59.87[abc]	60.33[abc]	64.03[c]	63.16[c]	62.49[bc]	3.24
Trial IV, June, 1973								
Alfalfa intake (kg)[f]	10.49[a]	10.87[a]	11.43[ab]	12.37[bc]	12.79[bc]	12.67[bc]	13.53[c]	1.20
Alfalfa intake	0.96[ab]	0.92[a]	1.03[ab]	1.08[b]	1.09[b]	1.01[ab]	1.02[ab]	0.055
Digestibility %								
Dry matter	53.99[abc]	48.10[a]	54.24[abc]	58.16[bc]	56.14[abc]	53.58[ab]	62.95[c]	3.00
Protein	59.94[ab]	58.95[ab]	65.42[ab]	63.70[ab]	60.02[ab]	58.11[a]	68.22[b]	3.14
Acid detergent fiber	57.87[abc]	52.73[a]	56.83[ab]	63.62[bcd]	65.09[cd]	58.50[abc]	66.94[d]	2.62
Trial V, July, 1973								
Alfalfa intake (kg)[g]	12.93[abc]	10.98[a]	14.18[bcd]	12.15[ab]	15.92[d]	16.54[d]	15.16[cd]	2.25

TABLE VIII (Continued)

Item	Breed and Previous Level of Winter Supplement							
	Hereford		Hereford x Holstein		Holstein			
	Moderate	High	Moderate	High	Moderate	High	Very High	SE
Alfalfa intake (adjusted)[h]	1.22^{bc}	0.98^{a}	1.32^{c}	1.09^{ab}	1.33^{c}	1.36^{c}	1.19^{abc}	0.848
Digestibility %								
Dry matter	52.18^{c}	43.74^{ab}	52.10^{c}	47.50^{abc}	49.76^{bc}	41.78^{a}	47.01^{abc}	2.23
Protein	61.94^{c}	54.72^{a}	62.26^{c}	59.75^{abc}	60.96^{bc}	55.47^{ab}	58.69^{abc}	1.84
Acid detergent fiber	54.97^{c}	46.58^{ab}	51.57^{bc}	49.00^{abc}	51.38^{bc}	43.02^{a}	46.73^{ab}	2.50

[a,b,c,d] Numbers with same superscript letters do not differ significantly ($P<.05$).

[e] 90% chopped hay, 10% ground milo, 5% fat.

[f] Baled hay.

[g] Chopped hay.

[h] Kg/kg $wt^{0.75}$.

CHAPTER V

THE INFLUENCE OF BREED AND LEVEL OF WINTER SUPPLEMENTATION ON FORAGE INTAKE OF RANGE COWS[1,2]

Summary

The effects of breed and level of winter supplement on dry matter and cellulose intake were measured using chromic oxide with 49 lactating 4-year-old Hereford, Hereford x Holstein (Crossbred) and Holstein cows on native Oklahoma tallgrass range. Trial I was conducted in winter when two levels of protein supplement (Moderate and High) were fed to seven cows of each breed. An additional group of seven Holsteins received a Very High level. Trial II was conducted in summer with no supplement fed. In Trial I (winter) cows fed the Moderate level consumed more forage cellulose ($P<.10$) and forage cellulose/kg weight$^{0.75}$ ($P<.01$) than cows fed the High level. In Trial II (summer) cows previously wintered on the Moderate level tended to consume more (non-significant) forage than cows wintered on the high level. Holsteins consumed more ($P<.05$) forage in both winter and summer than

---

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

[2]The author wishes to express appreciation to Leon Knori for his care of experimental animals and to R. K. Johnson for assistance with statistical analysis.

crossbreds. Crossbreds consumed more ($P<.05$) forage in winter but only slightly more in summer than Herefords.

Introduction

Increasing milk production in range cows by introducing genes from a dairy breed resulted in heavier weaning weight and greater production of beef from forage (Kropp et al., 1973). However, mature Angus x Holstein females in drylot (Wilson et al., 1969) and on range (Deutscher and Whiteman, 1971) required a higher level of supplement than beef cows. Hereford x Holstein and Holstein females on range and in drylot had greater winter weight loss and lower rebreeding performance when fed a winter supplement at the same rate as Hereford cows (Holloway et al., 1973). Data are available on the influence of milk yield on forage intake of dairy cows (Jones, Drake-Brochman and Holmes, 1965) and the effect of supplementation on forage intake of weaner calves (Scales et al., 1974) but little information is available on the influence of level of winter supplement on forage intake of lactating cows under range conditions. In order to evaluate the efficiency of high milking females on range, estimates of forage intake are needed. The purpose of this study was to determine the influence of level of winter supplement on winter and subsequent summer forage intake of cows differing widely in milk yield potential.

Materials and Methods

Trial I was conducted on winter range in March and Trial II on summer range in June. Forty-nine 4-year-old Hereford, Hereford x Holstein (Crossbred) and Holstein females, nursing calves at least

6 weeks old, were allowed to graze in a single pasture of 35 hectares for a period of 3 weeks during each trial. The pasture was not grazed previous to each trial to insure that adequate forage would be available. The pasture contained little bluestem (andropogon scorporius) as the predominant species.

At calving (December, January, and February) groups of seven Hereford, Crossbred and Holstein females were subjected to two levels of winter supplementation (Moderate and High). An additional group of Holsteins was also fed a Very High level.

The Moderate level was calculated to allow good rebreeding performance in mature Hereford females with a 10-15% weight loss from fall to spring. The High level of winter supplement was established by the Crossbred females and consisted of that amount of supplement estimated necessary to maintain a body condition and physiological condition comparable the Moderate Herefords. The Very High level of supplement, fed only to Holsteins, was calculated to maintain Holstein females in body condition similar to the High Crossbreds and Moderate Herefords. Supplement levels are shown in Table IX. Kropp et al., (1973) has fully described the management procedures and bases for selection of these breeds and winter feeding levels.

Seven days were allowed for adjustment to the pasture prior to each trial. Chromic oxide (20 g/head/day) was then individually fed twice daily (7 a.m. and 5 p.m.) to each cow for 7 days prior to and during a 7-day collection period when fecal grab samples were taken at the time of each feeding. Chromic oxide was administered via the supplement in Trial I and with 227 g ground corn as a carrier in Trial II (when no supplement was fed). Fecal grab samples (100 g from each sample) were composited over the 7-day collection period for each cow. Samples were dried at 100° C for 48 hours and analyzed for chromic oxide content (Williams, David and Iismaa, 1962) and cellulose (Crampton and Maynard, 1938).

Forage samples were collected using six lactating Angus x Hereford cows fitted with esophageal fistulae. Forage samples (Table X) from each cow were taken once daily for a period of six days during each trial and composited for in vitro determination of dry matter and cellulose digestibility (Tilley and Terry, 1963). Forage digestible energy values for each trial were calculated from forage composition tables (Waller et al., 1972) developed from fifteen years data on native Oklahoma grasses.

Forage cellulose and dry matter intakes were calculated with the assumption that digestibility coefficients for forage and supplement remained constant regardless of the proportion of each in the diet. Supplement dry matter digestibility was calculated to be 80% based on TDN values for supplement components (Crampton and Harris, 1969). Forage dry matter intake was calculated by dividing fecal output from forage by the in vitro forage indigestibility. Forage cellulose intake was calculated similarly by assuming 35% of supplement cellulose to be indigestible.

Data were subjected to analysis of variance using three breeds (Hereford, Crossbred and Holstein) in a 3 x 2 factorial arrangement. Very High Holsteins were deleted from this analysis and reference to breed and level of supplement effects and interactions in results are based only on the 3 x 2 factorial arrangement. Very High Holsteins were compared to all other groups by the procedure of Least

Significant Difference (Snedecor and Cochran, 1967). Significance levels indicated by superscript letters in tables were calculated by the Least Significant Difference procedure.

Results and Discussion

Estimated daily forage intake for Trial I (winter) is shown in Table IX. Cows fed the Moderate level of supplement consumed more forage dry matter ($P<.03$) and cellulose ($P<.09$) than cows fed the High level. Holsteins fed the Very High level consumed less ($P<.05$) forage cellulose than Holsteins fed the Moderate or High levels and less ($P<.05$) forage dry matter than Moderate Holsteins. A comparison of total DE intakes to theoretical requirements showed that cows fed the High level of supplement were only 0.1 to 2.5 Mcal/day closer to meeting their DE requirement than cows fed the Moderate level even though High level females received at least 4.6 Mcal/day more from supplement than Moderate females. Rittenhouse (1970) concluded that feeding high levels of energy can be expected to reduce forage intake while Crabtree and Williams (1971) reported forage intake reductions when concentrate made up 25% of the total diet. In Trial I, supplement constituted approximately 36% of the digestible energy intake in the diet of High level cows and 53% of the digestible energy of the Very High Holsteins.

Breed effects on forage intake in Trial I were significant ($P<.001$). Holsteins within each supplement level consumed more ($P<.05$) forage dry matter and cellulose than Crossbreds which in turn, consumed more ($P<.05$) than Herefords. The increased intake of Holsteins compared to the Crossbreds and Herefords was not surprising since the

Holsteins were approximately 80 kg heavier than either Crossbreds or Herefords and were producing 2.5 and 5.0 kg more milk per day than Crossbreds or Herefords, respectively (Lusby et al., 1974). Crossbreds produced 3 kg more milk per day but were similar in weight to the Herefords, suggesting that the increased forage intake noted for Crossbreds compared to Herefords was in response to the higher level of milk production.

