I. THE PERFORMANCE ON RANGE AND IN DRYLOT OF TWO-YEAR-OLD HEREFORD, HOLSTEIN AND HEREFORD X HOLSTEIN FEMALES AS INFLUENCED BY LEVEL OF WINTER SUPPLEMENTATION

II. RANGE BEHAVIOR OF HEREFORD, HOLSTEIN AND HEREFORD X HOLSTEIN HEIFERS

By

JOHNNIE ROBERT KROPP

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1970

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
May, 1972

I. THE PERFORMANCE ON RANGE AND IN DRYLOT OF TWO-YEAR-OLD HEREFORD, HOLSTEIN AND HEREFORD X HOLSTEIN FEMALES AS INFLUENCED BY LEVEL OF WINTER SUPPLEMENTATION

II. RANGE BEHAVIOR OF HEREFORD, HOLSTEIN AND HEREFORD X HOLSTEIN HEIFERS

Thesis Approved:

Robert Totusek
Thesis Adviser

Jack E. McCroskey

D Durham
Dean of the Graduate College

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. Robert Totusek, Professor of Animal Science, for his guidance and counsel during the duration of this study and the preparation of this manuscript.

Very special appreciation is extended to Dr. J. V. Whiteman, Professor of Animal Science, for his guidance and assistance in planning the statistical analyses of the data and for his suggestions in the preparation of this thesis.

Grateful acknowledgment is also extended to Dr. J. C. McCroskey, Associate Professor of Animal Science, for his helpful suggestions in the preparation of this manuscript and to Dr. R. D. Morrison, Professor of Mathematics and Statistics, for his assistance in conducting the statistical analyses of the data.

Special recognition is extended to Mr. D. F. Stepehens, Superintendent of the Fort Reno Livestock Research Station, for his suggestions and assistance and to Leon Knori for his care of the experimental animals and his help in maintaining necessary records.

Appreciation is extended to J. W. Holloway and other colleagues in the Graduate School and Animal Science undergraduates at Oklahoma State University for their assistance in conducting this research.

A very special thanks goes to the author's wife, Susan, and son, Paul David, for their understanding and cooperation throughout the duration of this study.

TABLE OF CONTENTS

Chapter Page

PART ONE

LIST OF TABLES

Table Page

PART ONE

PART TWO

LIST OF FIGURES

Figure Page

PART ONE

CHAPTER I

INTRODUCTION

Considerable pressure is being exerted to increase the milk production of beef cows in order to increase the weaning weight of their calves. Selection on the basis of weaning weight results in selection for higher milk production, but milk production potential can be increased most rapidly by infusing genes for high milk production from animals of dairy breeding. Research has shown a strong correlation between level of milk production of beef cows and weaning weight of their calves.

While it may be possible to greatly increase the level of milk production of range cows, the nutritional environment of the cow may be a limiting factor for maximum total productivity.

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 range brood cows differing widely in milk production potential.

CHAPTER II

LITERATURE REVIEW

Considerable information has been accumulated concerning the effects of winter plane of nutrition on the growth and productivity of range females and the performance of their calves; however, little information is available on Hereford X Holstein and Holstein females in relation to these factors when managed under range conditions.

Winter supplementation represents one of the largest single expenses to the cow-calf operator and is also an important factor in the milk producing ability and ultimate reproductive performance of the beef female. Most research reported has involved the establishment of nutritional levels at weaning or the onset of the wintering period. Little information is available concerning the effects of different nutritional levels post-calving on beef X dairy or dairy females while maintained on range pasture.

Since little information exists for these factors, this review will be concerned with the different nutritional levels on the productivity of beef, beef X dairy and dairy females with special emphasis on milk yield and composition, calf gain and reproductive performance.

Milk Production

The milk producing ability of the female is a very important factor of consideration in any commercial herd as well as in purebred herds. All performance and progeny tests which place special emphasis on weaning weight of the calf results in special emphasis on the milk production of the dam. However, the milk production of beef females is seldom tested due to the difficulty in obtaining good records under range conditions; therefore, weaning weights of their calves are the ultimate selection tool.

Under research conditions, many different and varied techniques have been employed to determine milk yields. Adequate records have been obtained on beef breeds; however, extremely limited data have been reported concerning beef X dairy and dairy breeds in regard to milk production under range conditions and limited nutritional environments. Therefore, milk yields and composition of beef X dairy and dairy females managed under dairy conditions will be presented to give some indication of their ability to produce milk. Knowing that these estimates were taken under high nutritional conditions, they will form an upper boundary for this discussion and may or may not be meaningful when discussing range milk yields.

Milk Determination Techniques

Many different techniques for determining milk yields have been used by various researchers depending upon available equipment, labor, past experiences and conditions that prevail.

The procedure of weighing the calf before and after nursing and using the difference in weight as the recorded milk yield has been the most extensively used; however, several modifications have been employed in regard to number and frequency of collection per day as well as during the entire lactation.

Drewry, Brown and Honea (1959) were instrumental in developing the calf nursing technique as a means of determining the milk producing ability of the beef female; thus, this procedure has been adopted by many other workers with limited modifications. Their procedure involved separation of the calves from their dams for a period of two-three hours in mid-afternoon on the day prior to estimating milk production and then allowing the calves to completely nurse out their mothers. This procedure was employed to insure that the cows would be free of milk prior to the start of the test. The calves were again separated from their dams at 6:00 p.m. and remained separated overnight. The next morning at 6:00 a.m., the calves were again weighed and then allowed to nurse. Immediately upon completion of nursing, the calves were weighed again. The difference between the initial weight and post-nurse weight was taken to be the milk yield. Similar procedure was followed again at 4:00 p.m. the same day. The daily milk production was estimated by adding the 12-hour and 10-hour milk yields together and was reported as a 22-hour production. Although the same procedure has been employed by many researchers, the number of estimates per 24-hour period as well as interval durations have varied considerably. The most common procedure has involved two 12-hour estimates, but three 8-hour estimates during early lactation and two 12-hour estimates during mid-and later lactation has been used extensively.

Many other techniques have been developed. Anthony et al. (1959) utilized a portable milking machine and 40 I.U. of oxytocin (to initiate milk let-down). A pre-test milk out was used to free the udder of available milk. The cow remained separated from her calf overnight, but was supplied with adequate feed and water. Twelve hours post-milk out, the cow was injected with oxytocin and the milker attached. The amount of milk obtained was reported on a 12-hour, FCM basis.

Gifford (1953) separated the calves from their dams for three days each month. The calves were allowed to nurse their dams twice daily. On the second day one-half of the udder of each cow was milked out by hand and the milk was weighed. The following day, the opposite side was hand-milked and the milk weighed. The two records were combined and used as an estimate of one day's production.

Konkoly and Barczy (1954), using Brown Swiss cows, compared the milk production of cows which suckled their calves and that of cows milked without suckling. The average daily production was higher for those cows that were milked without suckling. Greater fluctuations in the milk yields of the cows that suckled their calves were noted. Similar results were reported by Swanson (1956).

Schwulst _et al._ (1966) reported results of a study to develop a standard procedure for estimating both milk consumption and total milk production through the use of oxytocin. Three treatments were studied: (1) control; (2) oxytocin after the calf nursed and before machine milking; and (3) oxytocin before the calf nursed. No significant treatment effects were noted; however, a definite trend existed for higher milk consumption and total milk production when oxytocin was administered.

Lam _et al._ (1969) examined 18 Hereford cows on six occasions over a period of three weeks to determine the usefulness of three techniques for determining milk production. All cows were tested twice by each method. The three techniques were: (1) 6-hour oxytocin test to determine rate of secretion; (2) 24-hour calf nursing to estimate daily milk intake by the calf; and (3) overnight calf nursing plus oxytocin, which estimated udder capacity. Techniques one and two gave similar results for daily milk production; whereas technique three produced 23% greater yields ($P < .01$). On the basis of practicality of handling larger numbers of cattle under range conditions, the 6-hour oxytocin test appeared to be the most satisfactory.

Chow, Riggs and Schake (1967) studied frequencies and intervals utilizing the calf nursing and machine milking techniques in an attempt to arrive at the proper procedure for estimating milk production. Measurements were made by each method every 4, 6, 8 and 12 hours over a 24-hour period as well as one estimate at 17- and 24-hours, respectively. Mean milk yields differed significantly ($P < .01$) at all frequencies when the milking machine method was used. One 17-hour estimate resulted in the lowest yield, while two 12-hour estimates produced the greatest yield. When the calf nursing method was employed, one 17-hour estimate also resulted in the lowest yield; however, four 6-hour estimates produced the greatest yield. All frequencies differed significantly ($P < .01$). The correlation coefficient between calf nursing and machine milking was 0.83 ($P < .01$), suggesting that either technique appeared equally effective in estimating milk yields.

Lakshmanan *et al.* (1958) reported the effect on milk and milk fat production of frequent milking with the aid of oxytocin on dairy cows. When the cows were milked at two hour intervals, the average daily milk production was increased and butterfat decreased for the high producers. Following return to twice daily milking, the milk production returned to normal, but there was an over-compensatory increase in butterfat percentage. The moderate producers among the cows exhibited no significant changes in milk production of fat percentage. The response of the high producers was believed to reflect the effect of intramammary pressure on fat uptakes by the mammary gland and on the rate of milk secretion. Elliott (1959) concluded that three times daily milking resulted in an increase of 3 to 39% in milk yield. The increased production from increased frequency of milking appears to be linked to reduced intramammary pressure. Peterson and Rigor (1932) reported an inverse relationship between intramammary pressure and milk yield.

Linnerud et al. (1966) compared equally spaced intervals of twice daily, four times daily and twice daily plus hand stimulation or oxytocin injection spaced midway between the two milkings on Holstein, Jersey and Ayrshire cattle. Four times daily milking resulted in increased milk yields, primarily due to more frequent relief of intromammary pressure. Chow et al. (1967) reported some increased milk yields with increased frequency of milking; however, the most frequent milking (every four hours) did not yield the most milk in either machine milking or calf nursing.

Hendrix (1971) utilizing Angus X Holstein and Angus X Hereford females, compared twice daily nursing with a 12-hour interval between nursings and three times daily nursing with an 8-hour interval between nursings. Milk yield estimates of the females nursed three times daily were in general, greater at most stages of lactation; however, the only significant differences were noted at 110 and 172 days of lactation and when the average yield over the entire lactation was considered.

The increased milk yields reported by Elliott (1959) Peterson and Rigor (1932) and Linnerud et al. (1959), were with high producing dairy cattle. The amount of milk produced by beef cows does not approach that of dairy cows and more frequent milkings may not be an important factor in relieving intramammary pressure in the udder; however, reports of Chow et al. (1967) and Hendrix (1971) suggest that there may be a response.

Gleddie and Berg (1968) compared calf nursing and machine milking as to their value in determining milk yield. The calf nursing procedure generally produced lower estimates of milk yield than the milking machine procedure. The correlation coefficient between the two procedures was 0.58. Wistrand and Riggs (1968) noted no significant differences between calf nursing and machine milking in terms of estimating milk yields, but the calf nursing procedure tended to underestimate the yield of high producing cows due to limited calf capacity.