Chromic oxide in Trial II was administered via 227 g ground corn (corn, yellow, grain, ground, (4), IRN 4-02-992) fed twice daily. This procedure proved successful in permitting fast administration of chromic oxide with minimum disturbance to the cows and allowed collection of fecal grab samples in the individual feed stalls as in Trial I. Few refusals of the corn-chromic oxide mixture occurred even though the cows were grazing lush summer forage. When refusals did occur, the refused portion was weighed and the proper amount of chromic oxide administered in a gelatin capsule.

In summer, cows previously wintered on the Moderate level of supplement tended (non-significant) to consume more forage dry matter and cellulose than cows wintered on the High level. Moderate Herefords and Holsteins used in these trials did in fact gain 5% more weight from spring to fall than the High Herefords or Holsteins (Lusby et al., 1974). Several workers (Kropp et al., 1973; Jourbet, 1954; Hughes, 1971) have noted a tendency for animals wintered on sub-optimal nutrition to compensate for losses when adequate nutrition was made available.

Estimates of digestible energy (DE) intake (Table XI) indicate that Moderate Hereford and Moderate Crossbred cows consumed about

3 Mcal DE per day in excess of requirements (Crampton and Harris, 1969) while Moderate Holsteins were 10 Mcal in excess. High Herefords and High Crossbreds consumed about 1 Mcal per day over requirements compared to 8.5 Mcal for High Holsteins.

Breed effects on forage intake in Trial II were significant (P<.001). The similarity of intakes between Herefords and Crossbreds was surprising since Crossbreds were producing 3 kg per day more milk than Herefords. The fact that both groups were similar in weight and were consuming about 2.5% of body weight as forage dry matter suggest that both breeds were eating to capacity even though the energy requirement of the Crossbreds exceeded that of the Herefords.

The inverse relationship of forage intake to level of winter supplement observed in Trial I does not agree with roughage intake data by Holloway <u>et al</u>., (1974) and Lusby, Stephens and Totusek (1974) for cows of the same breeds and winter supplement levels fed <u>ad libitum</u> cottonseed hulls in drylot. Both reported that cows fed the Moderate level of supplement consumed less (P<.01) cottonseed hulls than cows fed the High level. However, when Lusby <u>et al</u>. (1974) substituted baled winter range forage for cottonseed hulls in drylot, High supplemented females consumed only slightly more (P>.24) roughage than Moderates. Apparently roughage palatability was an important factor in determining the effect of protein supplementation on roughage intake. With a readily consumed roughage, intake increased with higher levels of protein supplementation, possibly due to improved roughage digestibility (Lusby, Stephens and Totusek, 1974). Data from Trial I suggests an opposite response by cows grazing less palatable and less available mature winter forage on range, forage consumption decreased with increased supplementation.

Trial II DE intakes (Table XI) show that energy consumptions for Herefords and Crossbreds were only slightly above their theoretical requirements for maintenance and lactation while Holsteins had the capacity to consume 8-10 Mcal DE/day over their requirements. This suggests that Holsteins had the greates ability to compensate for suboptimal winter nutrition when abundant summer forage became available.

TABLE IX

SUPPLEMENT, DRY MATTER AND CELLULOSE INTAKE FOR TRIALS I AND II

Item	Breed and Level of Winter Supplementation							
	Hereford		Hereford x Holstein		Holstein			
	Moderate	High	Moderate	High	Moderate	High	Very High	SE
Daily Supplement, kg[a]								
Avg. for winter	1.11	2.41	1.22	2.81	1.45	3.09	4.53	
During Trial I	1.22	2.65	1.21	2.63	1.41	2.80	4.39	
Estimated intake, kg/head daily								
Trial I (winter)								
Dry matter	6.56^{f}	4.28^{g}	8.86^{de}	7.51^{ef}	12.98^{c}	10.37^{d}	8.23^{def}	0.80
Cellulose	1.89^{g}	1.70^{g}	2.68^{f}	2.47^{f}	3.79^{c}	3.44^{d}	3.08^{e}	0.24
Adjusted dry matter[b]	0.078^{ef}	0.046^{g}	0.104^{d}	0.085^{e}	0.131^{c}	0.109^{d}	0.080^{e}	0.0094
Adjusted cellulose[b]	0.022^{ef}	0.018^{f}	0.031^{cd}	0.027^{de}	0.038^{c}	0.036^{c}	0.030^{cde}	0.0028
Trial II (summer)								
Dry matter	8.97^{e}	8.21^{e}	9.96^{e}	9.00^{e}	15.94^{c}	15.29^{d}	15.09^{d}	1.78
Cellulose	2.66^{d}	2.45^{d}	2.91^{d}	2.69^{d}	4.67^{c}	4.56^{c}	4.03^{c}	0.52
Adjusted dry matter[b]	0.099^{d}	0.084^{e}	0.107^{cd}	0.093^{de}	0.144^{c}	0.144^{c}	0.122^{cd}	0.0160
Adjusted cellulose[b]	0.029^{de}	0.025^{e}	0.030^{cde}	0.028^{e}	0.042^{cde}	0.043^{c}	0.038^{cde}	0.0047

[a]Soybean, seedwo hulls, solv-extd grnd, mx 3 fbr, (5), IRN 5-04-612, 60%; Alfalfa, aerial pt, dehy grnd, (1), 1-00-025, 5%; Calcium phosphate, dibasic, comm, (6), 6-01-080, 2.9%;Masonex, 1.3%,Vitamin A,24,500IU/kg.

[b]Kg/kg body weight$^{0.75}$.

[c,d,e,f,g]Means on the same line with the same superscript letter do not differ significantly (P<.05).

TABLE X

COMPOSITION OF FORAGE SELECTED BY COWS WITH ESOPHAGEAL FISTULAE

Item	Cellulose	Digestibility of Cellulose[a]	Digestibility of Dry Matter[a]
	%	%	%
Trial I	36.0	45.8	53.8
Trial II	28.7	56.2	62.3

[a]Determined *in vitro*.

TABLE XI

ESTIMATED INTAKE OF DIGESTIBLE ENERGY BY COWS, WITH A COMPARISON TO THEIR REQUIREMENT

	Breed and Level of Winter Supplementation						
	Hereford		Hereford x Holstein		Holstein		
Item	Moderate	High	Moderate	High	Moderate	High	Very High
Trial I, March							
Cow weight, kg[a]	360	421	372	398	458	458	483
DE intake, Mcal							
Supplement[b]	4.02	8.74	3.99	8.68	4.65	9.24	14.49
Forage[c]	10.41	6.79	14.06	11.92	20.58	16.46	13.06
Total	14.43	15.53	18.05	20.60	25.23	25.70	27.55
DE requirement[e]	19.30	19.90	22.93	23.33	30.27	30.03	30.07
Trial II, June							
Cow weight, kg[a]	399	440	407	425	503	487	503
DE intake, Mcal							
Forage[d]	22.93	20.98	25.46	23.00	40.74	39.08	38.57
DE requirement[e]	19.80	20.70	23.53	23.93	30.35	30.30	30.50

[a]Cow weights taken one week prior to and two weeks after collection of fecal grab samples.
[b]Based on 3.300 Mcal/kg supplement.
[c]Based on 1.587 Mcal/kg winter forage.
[d]Based on 2.556 Mcal/kg summer forage.
[e]Crampton and Harris (1969).

CHAPTER VI

THE INFLUENCE OF LEVEL OF MILK INTAKE BY CALVES ON CELLULOSE INTAKE ON RANGE AND CREEP INTAKE AND DIGESTIBILITY IN DRYLOT[1,2]

Summary

Thirty-five 4-to 6-month-old Charolais crossbred calves in drylot and 42 on range nursing Hereford, Hereford x Holstein (Crossbred) and Holstein dams were utilized in two digestion and intake trials (drylot) and one forage intake study (range) to determine the influence of level of milk intake on roughage intake and digestibility. Calves received _ad libitum_ creep individually each day in drylot while none was fed on range. Holstein progeny received more ($P<.01$) milk and consumed less creep in drylot and less forage cellulose on range than Hereford progeny. No breed differences on cellulose digestibility in drylot were noted. Within breed correlation coefficients between milk intake and both creep intake and digestibility were negative for all breeds. Milk intake was negatively correlated with cellulose intake on range.

---

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

[2]The author wishes to express appreciation to Leon Knori for his care of experimental animals and to J. V. Whiteman for his assistance with statistical analysis.

Creep intake was highly and significantly correlated with cellulose digestibility and calf weight within each breed.

Introduction

The high correlation between calf weaning weight and milking ability of the dam has been well documented (Knapp and Black, 1941; Pinney, 1963). Holloway et al. (1974) reported that calves of Holstein cows in drylot consumed a lower proportion of total nutrient intake from non-milk sources than calves of Hereford or Hereford x Holstein females. Ndumbe, Runcie and McDonald (1964) showed that fermentation developed more rapidly in early weaned calves fed concentrates than in milk-fed calves. Warner, Flatt and Loosli (1956) reported that calves receiving dry feed in addition to milk showed increased rumen volume and papillary development when compared to milk fed calves. The purpose of this study was to determine the influence of varying levels of milk intake on cellulose digestibility and creep intake in nursing calves in drylot and on forage intake of nursing calves on range.