Arnett (1963) and Totusek and Arnett (1965) initiated an extensive study to compare three different methods for determining the milk producing ability of beef cows. The following procedures were used: (1) calf nursing (two 12-hour estimates); (2) handmilking one day each week with alternate udder halves being milked morning and evening while the calf nursing the other half; and (3) calf body weight (indirect estimate). Significant ($P < .01$) correlation coefficients were noted between 210-day milk production and calf nursing at 90 and 180 days, 0.87; between 210-day milk production and once weekly handmilking at 70, 112 and 210 days, 0.84, 0.90, and 0.85, respectively; and between 210-day milk production and calf body weight at 70, 112 and 210 days, 0.69, 0.80 and 0.88, respectively. Calf nursing and machine milking appeared to be equally effective in determining milk yield and both appeared superior to calf body weight.

Serwanja, Welch and Kidder (1967) compared calf nursing versus machine milking for determining milk yields. No significant differences were noted and the correlation coefficient between the procedures was 0.86.

These results indicate that there are several procedures that can be followed with reasonable accuracy in obtaining measurements of milk production for research purposes. The exact method employed depends upon the availability of facilities, labor and past experience; however, if oxytocin is used, a dosage of 20 I.U. seems desirable. Lamond, Holmes and Haydock (1969) concluded that 20 I.U. was a satisfactory dose as it should result in complete emptying of the udder in cows with different levels of milk production and in different stages of lactation. Oxytocin did not appear to influence secretion rate since such an effect would be expected to be dose-dependent.

The calf nursing procedure provides a more natural environment, since the beef cow is in the proper state for optimum lactation while nursing the calf. However, a definite disadvantage of this procedure is the inability of obtaining milk samples for composition studies (Pope _et_ _al_., 1963).

Milk Yields and Composition

One of the first research studies comparing the milk yields of beef, beef X dairy and dairy females was conducted by Cole and Johnasson (1948). The milk production of 17 Holstein X Angus females was compared to that of their parental breeds. The Angus cows produced an average of 2906 pounds of milk during an average 180-day lactation (16.1 pounds daily), while the Holstein cows produced 5600 pounds (31.1 pounds daily) and the first cross Holstein X Angus cows produced 4168 pounds (23.2 pounds daily).

The milk production of beef and dairy cattle varies considerably among breeds as well as among individuals within breed. Therefore, the milk producing ability of various beef, beef X dairy and dairy breeds will be reviewed.

Beef

The first extensive studies concerning the milk producing ability of beef cows managed under range conditions were conducted by Gifford (1953). A total of 77 milk and butterfat records were obtained during an eight month lactation period from 28 Hereford, seven Angus and five Shorthorn cows. The cows varied in age, but generally were in the first, second or third lactation. The average daily milk production and butterfat percentage for Hereford, Angus and Shorthorn females were 6.2 pounds, 2.95%; 8.4 pounds, 3.48%; and 8.6 pounds, 2.96%, respectively. Maximum milk yields and butterfat percentages were generally reached during the first month of lactation. The lactation curves of these females did not follow those reported for dairy females, but declined beginning with the first month and continued to decline until weaning.

The average daily milk production of purebred Angus cows was reported to be 14.1, 16.0 and 9.0 pounds for the first, third and sixth month of lactation, respectively, by Drewry *et al*. (1959).

Klett, Mason and Riggs (1962) estimated the milk production of 15 Angus and 15 Hereford cows at College Station, Texas. Angus cows produced 8.6 pounds daily as compared to 6.4 pounds daily for the Hereford cows; however, the Hereford cows had greater milk yields at the beginning of lactation, but were not as persistent in milk flow as the Angus cows. Average butterfat percentage for Angus and Hereford cows was 3.67 and 3.35%, respectively. In another study near Menard, Texas, 55 Hereford cows yielded an average of 7.11 pounds daily over a 138-day lactation.

Walker and Pos (1963) reported New Zealand work on 10 Angus and 10 Angus X Hereford cows mated to Angus bulls to calve as two-year-olds. The Angus and Angus X Hereford cows reached peak production of 14 pounds daily and 15 pounds daily, respectively, about eight weeks post-calving. Average daily yields for the 180-day lactation were greater for the Angus X Hereford cows (14 pounds daily) as compared to the Angus females (12 pounds daily).

Dickey et al. (1970) reported 14-hour milk yields of 5.68 and 5.63 for Angus and Hereford cows, respectively. Rutledge _et al_. (1971) studying 279 lactations from 193 cows, reported that Herefords averaged 11.0 pounds of milk daily and produced an average of 3.47% butterfat, 3.66% protein and 8.54% solids-not-fat.

Schwulst _et al_. (1966) reported the total milk yield, calf consumption and milk composition on a 12-hour basis of 24 Angus females. Milk consumption by the calf measured 5.57 pounds. When a measure of residual milk was obtained, 0.68 pounds was noted; therefore, total milk produced on a 12-hour basis was 6.25 pounds. The per cent butterfat, solids-not-fat and total solids were 4.34, 8.59 and 12.87%, respectively.