Materials and Methods

Thirty-five 4- to 6-month-old Charlais crossbred calves in drylot and 42 on range nursing four-year-old Hereford, Hereford x Holstein (Crossbred) and Holstein cows were utilized. In the drylot phase calves and dams were maintained in drylot from time of calving in December, January and February until weaning at 240 days of age. Cows were alotted to drylot according to sex of calf so that a ratio of three male: two female calves was established within each breed. All drylot calves except two were sired by one Charolais bull. Calves received <u>ad libitum</u>

a pelleted creep ration consisting of: Corn, dent yellow, grain, gr 2 US mn 54 wt, (4), IRN 4-02-931, 49.5%; Alfalfa, hay, s-c grnd, early blm (1), IRN 1-00-108, 15.0%; Sugarcane, molasses, mn 48 invert sugar 79.5 degrees brix, (4), IRN 4-04-696, 5.0%; Soybean, seed wo hulls, solv-extd grnd, mx 3 fbr, (5), IRN 5-04-612, 17.5%; Cotton, seed hulls, (1), IRN 1-01-599, 10.0%; Wheat, Flour by-prod., mx 9.5 fbr, (4), IRN 4-005-205, 3.0%.

Two digestion trials (Trial I in June and Trial II in July) were conducted in drylot. Chromic oxide (10 g/head/day) was administered with the creep, which was fed daily from 8:00 a.m. to 9:30 a.m. and 4:00 p.m. to 5:30 p.m. during trial periods, for five days prior to the collection of fecal grab samples and for five succeeding days during which 100 g rectal grab samples were taken at the time of each feeding. Grab samples were composited over the 5-day collection period for each calf, dried at 100° C for 48 hours, ground and analyzed for chromic oxide content (Williams, David and Iismaa, 1962) and cellulose (Crampton and Maynard, 1938). Cellulose digestion coefficients in drylot were calculated using the cellulose concentration of feed and feces and the chromic oxide concentration of the feces.

On range, 12 calves each from Hereford and crossbred dams and 18 from Holstein dams were selected for a forage intake study (Trial III) and maintained with their dams on 35 hectares of native tallgrass range in June. Age and sex distributions were equalized when possible. Calves received no creep on range. Chromic oxide administration, collection of fecal grab samples and analytical procedures were identical to those described for drylot with the exception that chromic oxide was administered via gelatin capsules on range. Two three-month-old nursing Angus x Hereford calves fitted with esophageol fistulae were used for collection of forage samples during each of the days when rectal grab samples were taken. Esophageol samples were composited for in vitro dry matter and cellulose digestibility determinations (Tilley and Terry, 1963). Cellulose intake on range was calculated using cellulose indigestibility as determined in vitro and the chromic oxide concentration of the feces. Cellulose was chosen to represent a nutrient found in forage on range and in creep in drylot but not in milk.

Milk intake of calves was established with the calf suckle technique as described by Kropp et al. (1973). Milk intake estimates were taken and calf weights obtained one week prior to fecal collections in each drylot trial. On range, milk intake and calf weight were averages of estimates taken one week prior to and two two weeks after fecal collection.

Data were analyzed by analysis of variance in a simple one-way classification with breed as the source of variation. Simple correlation coefficients were calculated for all combinations of milk intake, creep intake, cellulose digestibility and calf weight in drylot; and milk intake, cellulose intake and calf weight on range.

Results and Discussion

Data for drylot trials are shown in Table XII. Breed effects (reflecting milk intake) on total creep dry matter intake for the entire creep feeding period were significant ($P<.03$) as were breed effects on average daily creep intake. The ratio of creep intake to milk intake for Holstein progeny (0.19:1) was approximately half the ratio found for Hereford progeny (0.37:1) for the total lactation period.

In Trial I breed effects on daily creep dry matter intake were nonsignificant ($P>.19$) although Holstein progeny tended to consume less creep than Crossbred or Hereford progeny. Creep intake and milk intake in Trial II were higher than in Trial I, reflecting the increase in size of the calves during the month between trials. Hereford progeny had the smallest increase in milk consumption, but the largest increase in creep intake between Trials I and II. Hereford progeny in Trial II consumed more ($P<.05$) creep per day than Holstein or Crossbred progeny.

Little breed influence on cellulose digestibility was detected in Trial I ($P>.61$) or Trial II ($P>.23$). Milk intake was negatively correlated with cellulose digestibility and creep intake (Table XIII) in both drylot trials although these correlation coefficients were non-significant for all groups except the Holstein progeny in Trial II. Creep intake was positively and highly correlated with cellulose digestibility and calf weight$^{0.75}$ in both drylot trials except among Hereford progeny in Trial II.

Range calves in Trial III corresponded closely in weight and age to drylot calves in Trial I. Range intake data (Table XIV) show that forage dry matter intake on range was less than creep dry matter intake in drylot. However, since range forage contained approximately 45% dry matter at the time of Trial III, range calves consumed a similar amount of non-milk material as drylot calves in Trial I.

Breed effects on forage cellulose intake approached significance ($P<.12$). Holstein progeny received the most milk, but consumed the least forage while Hereford progeny received the least milk and consumed the most forage, in agreement with drylot creep intake trends. Correlation coefficients between cellulose intake and milk intake (Table XV) were negative and low within each breed of calf. Cellulose intake was positively correlated with calf weight$^{0.75}$ within Crossbred progeny ($P<.04$) and Holstein progeny ($P<.002$), but not within Hereford progeny ($P>.77$). The greater variation in cellulose intake among Hereford progeny (SD = 0.31 kg) than among Crossbreed progeny (SD = 0.23 kg) or Holstein progeny (SD = 0.18 kg) may explain this difference. As in drylot, the larger (and older) calves within each breed consumed more forage cellulose than smaller calves even though the largest breed of calf (Holstein progeny) consumed less cellulose than the smallest (Hereford progeny).

Discussion

The positive correlations between creep intake and digestibility and the negative correlations between milk intake and cellulose digestibility are in agreement with data by Stobo, Ray and Gaston (1966); Otterby and Rust (1965) and Warner, Flatt and Loosli (1956) who reported greater ruminal development in calves receiving dry feed with milk than in calves receiving little or no dry feed. The high correlation between non-milk feed intake (on range and in drylot) and calf weight probably reflects the influence of calf age on creep and forage intake. Milk intake did not vary greatly within breed and differences in weight were more a function of age than milk intake within each breed.

The trend for drylot calves with higher milk intakes to consume less creep has also been noted by Holloway _et al._ (1974). Data presented herein suggest that the same depression of non-milk feed intake at high levels on milk intake also holds true for calves grazing range forage. The lower proportion of non-milk:milk nutrients in the diet of dairy crossbreed progeny may reduce the overall efficiency of heavier weaning weights produced by increased milk production on range.

TABLE XII

BODY WEIGHT, MILK INTAKE, CREEP DRY MATTER INTAKE AND CELLULOSE DIGESTIBILITY FOR DRYLOT CALVES

Item	Breed of Dam			
	Hereford	Hereford x Holstein	Holstein	SE[g]
Trial I				
No. of calves	10	10	15	
Weight of calves	194	207	220	18
Daily milk intake, kg[a]	5.6[e]	7.8[d]	9.2[d]	0.92
Daily creep intake, kg	2.0	2.1	1.6	0.58
Kg creep: kg body weight	0.010	0.010	0.007	
Kg creep: kg milk	0.40	0.29	0.20	
Cellulose digestibility (%)	55.8	57.2	49.4	5.16
Trial II				
No. of calves	10	10	15	
Weight of calves	211	228	241	18
Daily milk intake, kg[a]	5.9[f]	8.3[e]	12.8[d]	0.93
Daily creep intake, kg	3.7[d]	2.7[e]	2.6[e]	0.41
Kg creep: kg body weight	0.170	0.120	0.110	
Kg creep: kg milk	0.71	0.36	0.23	
Cellulose digestibilty (%)	57.2	49.1	54.1	5.64
Total lactation period				
Total creep intake, kg[b]	410[d]	398[d,e]	335[e]	32.5
Daily creep intake, kg[b]	2.3[d]	2.3[d]	1.9[e]	0.21
Daily milk intake, kg[c]	6.7[f]	9.0[e]	10.9[d]	0.56
Kg creep: kg milk	0.33	0.26	0.17	

[a]Milk production estimates taken one week prior to digestibility trials.

[b]March 1 until weaning.

[c]Mean of seven monthly estimates.

[d,e,f]Means on same line with same superscript letters do not differ significantly (P<.05).

[g]Approximate standard error: n=12.