Melton et al. (1967a) studied the milk yields of 15 Angus, 15 Charolais and 15 Hereford cows as well as milk composition obtained at the beginning, midway and termination of lactation. Total pounds of milk, per cent butterfat, per cent solids-not-fat and per cent total solids were 1539 pounds, 2.69%, 8.65% and 11.34%; 1839 pounds, 2.83%, 8.88% and 11.71%; and 1339 pounds, 2.93%, 9.20% and 12.13% for Angus, Charolais and Hereford females, respectively. In later work, Melton, Cartwright and Nelson (1967b), using Hereford and Charolais females, related cow size to efficiency of beef production. Average daily milk yield for small, medium and large Hereford cows was 12.8, 11.9 and 10.6 pounds, respectively. Little difference existed in milk yields of large (13.7 pounds) or small (13.5 pounds) Charolais.

Caldwell, Patterson and Anthony (1962) estimated milk yields on 48 Angus, 53 Hereford, 20 Shorthorn and 14 crossbred cows. Twelve-hour milk yields at 30 days post-calving were 6.41, 5.85, 5.67 and 5.15 pounds for Angus, Hereford, Shorthorn and crossbred cows, respectively. The milk yield, relative to breed, remained the same throughout the lactation although steadily declining to 4.48, 3.71, 3.51 and 3.50 pounds at 250 days post-calving.

Reporting data collected from several herds, Harris et al. (1963) indicated that the average milk yield of beef cows was 8 to 9 pounds daily with a range from 3 to 30 pounds. Most cows reached peak lactation within 30 days post-partum and maintained this level until 90 days post-partum. From 90 days to weaning, there appears to be a steady decline in milk output. Butterfat tests averaged 4% with a range of 3 to 6%.

Gleddie and Berg (1968) studied the lactation trends of varying aged cows of four different breeds and crosses. Average 24-hour milk yields were 11.4 ± 3.7, 17.2 ± 4.2, 18.5 ± 3.1, 16.1 ± 3.1 and 9.9 ± 2.6 for Hereford, Galloway, Angus, Charolais X Angus and Angus X Galloway, respectively.

Beef X Dairy

Gowen (1918) conducted one of the earliest milk production experiments involving first generation crosses of the prominent dairy breeds on Angus cows. Gowen concluded that in a cross of a high producing line to a low producing line, the offspring tended to inherit the high milk producing ability of the dairy animal; however, the parental high fat percentage was suppressed in the offspring. The average daily production for the F, crossbred females was 23.0 pounds. Harris *et al.* (1963) reported a much lower estimate of 10 to 14 pounds for cows of mixed beef X dairy breeding.

Five to 10 Angus X Jersey and 10 Angus X Fresian females mated to Angus bulls to calve as two-year-olds were studied by Walker and Pos (1963). Angus X Fresian females reached maximum production of 18 pounds daily at nine weeks post-calving. Their lactation curve was somewhat low due to poor development, late calving and a late summer drought which accelerated the decline in production and depressed the season yield. Angus X Jersey females reached maximum production of 20 pounds daily at the 12th week of lactation. Average daily yields for the 180-day lactation were 14.0 and 17.5 pounds daily for Angus X Fresian and Angus X Jersey females, respectively.

Deutscher and Whiteman (1971) studied the productivity of 40 Angus

X Holstein crossbreds and 42 Angus heifers managed under range conditions. The Angus X Holstein females averaged 4.21 pounds daily more (13.96 versus 9.75) and produced 252.6 pounds more milk than the Angus females during the first 60 days of lactation. During the summer lactation or last 140 days, a production advantage of 483 pounds or 3.45 pounds daily (11.96 versus 8.51) was noted. The crossbreds excelled the Angus females by a highly significant ($P < .01$) 752 pounds or 3.76 pounds daily for the entire lactation. The average daily milk yields were 12.51 and 8.75 pounds for the Angus X Holstein and Angus females, respectively. Hendrix (1971) also reported a highly significant ($P < .01$) advantage in milk production for Angus X Holstein over Angus X Hereford females. The average daily milk productions were 15.5 and 10.6 pounds for Angus X Holstein and Angus X Hereford females, respectively.

Dairy

Konkoly and Barczy (1954) reported that the average daily milk production of Brown Swiss females nursing their calves was 28.6 pounds early in lactation and 18.2 pounds thirty weeks post-calving.

During six years, 42 Holstein cows from the dairy herd at the Scotts Bluff Experiment Station were maintained under beef cattle management by Plum and Harris (1971). Thirty-two cows had previously been milked in the station herd for an average of 2.4 lactations. Their production the year before they entered the beef experiment averaged 14,652 ± 353 pounds for a 305-day lactation or 48.0 pounds daily. The feeding program of the cows was variable among years and seasons with pasture in the summer and crop residues, silage, haylage and hay in the winter. At no time was grain or concentrates provided in the ration. The average 24-hour milk yields for the first, second, third, fourth, fifth and sixth months of lactation were 18.4, 21.0, 36.0, 24.8, 23.4 and 24.8 pounds, respectively. The mean yield for the 190-day lactation was 24.2 pounds daily. The amount of residual milk left during the first three months was 12.5, 7.0 and 2.9 pounds daily. The calves consumed all the milk in the udder during the last three months. Consequently, the amount of milk available for the calves during the first four months was practically constant, but the calves were not able to consume all of the milk.

Effects of Nutrition on Milk Yields

Numerous workers have reviewed the literature concerning the effects of plane of nutrition on cow productivity and performance of their offspring (Zimmerman, 1958; Zimmerman, 1960; Holland, 1961; Pinney, 1962, 1963; Arnett, 1963). This review will pertain to the more recent research dealing with the effect of varying nutritional levels on milk yields of beef cattle. In addition, some information concerning restricted or underfeeding of beef cattle as well as dairy cattle will be presented.