TABLE XIII

CORRELATION COEFFICIENTS BETWEEN CREEP INTAKE, MILK INTAKE, CELLULOSE DIGESTIBILITY AND CALF WEIGHT$^{0.75}$ WITHIN BREED IN DRYLOT[a]

Breed of Dam	Creep intake: milk intake	Cellulose digestibility: milk intake	Creep intake: milk digestibility	Creep intake: weight$^{0.75}$
Trial I				
Hereford (10)[b]	-0.14	-0.24	0.94[c]	0.61[e]
Crossbred (10)	-0.15	-0.02	0.70[c]	0.91[c]
Holstein (15)	-0.29	-0.13	0.86[c]	0.85[c]
Trial II				
Hereford (10)[b]	-0.55[e]	-0.23	0.19	0.42
Crossbred (10)	-0.35	-0.06	0.69[d]	0.84[c]
Holstein (15)	-0.56[d]	-0.50[e]	0.51[d]	0.51[d]

[a]Creep intake during 5-day fecal collection period; milk intake and body weight measured one week prior to fecal collection period.

[b]Numbers in parentheses represent the number of animals.

[c]Significantly different from zero ($P < .01$).

[d]Significantly different from zero ($P < .05$).

[e]Significantly different from zero ($P < .10$).

TABLE XIV

BODY WEIGHT, MILK INTAKE AND FORAGE INTAKE FOR RANGE CALVES

Item	Breed of Dam: Hereford	Breed of Dam: Hereford x Holstein	Breed of Dam: Holstein	SE[e]
Trial III				
No. of calves	12	12	18	
Weight of calves, kg	169	208	221	
Daily milk intake, kg[a]	6.5[d]	10.2[c]	11.9[c]	1.41
Cellulose intake, kg	0.36	0.32	0.28	0.12
Forage dry matter intake, kg[b]	1.30	1.14	1.00	0.43
Forage dry matter intake: milk intake[b]	0.20	0.11	0.08	
Kg dry matter: kg body weight	0.008	0.005	0.004	

[a]Mean of two 24-hour estimates taken one week prior to and two weeks after cellulose intake was measured.

[b]Based on forage containing 28% cellulose (dry matter basis).

[c,d]Means on same line with the same superscript letters do not differ significantly ($P<.05$).

[e]Approximate standard error: n=14.

TABLE XV

CORRELATION COEFFICIENTS BETWEEN CELLULOSE INTAKE CALF WEIGHT$^{0.75}$ AND MILK INTAKE ON RANGE[a]

Breed of Dam	Cellulose intake: milk intake	Cellulose intake: weight$^{0.75}$
Hereford (12)[b]	-0.26	-0.09
Crossbred (12)	-0.30	0.60[d]
Holstein (18)	-0.09	0.79[c]

[a]Milk intake measured one week prior to and two weeks after fecal collections.

[b]Numbers in parentheses represent the number of animals.

[c]Significantly different from zero ($P < .01$).

[d]Significantly different from zero ($P < .05$).

[d]Significantly different from zero ($P < .10$).

CHAPTER VII

THE EFFECTS OF BREED AND WINTER SUPPLEMENT OF COWS ON FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS OF THEIR PROGENY[1,2]

Summary

The effects of breed and level of winter supplementation of dam on postweaning feedlot performance and carcass characteristics of 34 individually-fed and 85 group-fed progeny of Hereford, Hereford x Holstein (Crossbred) and Holstein cows were determined. Calves were sired by Charolais bulls. Individually-fed calves had been raised in drylot while group-fed calves were reared on pasture.

Feedlot performance and carcass traits were not significantly influenced by level of winter supplement of dam. In breed comparisons, Holstein progeny were heavier in weight and larger in skeletal size at entry and slaughter than Hereford progeny with Crossbred progeny intermediate. Holstein Progeny required a longer feeding period to reach comparable quality grade than Hereford progeny. Hereford progeny

---

[1]Journal Article 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]The author wishes to express appreciation to Jack Eason and Dale Rorick for care of experimental animals.

were more efficient in feed conversion than Holstein progeny.

Rib eye area/100 kg carcass was greater for Hereford than Holstein progeny while Holstein progeny tended to have less back-fat than Hereford progeny. Hereford progeny tended to have higher (non-significant) cutability than Holstein progeny. Conformation score decreased while marbling and quality grade increased with increasing percentage of Holstein breeding.

Introduction

The infusion of Holstein blood into beef herds has resulted in increased weaned calf weight (Kropp, et al., 1973; Holloway, et al., 1973) but has raised questions about the subsequent feedlot performance and carcass characteristics of calves with a percentage of dairy breeding. Several workers (Hanke et al., 1964; Burroughs, et al., 1965; Minish, Newland and Henderson, 1966) have reported that straightbred dairy calves gained faster but less efficiently than straightbred calves of British breeds when fed to equal time or weight. Others (Cole, et al., 1964; Minish, Newland and Henderson, 1966; Garrett, 1971) showed that Holsteins were lower in quality grade and conformation grade than calves of British breeds when fed to equal slaughter weight. Dean et al. (1974) reported that Hereford x Charolais calves gained faster and more efficiently than Holstein x Charolais calves when fed to equal degrees of fatness.

The objective of this research was to obtain further data on the feedlot performance and carcass traits of calves with 0, 25 and 50% Holstein breeding when fed to approximately equal slaughter grade.

Materials and Methods

The feedlot performance and carcass characteristics of calves with 0, 25, or 50% Holstein breeding were determined. Calves were from four-year-old Hereford, Hereford x Holstein (Crossbred) and Holstein females and were sired by Charolais bulls. One group of cows was maintained on range yearlong while a second group was confined in drylot from the time they calved until their calves were weaned at 240 days of age. Allotment to drylot was made on the basis of sex of calf so that a ratio of 3 male:2 female was established within each breed-treatment combination. Treatment consisted of two levels of winter supplement fed to cows of each breed on range and in drylot. An additional supplement level (Very High) was fed only to a group of Holstein cows and resulted in calves produced by cows of seven breed-supplement combinations. Calves were born in December, January and February and weaned at 240± 7 days. Calves in drylot received creep while those on range did not. At weaning calves were shrunk for 12 hrs., then weighed, photographed and vaccinated for blackleg, parainfluenza-3 and infectous bovine rhinotraecheitis.

Skeletal size was estimated from 20.3 x 25.4 cm. photographs taken with each calf behind a grid at the beginning and end of the feeding period. Height was defined as the distance from hip (tuber coxae) to the floor and length as the horizontal distance from point of the shoulder (dorsal anterior humerous) to hip. Before photographing, tuber coxae and dorsal anterior humerous were marked with contrasting chalk to facilitate more accurate measurements. Lusby et al. (1974) have reported complete management practices for dams of these calves.

Calves from drylot cows were individually self-fed daily in box stalls from 4 p.m. to 8 a.m. and placed as a group in an outside loafing area the remainder of the day. Group-fed calves were maintained in a barn which covered the self-feeding area but allowed access to outside pens.

Previous trials with these breeds of calves (Dean, 1974) showed group-fed calves consumed more feed than individually-fed calves. Consequently, individually-fed calves received a ration higher in energy (Table XVII) than group-fed calves (Table XVI) in an attempt to equalize performance between the two feeding phases.

Each calf was fed to an estimated quality grade of low choice based on apparent fatness. Final weights and photographs were taken after 12 hr. shrink.

Group-fed calves were slaughtered in a commercial slaughter plant and chilled 72 hours before quality grade, marbling score, maturity, conformation score and kidney, heart and pelvic fat were estimated by a U. S. D. A. grader. Individually-fed calves were slaughtered at the Oklahoma State University Meat Laboratory with carcass characteristics evaluated by a staff member. Rib eye area and back fat thickness were measured from a tracing at the 12th-13th rib separation on each carcass. Cutability was predicted as described by Murphey et al., (1960).

A least squares analysis using three breeds (Hereford, Crossbred and Holstein) and two levels of winter supplement on the dam (Moderate and High) was used. Very High Holsteins were excluded from this analysis to allow a balanced 3 x 2 x 2 arrangement of breed, supplement level and sex and interations. References to breed and supplement level effects refer to these lease squares means. Since no sex x supplement leve, sex breed or sex x breed x supplement level interactions were found (P>.05), another least squares analysis was conducted to obtain sex adjusted least squares means for all breed-supplement level combinations.

An analysis of variance was then conducted with all breed-supplement level combinations included in a simple one-way classification with this combination being the classification factor. The error mean square from this analysis was used to calculate a Least Significant Difference (Snedecor and Cochran, 1967) which was employed in comparing Very High Holsteins to other groups. Significance levels indicated by superscript letters in tables were calculated by the Least Significant Difference procedure.

Results and Discussion

Level of Supplement Comparisons

Average daily gain for individually-fed calves (Table XIX) tended to increase (P<.09) with increased level of supplement intake by the dam. This trend was not noted among group-fed calves (Table XVIII). Little (P<.26) influence of supplement level of the dam on other performance traits (Tables XVIII and XIX) or carcass traits (Tables XXII and XXIII) was noted for group or individually-fed calves.

Breed Comparisons

Tables XX, XXI, XXIV and XXV present means for calves by breed of dam. These means are weighted averages of the least squares treatment means presented in Tables XVIII, XIX , XXII and XXIII; standard errors are the same as those given in breed-supplement level tables.

Initial Weight

Holstein progeny were heavier than crossbred progeny although differences were significant (P<.05) only among group-fed calves. Crossbred progeny were heavier (P<.05) than Hereford progeny in both group and individually-fed calves.

Slaughter Weight

Slaughter weight followed the trend of initial weight with Holstein progeny heavier than crossbred progeny; differences were significant (P<.05) only among group-fed calves. Both group and individually-fed Crossbred progeny were heavier (P<.05) than Hereford progeny.

Age at Slaughter and Days Fed

Holstein progeny were the oldest and Hereford progeny the youngest in each comparison. Crossbred progeny were older (P<.05) than Hereford progeny and younger than Holstein progeny (nonsignificant) in both group and individual-feeding systems. Since age at slaughter was computed by using days fed plus 240 days, differences in days fed and the resulting statistical analysis were identical to that of age at slaughter.

Daily Gain

Average daily gain data are conflicting. Individually-fed Hereford progeny gained faster (P<.05) than individually-fed Crossbred or Holstein progeny; no trend was noted among group-fed calves. An average 43-day longer feeding period for group-fed Hereford progeny to reach a quality grade comparable to individually-fed Hereford progeny may explain the lower gains among group-fed Hereford progeny.

Feed Efficiency

Feed efficiency decreased in both group and individually-fed calves as percentage of Holstein breeding increased. Statistical analysis was possible only for individually-fed calves. Among individually-fed calves, Hereford progeny were more efficient ($P<.05$) than crossbred progeny which in turn were more efficient ($P<.05$) than Holstein progeny. Feed required per unit gain was 10 and 29% greater for Crossbred progeny than Hereford progeny and 8.5 and 17% greater for Holstein progeny than Crossbred progeny for group and individual feeding, respectively.

Skeletal Size

Holstein progeny were larger ($P<.05$) than Hereford progeny at weaning (initial measurement) in each comparison with Crossbred progeny intermediate. Measurements at slaughter indicated that group and individually-fed calves from Hereford and Crossbred dams were similar in skeletal size while both were smaller ($P<.05$) than Holstein progeny.

Hot Carcass Weight and Carcass Weight/Day of Age

Carcass weight trends were similar to slaughter weights. In both group and individual comparisons Holstein progeny had heavier ($P<.05$) carcasses than Hereford progeny with Crossbred progeny intermediate. Little ($P>.77$) influence of breed on carcass weight/day of age was seen among individually-fed calves while group-fed Holstein progeny produced more ($P<.05$) carcass weight/day of age than Hereford or Crossbred progeny.

Rib Eye Area and Rib Eye Area/100 kg Carcass

Rib eye area tended to increase ($P<.15$) with increasing percentage of Holstein breeding among group-fed calves while little ($P>.46$) breed influence on rib eye area was noted among individually-fed calves. Both Hereford and Crossbred progeny had greater ($P<.05$) rib eye area/ 100 kg carcass than Holstein progeny in each comparison. Among individually-fed calves, Hereford progeny had more ($P<.05$) rib eye area/100 kg carcass than Crossbreds.

Fat Thickness and Fat Thickness/ 100 kg Carcass

Backfat thickness measurements indicated that the goal of slaughter at equal fatness was achieved among group-fed calves (Table XXIX) but not for individually-fed calves (Table XXV). For reasons not apparent, individually-fed calves reached a higher quality grade with less backfat than group-fed calves. For this reason group-fed calves were fed longer in an attempt to achieve a grade of low choice and were fatter at slaughter than individually-fed calves. The greater fatness of individually-fed Crossbred progeny compared to Holstein and Hereford progeny may also be explained on the same basis.

When fatness was expressed on a carcass weight basis, fatness generally decreased as percentage of Holstein breeding increased, due to heavier carcass weights with increased increments of Holstein breeding.

K, H, P Fat and K, H, P
Fat/100 kg Carcass

Differences in K, H, P fat were nonsignificant (P>.43). Holstein progeny tended to have more K, H, P fat than Crossbred or Hereford progeny although the heavier carcass weights of Holstein progeny reversed this trend when K, H, P fat was expressed as a precentage of carcass weight.

Cutability

Increased percentages of Holstein breeding resulted in small decreases in cutability for group-fed (P<.24) and individually-fed (P<.31) calves.

Conformation, Marbling and
Carcass Grade

Holstein progeny had the lowest conformation scores in both comparisons. Hereford progeny had the highest conformation scores (nonsignificant) among individually-fed calves while Crossbred progeny were highest among group-fed calves. Carcass grade was not affected by breed (P>.70). Individually-fed calves were approximately equal in quality grade while group-fed Holstein progeny were higher in grade than Hereford or Cross-bred progeny. Marbling score followed the same trend as quality score.

Discussion

The increase in initial weight (weaning weight) was expected since Crossbred and Holstein progeny consumed approximately 50 and 100% more milk than Hereford progeny, respectively, preweaning (Lusby et al., 1974).

The increased slaughter weight of Holstein and Crossbred progeny is consistant with data from Dean (1974) and was a result of both heavier initial weight and longer feeding period to reach choice grade.

The decreased gains of Holstein progeny compared to Hereford progeny among individually fed calves agrees with Dean (1974) who reported higher gains for Hereford progeny than Holstein progeny in both group and individual comparisons. Data from these trials and those of Dean (1974) disagree with many workers (Bohstedt, 1922; Fuller and Roche, 1929; Cole et al., 1964; Hanke et al., 1964; Burroughs et al., 1965; Minish, Newland and Henderson, 1966) who reported greater gains for straight-bred Holsteins than straight-bred Herefords. However, calves in trials reported in this paper were fed from similar condition and equal initial age to approximately equal degree of fatness while in previous research calves were fed to equal weight or time. Growth trials of equal duration would favor the larger framed Holsteins over the smaller, earlier maturing Herefords. The greater differences in feed efficiency between Holstein progeny and Hereford progeny compared to results of others (Branaman et al., 1962; Hanke et al., 1964; Burroughs et al., 1965; Larson et al., 1966; Garrett, 1969) may also be explained by feeding to equal fatness rather than to equal time or weight.

The increased carcass weight with increased percentage of Holstein breeding is consistent with Dean et al. (1974), reflecting the heavier slaughter weight and skeletal size of Holstein progeny. The superiority of Hereford progeny for muscling as indicated by rib eye area per unit of carcass weight is in agreement with other comparisons of British breeds and Holsteins (Cole et al., 1964; Judge et al., 1965; Minish, Newland and Smith et al., 1966; Wellington, 1971).

Hereford progeny were generally fatter (as indicated by backfat) at slaughter than Holstein progeny in agreement with Dean et al. (1974), Judge et al. (1965) and Wellington (1971). Higher cutability estimates for Hereford vs. Holstein progeny contrast with previous data (Hanke et al., 1964; Burroughs et al., 1965; Larson et al., 1966). Again differences may be explained because cutability estimates reported by these authors were from cattle fed to equal time or weight instead of equal grade. Lower conformation scores for Holstein progeny are consistent with Larson et al. (1966) and Dean et al., (1974). The comparable marbling ability of Holstein progeny and Hereford progeny has been also reported by Dean et al. (1974), Larson et al. (1966) and Ziegler et al. (1971). This should especially be true if calves are fed to comparable fatness.

Data presented herein suggests that dairy crossbred calves cannot be economically fed to the same degree of external fatness as calves of British breeds. The longer feeding period required by Holstein progeny to reach quality grade comparable to that achieved by the earlier maturing Hereford progeny led to overall loss of feed efficiency and reduced daily gains by the Holstein progeny.

Dairy crossbred calves also produced large carcasses which might bring objections from meat processors. It was, however, interesting to note that Holstein progeny when fed to equal degree of fatness, consistently marbled better than Hereford progeny.

TABLE XVI

RATION FOR GROUP-FED CALVES

Ingredient	International Reference No. (IRN)	Unit	Amount
Corn, yellow, grain, grnd, (4)	4-02-992	%	60.2
Cotton, seed hulls, (1)	1-01-599	%	15.0
Alfalfa, hay, S-C grnd, early blm, 1	1-00-108	%	10.0
Cotton, seed W some hulls, solv-extd grnd, mn 41 prot, mx 14 fbr mn 0.5 fat, (5)	5-01-621	%	8.0
Molasses, mn 48% invert sugar mn 79.5 degrees brix, (4)	4-04-696	%	5.0
Urea, mn 45% nitrogen, (5)	5-05-070	%	1.0
Calcium phosphate, dibasic, comm, (6)	6-01-080	%	0.5
Salt, NaCl, comm (6)	6-04-152	%	0.3
Chlortetracycline, (8)	8-01-224	mg/kg	15.0
Vitamin A		IU/kg	10.0

TABLE XVII

RATION FOR INDIVIDUALLY-FED CALVES

Ingredient	International Reference No. (IRN)	Unit	Amount
Corn, yellow, grain grnd, (4)	4-02-992	%	87.0
Cotton, seed hulls, (1)	1-01-599	%	5.0
Supplement, pelleted			
Composition of supplement:			
Soybean, seeds w/o hulls, solv extd grnd, mx 3% fiber, (5)	5-04-612	%	50.0
Urea, mn 45% nitrogen	5-05070	%	10.0
Cotton, seed W some hulls, solv-extd grnd, mn 41 prot, mx 14 fbr, mn 0.5 fat, (5)	5-01-621	%	19.8
Wheat, flour, by-prod, mx 9.5 fbr, (4)	4-05-205	%	3.5
Salt, NaCl, comm, (6)	6-01-080	%	4.5
Potassium chloride, KCl, cp, (6)	6-03-756	%	3.2
Calcium carbonate, $CaCO_3$, comm, mn 38% calcium, (6)	6-01-069	%	7.5
Trade mineral		%	0.3
Chlortetrycycline, (8)	8-01-224	mg/kg	105.0
Vitamin A		IU/kg	3400.0