The effect of four different planes of feeding on the milk and butterfat production of Holstein females was reported by Graves *et al.* (1940). Twelve Holstein females were fed throughout lactation one of the following rations: (1) full grain; (2) alfalfa hay plus pasture; (3) ration 2 plus barley; and (4) ration 2 plus corn silage. The cows were milked twice daily by machine throughout the lactation. The average daily milk production and butterfat percentage were 31.2

pounds, 3.37%; 25.9 pounds, 3.19%; 33.1 pounds, 3.14%; and 27.2 pounds, 3.19% for rations 1, 2, 3 and 4, respectively. Reduced butterfats resulted when alfalfa hay and pasture were fed. Cows with the inherent ability for high milk production did not produce near capacity when fed under pasture conditions.

Baker and Tomhave (1944) determined the effect of varied levels of total digestible nutrients on milk production of dairy cows. Five groups of Holsteins were fed at the levels of 90, 100, 110, 120 and 130%, respectively, of the Haecker standard (0.341 pound of TDN above maintenance for each pound of milk testing 4% butterfat). Roughage, primarily alfalfa hay, was fed to meet the maintenance requirement for TDN and the production requirement was met by addition of concentrate. Feeding levels were adjusted either upward or downward each week depending upon changes in milk yields. By the end of the test, the feeding levels had changed to 82.2, 98.0, 105.3, 122.4 and 131.0% of the Haecker standard, respectively. The average daily milk production data for groups 1, 2, 3, 4 and 5 were 26.3, 30.2, 32.4, 39.6 and 36.0 pounds, respectively. Levels of feeding over 122.4% of the Haecker standard appeared to result in decreased milk yields. The greatest efficiency in terms of amount of milk produced per pound of TDN fed was obtained at the lowest feeding level and, possibly, cows at even lower levels would further increase efficiency.

Flux and Patchell (1954) studied the effects of undernutrition after calving on the quantity and quality of milk produced by 14 sets of monozygous Jersey and Jersey crossbreds. Before calving, the cows were managed in a single herd and reasonably well fed, having a small amount of pasture over the winter months plus hay and silage. After calving, the animals were managed under good conditions for the first two weeks. From the third to the eighth week inclusive post-calving, the sets were divided into a normal group which was continued on a normal plane of nutrition and a low group which were underfed. After the six week feeding period, the normal plane cows produced an average of 204 pounds more milk and 8.1 pounds more butterfat than the poorly fed group. These differences were both highly significant; however, no significant difference was noted between the two groups at the end of the 270-day lactation. Only an average of 2.4 pounds daily separated the two groups. In terms of milk composition, the effect of undernutrition increased per cent butterfat and decreased per cent solids-not-fat and total protein. All differences were highly significant for the feeding period; however, only the per cent solids-not-fat remained significant at the end of the lactation. Similar results were reported by Patchell (1957) and Flux and Patchell (1957) although underfeeding was practiced only during the first ten days of lactation.

Harris *et al*. (1962) studied the effect of optimum or restricted winter feeding on Hereford cows. The optimum group was full fed good quality grass hay plus two pounds of cottonseed meal daily during the winter period and had access to improved river bottom pasture. The restricted group was fed inferior quality grass hay *ad libitum*. No protein supplement was added and the cows were confined to a small sod lot during the winter period. The average daily fat-corrected-milk yields during April were 9.18 and 6.02 pounds for the optimum and restricted groups, respectively. After 56 days on good spring grass, the comparable milk productions were 8.9 and 9.0 pounds, indicating the ability of the restricted group to respond to lush grazing by an increased milk flow; however, the calves from this group were lighter at weaning. In later work, Harris et al. (1963) concluded that reduced planes of nutrition post-calving results in reduced milk production of the beef female. Reporting work on 20 first-calf Hereford and 10 bred Hereford heifers fed the optimum and restricted levels previously mentioned, Harris et al. (1965) indicated that the restricted fed heifers lost 62 more pounds during the winter and exhibited reduced milk production when compared to the optimum fed heifers; however, the restricted group secreted more milk when placed on lush grazing.

Milk production estimates were obtained in three trials with fall calving Hereford females by Furr and Nelson (1964). Various levels of winter supplement was fed in addition to native grass on prairie hay. In trial I, cows wintered at a lower level of nutrition produced an average of 5.92 pounds of milk daily compared to 6.40 pounds for the high level cows over the last 172 days of lactation. Milk production declined in late winter for both groups, but increased again in the spring when the nutritive value of the grass had increased. Cows wintered at the lower level showed a greater increase in production when the spring grass became available. In trial II, similar results were reported and indicated that a higher level of winter supplementation significantly increased milk production. In trial III, average daily milk yields were 6.82, 6.88, 5.33 and 6.54 pounds for cows supplemented at low and high levels in traps with prairie hay as the roughage and low and high levels on native range, respectively.

Smithson et al. (1964), reporting on the effect of high and low winter feeding levels in alternate years on growth and development of beef heifers, concluded that low level feeding during the second winter as a lactating two-year-old resulted in reduced milk flow and was the most damaging. Also reporting data and milk yields from their study were Pinney _et al_. (1962a), Renbarger _et al_. (1964) and Turman _et al_. (1964). Data through ten winters of treatment and nine calf crops were summarized by Hughes (1971). The low level of winter supplementation appeared to delay attainment of maximum milk producing capacity, while the very high level fed during the early growth stages suppressed milk flow during the latter periods of lactation. Performance and production of the low level cows approached that of the high and moderate levels by the fourth calf crop. The data also indicated that a very high level of nutrition in early life can be detrimental to the production of the beef cow when measured by calf weaning weight. Mangus and Brinks (1971) also indicated a detrimental effect upon subsequent cow productivity resulted from higher levels of nutrition during the pre-weaning growth period of the beef heifer and that relatively low levels of pre-weaning nutrition resulted in higher cow productivity. A low correlation (0.14) between a heifer's weaning weight and her subsequent productivity indicated that the heifer's weaning weight is a poor criterion for selection to increase cow productivity. Data indicating similar results with beef cattle were reported by Christian, Hauser and Chapman (1965), Totusek (1968), Koch (1969) and Holloway (1971).