TABLE XVIII

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR FEEDLOT PERFORMANCE OF GROUP-FED CALVES

	Breed of Dam and Supplement Level							
	Hereford		Hereford x Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE[h]
No. of hear	14	13	12	14	10	10	11	
Initial wt., kg[a]	246[d]	253[cd]	270[cd]	281[bc]	294[bc]	310[b]	305[b]	11.65
Slaughter wt., kg.	450[d]	454[d]	504[c]	488[cd]	566[b]	570[b]	556[b]	15.83
Age at slaughter, days[f]	429[c]	428[c]	461[c]	438[bc]	457[bc]	474[b]	468[bc]	18.30
Days fed	189[c]	188[c]	221[bc]	198[bc]	217[bc]	234[b]	228[bc]	18.30
Daily gain, kg.	1.12	1.08	1.07	1.07	1.30	1.11	1.16	0.14
Kg. feed/kg. gain[g]	8.54	8.77	9.25	9.80	10.18	10.40	10.40	
Skeletal size								
Initial height, cm.	85.1[d]	85.6[d]	88.7[c]	88.7[c]	94.6[b]	94.5[b]	94.2[b]	0.92
Initial length, cm.	60.7[d]	61.2[d]	62.0[cd]	61.4[cd]	66.7[b]	64.4[bc]	64.0[bc]	1.22
Slaughter height, cm.	100.7[c]	101.2[c]	102.1[c]	100.0[c]	107.0[b]	110.0[b]	109.6[b]	1.60
Slaughter length, cm.	69.4[d]	71.4[d]	65.9[cd]	72.6[d]	79.2[b]	82.5[b]	82.4[b]	1.81

[a] Actual weaning weight.
[b,c,d] Means on the same line with the same superscript letter are not significantly different (P<.05).
[f] 240 days + average days fed.
[g] Simple average of steer and heifer per means.
[h] Approximate standard error: n=12.

TABLE XIX

LEAST SQUARES MEANS AND STANDARD DEVIATIONS
FOR FEEDLOT PERFORMANCE OF
~~INDIVIDUALLY-FED CALVES~~

Item	Hereford Moderate	Hereford High	Hereford x Holstein Moderate	Hereford x Holstein High	Holstein Moderate	Holstein High	Holstein Very High	SE[h]
	Breed of Dam and Supplement Level							
No. of head[a]	5	4	5	5	5	5	5	
Initial wt., kg.	249^{e}	257de	268^{cde}	298^{bc}	285^{bcd}	302^{b}	302^{b}	11.9
Slaughter wt., kg.	458^{cd}	427^{d}	489^{cde}	519^{bc}	463^{cd}	554^{b}	572^{b}	22.5
Age at slaughter, days[g]	402^{cd}	365^{d}	466^{b}	455^{bc}	462^{b}	483^{b}	481^{b}	15.9
Days fed	162^{cd}	125^{d}	226^{b}	205^{bc}	222^{b}	243^{b}	241^{b}	15.9
Daily gain, kg.	1.29^{bc}	1.36^{b}	0.98^{de}	1.08^{bcde}	0.80^{e}	1.04^{cde}	1.15^{bcd}	0.10
Kg. feed/kg. gain	6.42^{e}	5.75^{e}	8.06^{cd}	7.67^{d}	10.31^{b}	9.20^{b}	8.19^{c}	0.90
Skeletal size								
Initial height, cm.	91.3^{c}	87.5^{d}	87.6^{d}	90.3^{cd}	92.7^{c}	95.9^{b}	92.4^{c}	0.97
Initial length, cm.	62.7^{bc}	60.1^{c}	60.1^{c}	60.5^{c}	62.9^{bc}	65.6^{b}	64.6^{bc}	1.83
Slaughter height, cm.	99.4^{bc}	97.5^{c}	97.5^{c}	98.4^{bc}	105.2^{b}	103.0^{bc}	105.2^{b}	3.01
Slaughter length, cm.	73.2	68.9	68.9	70.2	75.5	73.9	73.9	3.08

[a]One high hereford died of an intestinal obstruction.

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

[g]240 days + average days fed.

[h]Approximate standard error: n=15.

TABLE XX

BREED MEANS AND STANDARD DEVIATIONS FOR FEEDLOT PERFORMANCE OF GROUP-FED CALVES

Item	Breed of Dam			
	Hereford	Hereford x Holstein	Holstein	SE[f]
No. of head	27	26	31	
Initial wt., kg[a]	249[d]	276[c]	303[b]	11.65
Slaughter wt., kg	453[d]	496[c]	564[b]	15.83
Age at slaughter, days[e]	429[c]	450[b]	466[b]	18.30
Days fed	189[c]	210[b]	226[b]	18.30
Daily gain, kg	1.10	1.07	1.19	0.14
Kg feed/kg gain	8.62	9.52	10.33	
Skeletal size				
Initial height, cm	85.3[d]	88.7[c]	94.4[b]	0.92
Initial length, cm	61.0[c]	61.7[bc]	64.4[b]	1.22
Slaughter height, cm	101.0[c]	101.0[c]	108.9[b]	1.60
Slaughter length, cm	70.4[c]	74.3[c]	81.4[b]	1.81

[a]Actual weaning weight.

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

[e]240 days + average days fed.

[f]Approximate standard error: n=28.

TABLE XXI

BREED MEANS AND STANDARD DEVIATIONS FOR FEEDLOT PERFORMANCE OF INDIVIDUALLY-FED CALVES

Item	Breed of Dam			
	Hereford	Hereford x Holstein	Holstein	SE[f]
No. of head	9	10	15	
Initial wt., kg[a]	252^{c}	283^{b}	296^{b}	11.9
Slaughter wt., kg	444^{c}	504^{b}	530^{b}	22.5
Age at slaughter, days[e]	386^{c}	456^{b}	475^{b}	15.9
Days fed	146^{c}	216^{b}	235^{b}	15.9
Daily gain, kg.	1.32^{b}	1.03^{c}	1.00^{c}	0.10
Kg feed/ kg gain	6.07^{d}	7.86^{c}	9.23^{b}	0.90
Skeletal size				
Initial height, cm	89.6^{c}	88.9^{c}	93.7^{b}	0.97
Initial length, cm	61.5^{c}	60.3^{c}	64.4^{b}	1.83
Slaughter height, cm	98.6^{c}	98.0^{c}	104.5^{b}	3.01
Slaughter length, cm	71.3	69.6	74.4	3.08

[a]Actual weaning weight.

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

[e]240 days + average days fed.

[f]Approximate standard error: n=12.

TABLE XXII

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR CARCASS CHARACTERISTICS OF GROUP-FED CALVES

	Breed of Dam and Supplement Level							
	Hereford		Holstein x Hereford		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE[h]
No. of head	14	13	12	14	10	10	11	
Hot carcass wt., kg	271^{d}	283^{d}	305^{cd}	301^{cd}	364^{b}	360^{b}	336^{bc}	14.46
Carcass wt./day of age, kg	0.63	0.66	0.67	0.69	0.8	0.76	0.72	
Rib eye area, cm	78.3	77.2	79.9	79.6	84.9	82.6	80.6	3.75
REA/100 kg carcass, cm	28.9	27.3	26.2	26.4	23.3	22.9	24.0	
Fat thickness[a], cm	1.90	1.81	1.80	2.03	1.84	1.98	1.88	0.20
Fat thickness/100kg[a] carcass, cm	1.04	0.64	0.59	0.67	0.51	0.55	0.56	
K, H, P Fat[e], %	2.81	3.15	3.04	3.12	3.32	2.94	3.46	0.21
K, H, P Fat/100kg[e] Carcass	1.04	1.11	1.00	1.04	0.91	0.82	1.03	
Cutability, %	49.2	48.8	48.8	48.2	47.8	47.8	47.7	0.73
Conformation score[f]	10.7	10.5	10.8	10.9	10.3	9.5	10.5	0.90
Marbling score[g]	11.4	12.6	12.2	12.2	12.2	14.9	15.8	1.16
Carcass grade[f]	8.3	8.8	8.9	8.7	9.4	9.4	10.2	0.68

[a]Average of three measurements taken 1/4, 1/2, and 3/4 length of longissimus.
[b,c,d]Means on the same line with the same superscript letter do not differ significantly ($P < .05$).
[e]Kidney, heart and pelvic fat.
[f]9 = High Good, 10 = Low choice, 11 = Average choice.
[g]12 = Slight +; 13 = Small -, 14 = Small, 15 = Small +, 16 = Modest.
[h]Approximate standard error: n=12.

TABLE XXIII

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR
CARCASS CHARACTERISTICS OF
~~INDIVIDUALLY-FED~~ CALVES

	Breed of Dam and Supplement Level							
	Hereford		Hereford x Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE[h]
No. of head	5	4	5	5	5	5	5	
Hot carcass wt., kg	291[de]	263[e]	313[cd]	328[c]	304[cd]	330[c]	372[b]	11.70
Carcass wt/day of age, kg	0.72[bcd]	0.71[bcd]	0.63[d]	0.74[bc]	0.66[cd]	0.69[bcd]	0.78[b]	.04
Rib eye area, cm	81.9	83.5	77.3	89.5	81.2	77.4	79.3	4.06
REA/100kg carcass, cm	28.1	31.8	21.7	27.3	26.7	23.4	21.3	
Fat thickness, cm	1.57	1.30	2.22	1.82	1.24	1.45	1.62	0.22
Fat thickness/100kg carcass, cm	0.54	0.49	0.71	0.55	0.41	0.44	0.44	
K, H, P Fat[e], %	3.47	2.97	3.00	3.60	2.83	3.97	3.64	0.26
Cutability, %	49.3	51.0	47.5	48.8	50.3	47.9	47.3	0.81
Conformation score[f]	11.0	11.0	10.2	10.2	8.8	8.5	9.6	1.52
Marbling score[g]	14.3	14.7	13.5	14.6	12.0	14.0	14.2	0.82
Carcass grade[f]	10.0	10.3	9.5	10.2	10.0	10.3	10.2	0.36

[a]Average of three measurements taken 1/4, 1/2, and 3/4 length of longissimus.
[b,c,d]Means on the same line with the same superscript letter do not differ significantly (P<.05).
[e]Kidney, heart and pelvic fat.
[f]9 = High Good, 10 = Low choice, 11 = Average choice.
[g]12 = Slight +; 13 = Small -, 14 = Small, 15 = Small +, 16 = Modest.
[h]Approximate standard error: n=15.

TABLE XXIV

BREED MEANS AND STANDARD DEVIATIONS FOR CARCASS CHARACTERISTICS OF GROUP-FED CALVES

	Breed of Dam			
Item	Hereford	Hereford x Holstein	Holstein	SE[h]
No. of head	27	26	31	
Hot carcass wt., kg	276[d]	303[c]	353[b]	14.46
Carcass wt./day of age, kg	0.64[c]	0.68[c]	0.76[b]	0.03
Rib eye area, cm	77.7	79.8	82.7	3.75
REA/100 kg carcass, cm	28.0[b]	26.3[b]	23.4[c]	1.20
Fat thickness,[a] cm	1.85	1.91	1.90	0.20
Fat thickness/100 kg[a] carcass, cm	0.84[b]	0.63[bc]	0.54[c]	0.21
K, H, P fat/100 kg[e] carcass	1.07	1.02	0.92	
Cutability, %	50.0	48.5	47.8	0.73
Conformation score[f]	10.6	10.9	10.1	0.90
Marbling score[g]	12.0	12.2	14.3	1.16
Carcass grade[f]	8.5	8.8	9.7	0.68

[a]Average of three measurements taken 1/4, 1/2, and 3/4 length of longissimus.

[b,c,d]Means on the same line with the same superscript letter do not differ significantly ($P<.05$).

[e]Kidney, heart and pelvic fat.

[f]9 = High good, 10 = Low choice, 11 = Average choice.

[g]12 = Slight +, 13 = Small -, 14 = Small, 15 = Small +, 16 = Modest.

[h]Approximate standard error: n=28.

TABLE XXV

BREED MEANS AND STANDARD DEVIATIONS FOR CARCASS CHARACTERISTICS OF INDIVIDUALLY-FED CALVES

	Breed of Dam			
Item	Hereford	Hereford x Holstein	Holstein	SE[h]
No. of head	9	10	15	
Hot carcass wt., kg	278[c]	321[b]	335[b]	11.70
Carcass wt./day of age, kg	0.72	0.69	0.71	0.04
Rib eye area, cm	82.6	83.4	79.3	4.06
REA/100 kg carcass, cm	29.9[b]	26.0[c]	23.8[d]	1.86
Fat thickness, cm	1.44	2.02	1.44	0.22
Fat thickness/100 kg carcass, cm	0.52	0.63	0.43	0.14
K. H, P fat/100kg carcass[e]	1.16	1.03	1.04	
Cutability, %	50.1	48.2	48.5	0.81
Conformation score[f]	11.0	10.2	9.0	1.52
Marbling score[g]	14.5	14.1	14.4	0.82
Carcass grade[f]	10.1	9.8	10.2	0.36

[a]Average of three measurements taken 1/4, 1/2, and 3/4 length of longissimus.

[b,c,d]Means on the same line with the same superscript letter do not differ significantly (P<.05).

[e]Kidney, heart and pelvic fat.

[f]9 = High Good, 10 = Low choice, 11 = Average choice.

[g]12 = Slight +; 13 = Small -, 14 = Small, 15 = Small +, 16 = Modest.

[h]Approximate standard error: n=12.

LITERATURE CITED

Andersen, P. E., J. T. Reid, J. J. Anderson and J. W. Stroud. 1959. Influence of level of intake upon the apparent digestibility of forages and mixed diets by ruminants. J. Anim. Sci. 18:1299.

A. O. A. C. 1965. Official Methods of Analyses (10th ed.). Association of Official Agricultural chemists. Washington, D. C.

Balch, C. C. and R. C. Campling. 1962. Regulation of Voluntary food intake in ruminants. Nutr. Abstr. and Rev. 32:669.

Baumgardt, B. R. 1969. Control of feed intake in the regulation of energy balance. Physiology of Digestion and Metabolism in the Ruminant, Proc. Intern. Symp., 3rd, Cambridge, England Newcastle, England: Oriel Press, p. 235.

Blaxter, K. L., and W. A. Wood. 1951b. Nutrition of the young Ayshire calf; 3. The metabolism of the calf during starvation and subsequent realimentation. Brit. J. Nutr. 5:29.

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

Blaxter, K. L., F. W. Wainman and R. S. Wilson. 1961. The regulation of food intake by sheep. Anim. Prod. 3:51.

Bines, J. A., S. Suzuki and C. C. Balch. 1969. The quantitative significance of long-term regulation of food intake in the cow. Brit. J. Nutr. 23:695.

Bohstedt, G. 1922. Feeding dairy steers. Ohio Agr. Exp. Bimonthly Bull. 83:193.

Branaman, G. A., A. M. Pearson, W. T. Magee, R. M. Griswold and G. A. Brown. 1962. Comparison of the cutability and eatability of beef and dairy-type cattle. J. Anim. Sci. 21:355.

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

Burroughs, W. and Paul Gerlaugh. 1949a. The influence of soybean oil meal upon reoughage digestion in cattle. J. Anim. Sci. 8:1.

Burroughs, W., Paul Gerlaugh, B. H. Edgington and R. M. Bethke. 1949c. The influence of corn starch upon roughage digestion in cattle. J. Anim. Sci. 8:271.

Burroughs, W., L. S. Gall, Paul Gerlaugh and R. M. Bethke. 1950. The influence of casein upon roughage digestion in cattle with rumen bacteriological studies. J. Anim. Sci. 9:214.

Campling, R. C., M. Freer and C. C. Balch. 1961. Factors effecting the voluntary intake of food by cows. 2. The relationship between the voluntary intake of roughages, the amount of digesta in the reticulo-rumen and the rate of disappearance of digesta from the alimentary tract. Brit. J. Nutr. 15:531.

Conrad, H. R., J. W. Hibbs and N. Frank. 1958. High roughage system for raising dairy calves based on early development of rumen function. IX. Effect of rumen inoculations and chlortetrycycline on rumen function of calves fed high roughage pellets. J. Dairy Sci. 41:1248.

Conrad, H. R., A. D. Pratt and J. W. Hibbs. 1964. Regulation of feed intake in dairy cows. 1. Change in importance of physical and physiological factors with increasing digestibility. J. Dairy Sci. 47:54.

Conrad, H. R. 1966. Symposium on factors influencing the voluntary intake of herbage by ruminants: Physical and physiological factors limiting feed intake. J. Anim. Sci. 25:227.

Cole, J. W., C. B. Ramsey, C. S. Hobbs and R. S. Temple. 1964. Effects of type and breed of British, Zebu and dairy cattle in production. III. Percent wholesale cuts and yield of edible portion as determined by physical and chemical analysis. J. Anim. Sci. 23:71.

Cox, C. P., A. A. Foot, Z. D. Hasking, C. Line and S. J. Rowland. 1956. The direct evaluation of pasture in terms of milk production of individually grazed cows. J. Brit. Grassl. Soc. 11:2.

Crabtree, J. R. and G. L. Williams. 1971. The voluntary intake and utilization of roughage-concentrate diets by sheep. 1. Concentrate supplements for hay and straw. Anim. Prod. 13:71.

Crampton, E. W. and L. A. Maynard. 1938. The relationship of cellulose and lignin content to nutritive value of animal feeds. J. Nutr. 15:383.

Crampton, E. W. 1957. Interrelationships between digestible nutrient and energy content, voluntary dry matter intake and the overall feeding value of forages. J. Anim. Sci. 16:546.

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

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

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

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

Egan, A. R. 1970. Nutritional status and intake regulation in sheep. VI. Evidence for variation in setting of an intake regulatory mechanism relating to the digesta content of the reticulorumen. Aust. J. Agric. Res. 21:735.

Flux, D. S. and M. R. Patchell. 1943. The effect of undernutrition after calving on the quantity and composition of the milk produced by dairy cattle. J. Agr. Sci. 45:246.