Arnett (1963) studied the influence of moderate versus very high levels of nutrition on the performance of 12 sets of twin beef females maintained in drylot. One heifer of each set was full-fed a high energy ration to achieve maximum possible gains and the second heifer was fed a ration adequate in all nutrients, but containing a moderate level of energy. Average daily milk production on a 210-day FCM basis for the first, second and third lactation were: moderate - 9.7, 9.6 and 9.0 pounds and very high - 7.6, 7.1 and 7.8 pounds, respectively. the correlation of the difference in the body weight within twin sets to the difference in their average daily milk yield was 0.65 ($P < .01$) when pooled over the three years data, indicating that the degree of fatness was associated with the productivity of the cow. Milk composition data was obtained during all three lactation periods. The per cent butterfat did not differ between treatments, but varied somewhat from period to period. The overall mean for per cent butterfat was 3.3% for both treatments. The very high level cows had significantly higher per cent total solids for the first ($P \simeq .09$) and second ($P \simeq .03$) lactations and when the three years data were pooled ($P \simeq .06$). The overall means for per cent total solids were 12.4 and 12.5% for the moderate and very high levels, respectively.

Swanson and Spann (1954) observed that Jersey heifers fed at a normal rate produced twice as much milk as twin mates which had been fed for rapid growth. They concluded that excess fattening during growth was detrimental to their lactating ability. Swanson (1957) reported that fat deposits had inhibited the development of the lobule-alvestor system.

Bond _et al_. (1964) utilized 54 grade Angus heifers to study the effect of different levels of energy and protein on feed intake and milk production. The heifers were individually fed a pelleted ration in drylot and remained on this ration until 180 days post-calving with first calf, at which time they were switched to a high roughage ration *ad libitum* until pregnant with their third calf. Heifers on low energy or protein weighed less and gave less milk (low energy - 3.4 pounds; low protein - 4.6 pounds) than the medium or high heifers (energy: medium - 6.7 pounds, high - 6.6 pounds; protein: medium - 6.3 pounds, high - 5.8 pounds).

Experimenting with the nutrition of dairy heifers, Broster *et al*. (1964) fed 42 first calf Holstein females four different diets: (1) low energy, low protein; (2) low energy, medium protein; (3) high energy, medium protein; and (4) high energy, high protein. Reported average daily milk yields were 38.8, 38.1, 38.2 and 39.0 pounds for treatments 1, 2, 3, and 4, respectively. Treatments had little effect on butterfat per cent. They concluded that no appreciable difference in yield and composition of milk existed among treatments when fed during late pregnancy. Broster and Tuck (1967), in later work with 45 first calf Holstein heifers, studied the effect of low and high feeding during the last six months of pregnancy and the first eight weeks of lactation on milk yields. The higher level of feeding during pregnancy increased the daily milk yield in early lactation by 1.9 pounds daily and the total lactation yield by 2.9 pounds daily. High level of feeding reduced the rate of decline in yield through mid-lactation, but had negligible effects on milk composition. The higher level of feeding after calving increased the daily milk yield during the first two months of lactation by 6.2 pounds daily and also reduced the rate of decline in production after the peak lactation period had been surpassed.

Huber *et al*. (1964) used 35 Holstein females to study the effects of supplementing medium-quality pasture with ground corn or corn silage on milk production and composition. Energy levels were varied by the addition of ground corn or corn silage. As energy increased, milk yields increased with exception to the straight corn diet. Solids-not-fat decreased as corn level decreased, with milk protein accounting for most of the change. However, butterfat per cent increased as corn level decreased, resulting in a definite inverse relationship between per cent butterfat and level of energy. In similar work, Huber and Bowan (1966) reported a significant ($P < .01$) linear response between level of energy and milk yields. In both the low and high protein groups, as the level of energy increased, milk yields increased; however, butterfat per cent decreased.

Dunn et al. (1965) evaluated the dam's energy intake on milk production. One hundred twenty-two Angus and 118 Hereford bred yearlings received either 7.7 megcals (low) of calculated DE or 17.4 megcals (high) of calculated DE daily for 140 days pre-calving. At calving the heifers in the low groups were divided and fed 27.4 and 48.4 megcals of DE daily for 120 days post-calving for moderate and high levels, respectively. The high pre-calving group was divided into low, moderate and high groups and fed 14.1, 27.4 and 48.4 megcals DE daily also for 120 days post-calving. Milk production estimates were taken 53, 81 and 109 days post-calving for both breeds. The average 24-hour daily production for Angus cows were higher for all treatments than the Hereford cows. Angus treatment milk yields were 5.2, 6.3, 4.6 5.4 and 8.8 pounds daily for low-moderate, low-high, high-low, high-moderate and high-high, respectively. Hereford yields were 4.6, 4.9, 4.5, 4.8 and 6.4 pounds daily for the same treatments. A definite trend existed for milk yields; as the post-calving energy level increased, milk yield increased. Lamond et al. (1969) reported a correlation of 0.94 between average daily milk yield in kilograms and energy in kilocalories. Poorer quality pasture resulted in reduced milk yields and fat percentage tended to decline with advanced lactation.