Freer, M. and R. C. Campling. 1963. Factors affecting the voluntary intake of food by cows. 5. The relationship between voluntary intake of food, the amount of digesta in the reticulo-rumen and the rate of disappearance of digesta from the alimentary tract with diets of hay, dried grass or concentrates. Brit. J. Nutr. 17:79.

Fuller, J. G. 1927. Crossbreeding types for baby beef production. Amer. Soc. Anim. Prod. p. 53.

Fuller, J. G. and B. H. Roche. 1929. Comparing crossbred Angus-Holstein calves with Angus and Holstein calves for baby beef. Wisc. Agr. Exp. Sta. Bull. 405.

Garrett, W. N. 1971. Energetic efficiency of beef and dairy steers. J. Anim. Sci. 32:451.

Gillooly, J. E., L. L. Wilson, C. E. Thompson, M. C. Rugh, T. R. Long and H. R. Purdy. 1967. Effects of energy level and cow size on milk yield and calf gain. J. Anim. Sci. 26:1468.

Hale, E. B., C. W. Duncan and C. F. Huffman. 1940. Rumen digestion in the bovine with some observations on the digestibility of alfalfa hay. J. Dairy Sci. 23:953.

Hanke, H. E., R. E. Smith, O. E. Kolari, A. L. Harvey, W. J. Aunam and L. E. Hanson. 1964. A comparison of feedlot performance and carcass traits of Herefords, Shorthorns and Holstein steers. Minn. Agr. Exp. Sta. MB-4.

Holloway, J. W., D. F. Stephens, Leon Knori, K. S. Lusby, R. A. Dean, J. V. Whiteman and Robert Totusek. 1973. Performance of three-year-old Hereford, Hereford x Holstein and Holstein females as influenced by level of winter supplement under range conditions. Res. Rep. MP-90. Okla. Agr. Exp. Sta. and U. S. D. A. P-3.

Holloway, J. W., Leon Knore, R. A. Dean, K. S. Lusby, J. V. Whiteman and Robert Totusek. 1974. Performance as three-year-olds of Hereford, Hereford x Holstein and Holstein females on range and in drylot. (Submitted for Publication).

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

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

Jones, J. G. W., R. M. Drake-Brockman and W. Holmes. 1965. The feed intake of grazing cattle. III. The influence of milk yield. Anim. Prod. 7:141.

Jourbet, D. M. 1954. The influence of winter nutritional depressions in the growth reproduction and production of cattle. J. Agr. Sci. 44:5.

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

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

Langemann, F. W., and N. N. Allen. 1955. The development of rumen function in the dairy calf. I. Some characteristics of the rumen contents of cattle of various ages. J. Cairy Sci. 38:651.

Larson, W. N., L. B. Embry and L. J. Nygaard. 1966. Feedlot performance and carcass characteristics of Hereford and Holstein steers as affected by ration and slaughter weight. South Dakota Exp. Sta. 66-12:63.

Lassiter, C. A., C. F. Huffman and C. W. Duncan. 1958. Effect of level of feed intake using hay:grain ratios on feed utilization of dairy cows. J. Dairy Sci. 41:721.

Lusby, K. S., D. F. Stephens and Robert Totusek. 1974. Influence of breed and level of winter supplementation on roughage intake and digestibility. (Unpublished data).

Lusby, K. S., D. F. Stephens, J. V. Whiteman and Robert Totusek. 1974. The performance on range and in drylot of four-year-old Hereford, Hereford x Holstein and Holstein females as influenced by level of winter supplementation. (Unpublished data).

Lusby, K. S., Robert Totusek, L. Knori, D. F. Stephens, J. V. Whiteman, J. W. Holloway and R. A. Dean. 1974. Performance of four-year-old Hereford, Hereford x Holstein and Holstein females as influenced by level of winter supplementation under range conditions. Res. Rep. MP-92. Oklahoma Agricultural Experiment Station and U. S. D. A. P-56.

Lusby, K. S., D. F. Stephens and Robert Totusek. 1974. The influence of breed and level of winter supplement on forage intake of range cows. Unpublished.

MacLusky, D. S. 1960. The quantities of herbage eaten by grazing dairy cows. Proc. Brit. Grassland Soc. 15:181.

McCarthy, B., and E. M. Kesler. 1956. Relation between age of calf, blood glucose, blood and rumen levels of volatile fatty acids, and in vitro cellulose digestion. J. Dairy Sci. 39:1280.

McCullough, M. E. 1959. Conditions influencing forage acceptability and rate of intake. J. Dairy Sci. 42:572.

McCullough, M. E., and J. E. Russel. 1962. Forage and nutritional factors influencing potential and economic use of forage for dairy cattle. J. Anim. Sci. 21:1036 (Abstr.).

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

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

Murphey, C. E., D. K. Hallet, W. B. Tyler and J. C. Pierce, Jr. 1960. Estimating yields of retail cuts from beef carcasses. J. Anim. Sci. 19:1240 (Abstr.).

Ndumbe, R. D., K. V. Runcie and P. McDonald. 1964. The effect of early weaning on the blood sugar and rumen levels of the growing calf. Brit. J. Nutr. 18:29.

Otterby, D. E. and J. W. Rust. 1965. Effects of age and diet on rumen and blood components of the young calf. J. Dairy Sci. 48:1716.

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

Reynolds, P. F. and I. L. Lindahl. 1960. Effect of pelleting on the digestibility of hay by sheep. J. Anim. Sci. 19:873.

Rittenhouse, L. R., D. E. Clanton and C. L. Streeter. 1970. Intake and digestibility of winter range forage by cattle with and without supplements. J. Anim. Sci. 31:1215.

Savage, E. S., and C. M. McCay. 1942. The nutrition of calves; a review. J. Dairy Sci. 25:595.

Scales, G. H., A. H. Denham, C. L. Streeter and G. M. Ward. 1974. Winter supplementation of beef calves on sandhill range. J. Anim. Sci. 38:442.

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

Stobo, I. J. F., J. H. B. Roy and H. J. Gaston. 1966. Rumen development of the calf. 1. The effect of diets containing different proportions of concentrates to hay on rumen development. Brit. J. Nutr. 20:171.

Taylor, J. C. 1969. A relationship between weight of internal fat, 'fill,' and herbage intake of grazing cattle. Nature. 184:2021.

Tilley, J. M. A., and R. A. Terry. 1963. A two-stage technique for in vitro digesta of forage crops. J. Br. Grassl. Soc. 18:104.

Van Soest, P. R. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. J. Ass. Official Agr. Chem. 46:829.

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

Waller, G. R., R. D. Morrison and A. B. Nelson. 1972. Chemical composition of native grasses in Central Oklahoma from 1947 to 1962. Okla. Ag. Exp. Sta. Bull. B-697.

Ward, G. M., and P. L. Kelly (1969) Influence of roughage-to-concentrate ratios on ad libitum consumption by lactating cows. J. Dairy Sci. 52:1017.

Warner, R. G., W. P. Flatt and J. K. Loosli. 1956. Dietary factors influencing the development of the ruminant stomach. J. Agr. Food Chem. 4:788.

Wellington, G. H. 1971. Dairy Beef. J. Anim. Sci. 32:424.

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

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

Wiktorsson, H. 1970. Digestibility experiments with dairy cows consuming different quantities of concentrates. J. Dairy Sci. 54:374.

Wright, P. L., A. L. Pope and P. H. Phillips. 1962. Effect of protein and energy intake on lamb production and certain blood constituents of ewes. J. Anim. Sci. 22:586.

Woodman, H. E., R. E. Evans and A. Eden. 1937. Sheep nutrition. II. Determinations of the amounts of grass consumed by sheep on pasturage of varying quality. J. Agr. Sci. 27:212.

Ziegler, J. H., L. L. Wilson, and D. S. Cole. 1971. Comparisons of certain carcass traits of several breeds of crosses of cattle. J. Anim. Sci. 32:446.

VITA

Keith Stewart Lusby

Candidate for the Degree of

Doctor of Philosophy

Thesis: LEVEL OF MILK PRODUCTION IN RANGE COWS: EFFECTS ON WINTER FEED REQUIREMENTS, FORAGE INTAKE AND DIGESTIBILITY IN COWS AND PREWEANING FORAGE INTAKE, DIGESTIBILITY AND POSTWEANING FEEDLOT PERFORMANCE OF THEIR CALVES

Major Field: Animal Nutrition

Biographical:

Personal Data: Born in Prescott, Arkansas, February 13, 1948, the son of W. I. and Catherine Lusby. Married to former Rosemary Barnard, December 27, 1972.

Education: Graduated from Prescott High School, 1966. Attended Southern State College (Ark.) from 1966 to 1968. Received the Bachelor of Science in Agriculture, 1970, and the Master of Science, 1971, from Kansas State University. Completed the requirements for the Doctor of Philosophy in Animal Nutrition at Oklahoma State University in December, 1974.

Professional Experience: Raised on livestock farm in southern Arkansas. Worked as an undergraduate on livestock farms at Southern State College and Kansas State University. Worked in commercial feedlot at Scott City, Kansas. Graduate Assistant at Kansas State University and Oklahoma State University.

Professional Organizations: Gamma Sigma Delta, Americal Society of Animal Science and Associate member of Society of Sigma Xi.

Date of Degree: December 30, 1974.