Gillooly et al. (1967) allotted 24 mature Angus X Holstein females to two energy levels (115% and 85% of recommended N.R.C. requirements) and to two body sizes. Body size did not significantly effect production; however, the higher energy level resulted in significantly increased milk yields and per cent solids-not-fat. Average 12-hour milk yields were 11.9 and 8.7 pounds for high and low energy levels, respectively. Similar work from the same data was reported by Wilson et al. (1969). Two ration energy levels of 38.64 and 28.56 megcals DE per head daily, corresponding to 115% and 85% of N.R.C. (1963) requirements, respectively, were fed. The forages used were 70% orchard grass - 30% alfalfa haylage and mid-bloom hay with average estimated as fed values of 1470 and 2190 kcal DE per kilogram, respectively. The two rations contained equal amounts of forage in an approximate ratio of 3:1 haylage: hay. The low energy rations included 2.2 pounds per head daily of a mixture of 82.6% soybean meal and 17.4% ground corn. The high energy ration consisted of 8.6 pounds per head daily of a 95.5% ground corn and 4.5% soybean mixture. The two rations were isonitrogenous and supplied approximately 150% of the N.R.C. total protein requirement.

The cows receiving 115% of the energy requirement maintained their initial weight, while the cows on the 85% energy level lost an average of 120 pounds. The N.R.C. energy requirements for lactating beef cows are based on maintaining the cow weight without weight gain or loss. The weight changes suggest that Angus X Holstein females will not maintain their post-parturition weight on 100% of the N.R.C. requirements for beef cows, largely due to the relatively high milk producing ability. Condition scores averaged 12.7 and 10.1 for the 115 and 85% energy levels, respectively ($P < .01$). The overall 12-hour milk yields were 12.0 and 8.7 for the high and low energy levels, respectively. The difference of 3.3 pounds was highly significant ($P < .01$). Energy level did not significantly influence per cent butterfat and per cent protein; however, the 115% energy level resulted in a significantly ($P < .01$) greater per cent solids-not-fat than did the 85% energy level. The per cent butterfat, protein and solids-not-fat were 3.39, 3.38 and 8.43% and 3.47 3.54 and 8.79% for the 85 and 115% energy levels, respectively.

McGinty, Essig and Belew (1971) studied the effect of added energy in excess to that recommended by N.R.C. for mature lactating beef cows. Two groups of first calf, two-year-old crossbred heifers were used. Both Angus X Hereford and Red Angus X Brown Swiss X Hereford heifers were fed 112 and 135% of the recommended N.R.C. requirements, representing the low and high energy levels, respectively. All heifers were fed the same ration prior to calving and all were in excellent condition. Differences in the precalving weights were small, but by 90 to 100 days post-calving, the high energy group had regained their pre-calving weight plus 13 pounds, whereas the low energy group lacked 20 pounds reaching their initial weight. The Red Angus X Brown Swiss X Hereford females produced approximately two pounds more milk daily than the Angus X Hereford females for both low and high energy levels (low - 11.4 versus 0.0; high - 11.2 versus 9.5).

In summary, Pope et al (1963) recommended preparation for milk production by means of winter feeding must begin before calving and especially during the last six weeks in order to properly develop the secretory tissue and must precede each lactation. Average daily milk production the following summer reflects the plane of nutrition immediately preceding lactation. No carry-over from prior treatment will be noted, providing that females are well fed the preceding winter. Therefore, the feeding level prior to and during lactation has a marked influence on milk yields.

Effect of Calf Capacity on Milk Yields

Since the lactation curve of beef cows does not always follow that of a typical dairy curve, there must be an additional factor in early lactation that contributes to the gradual decline. If the consumption of the calf does not empty out the udder, normal secretion can not take place. In an extensive review on the physiology and biochemistry of lactation, Peterson (1942) noted that not only is all milk secreted in the interims between milkings, but also, due to the intra-alveolar pressure developed by the accumulating milk, the rate of secretion diminishes with time and in some instances may be completely stopped before milking. Further, if milk is not removed from the udder, pressure within the udder is created and at certain maximums, resorption takes place (Peterson and Rigor, 1932). As pressure increases there is a decrease in the rate of milk secretion.

Information on the amount of milk that calves consume has been reported by numerous workers; however, many of these calves were bucket-fed under veal production conditions. Gifford (1953) concluded that the quantity of milk consumed by the calf is a definite restriction on the maximum milk producing ability of the dam. Therefore it seems logical that the rate of consumption during the first month of lactation sets the pattern for the remainder of the lactation curve. Schwulst *et al*.(1966) found that during the second and third weeks of lactation, the cow's residual milk was 15 and 11% of her total secretion, respectively. Gleddie and Berg (1968) estimated that the average production of the cows was 2.64 pounds or 18% higher than the calves' consumption during the first month of lactation. Plum and Harris (1971), working with Holsteins under beef cattle management, reported that 12.5, 7.0 and 2.9 pounds of residual milk remained in the udder during the first, second and third months of lactation, respectively. However, Neville (1962), Brumby *et al*. (1963) and Christian *et al*. (1965) observed that calves consumed approximately 20 pounds of milk during early lactation, indicating that large quantities of milk can be consumed.

Effect of Milk Yield on Gains of Suckling Calves

Milk yield on beef cattle is known to have a marked influence on the growth of the calf from birth to weaning, but the extent of this association has varied considerably between studies. Knapp and Black (1941) found that the correlation between daily gain of the calf and quantity of milk produced by the dam was 0.517 ($P < .01$). The calves were individually fed grain and hay *ad libitum*. Of all the feeds consumed by the calf, milk had the greatest effect on gain. The gross correlations between daily milk production of Hereford dams and daily weight gain of the calves was 0.60, 0.71, 0.52 and 0.35 for the first, second, third and fourth month of lactation, respectively. After the fourth month of lactation, the correlations were small and non-significant.

The effect of low milk production on growth of calves was studied by dividing the cows into three groups: (1) cows producing less than 6.5 pounds of milk daily; (2) cows producing between 6.5 and 12.9 pounds daily; and (3) cows producing over 13 pounds daily. The three groups produced calves weighing 325, 405 and 425 pounds, respectively, at weaning. A minimum of six to eight pounds of milk daily was required during the first three months of lactation to produce at least a 400 pound calf at weaning under these conditions. Daily milk production of no more than 18 pounds during the first three months produced calves that weighed 475 to 525 pounds at weaning.

Drewry _et al._ (1959) studied the relationships among several factors associated with mothering ability of beef cattle. Milk production of 48 Angus cows was estimated for one day in the first, third and sixth month of lactation. When observations from two years were combined, the estimated milk required to produce a pound of gain was 12.5, 10.8 and 6.3 during the first, third and sixth month of lactation, respectively. Similar results were reported by Gifford (1953) in a review of calves fed under veal production. The correlation between the estimated daily milk production of the dam and total calf weight gain from birth were 0.15, 0.35, and 0.48 for the first, third and sixth month of lactation, respectively, suggesting that the relationship may be influenced by the age of the calf. When pounds of milk required per pound of gain and preweaning growth were correlated, it seemed to indicate that those calves suckling higher producing dams made the least gain from a pound of milk, probably due to the higher maintenance requirements of the heavier calves.

Neville et al. (1960) reported the influence of sire, dam's milk production and other factors on the 120 - and 240 - day weight of Hereford calves. The cows were on three levels of nutrition until the calves were 120 days old then on the same level thereafter. Average daily milk production of four months and four month calf weight corrected for sire and sex effects were: low plane - 8.5 and 218 ~~pounds~~; medium plane - 10.2 and 251 pounds; and high plane - 11.5 and 273 pounds, respectively. Similar results reported for eight month milk production and calf weight were: low - 8.1 and 400 pounds; medium - 9.6 and 448 pounds; and high - 10.5 and 461 pounds, respectively. In analysis of further data, Neville (1962) concluded that on the average, calves from cows fed grass silage or corn silage plus one pound of cottonseed meal during the first 120 days of lactation required 12.5 pounds of milk per pound of gain, while the calves from cows fed corn silage, one pound of cottonseed meal and limited wheat pasture required 23.5 pounds of milk per pound of gain. Of the total variance in 240-day calf weight, 66% was due to differences in milk consumption. As nutrition improved and milk production increased, there was a lower correlation between milk production and 240-day weight. Also as nutritional treatments improved, additional milk was required to produce a pound of gain at either 120 or 240 days of age. The relationship of milk to calf weight gain was greatest during the first 60 days of lactation and steadily declined until weaning.

Velasco (1962) reported correlations between milk production and average daily gain of the calves of 0.96, 0.68 and 0.57 ($P < .01$) for the first three months of lactation, respectively. Thereafter the correlations decreased considerably until the month prior to weaning when it increased markedly to 0.77 ($P < .01$). Correlations between daily milk production and daily calf gains from birth to weaning were 0.76 and 0.55 for cows fed a low and high level of winter nutrition, respectively. Similar results were reported by Pinney (1962). A correlation coefficient of 0.82 between milk production of the dam and gain of the calf from birth to weaning was reported. In later work, Pinney (1963) concluded that 50-67% of the variation in calf gain from birth to weaning could be attributed to differences in the dam's milk producing ability. In a similar study, but with fall-calving cows, Furr (1962) reported correlations between milk yield and calf gain of 0.81 and 0.85 for cows fed at a low and high level of winter nutrition, respectively. Concerning two-year-old heifers, the correlations of daily calf gain with milk yield were 0.75 and 0.91 for the low and high level cows fed in traps and 0.80 for both low and high level cows fed on native range, respectively.

Brumby et al.(1963) concluded that 50% of the variation in weaning weight of the calf may be attributed to differences in the milk production of the dam. There was a marked influence on the growth of the young calves by deficiences in milk yield. A declining dependence of the liveweight gain of the growing calf upon its milk consumption was noted; the regression of liveweight gain on milk consumption declined with increasing age. This regression appeared linear from birth to 24 weeks. At weaning the correlation between liveweight gain of the calf and the milk producing ability of its dam was 0.7.

Klett *et al.* (1965) found significant correlations ($P < .01$) ranging from 0.67 to 0.81 when milk yield was correlated with calf weight at various stages of lactation in an Angus herd. Non-significant correlations resulted in the Hereford herd and suggested that the Angus females provided a greater proportion of nutrients to their calves in the form of milk than the Hereford females. The per cent composition of the milk had little, if any, effect on calf weights as measured by non-significant correlations. Melton *et al.* (1967a) found that the correlations between total gain of the calf and per cent butterfats, solids-not-fat and total solids were near zero.

Christian *et al.* (1965) reported correlations of 0.62, 0.46, o.48, 0.40, 0.30 and 0.64 between weaning weight and birth weight, milk yield from 0 to 60 days, milk yield from 60 to 240 days, butterfat yield from 60 to 240 days and creep feed from 60 to 240 days, respectively. Correlations were approximately equal in magnitude when average daily gain from birth to weaning was considered with the above factors. A small correlation of birth weight of the calf with the dam's milk production was noted, suggesting that the size of the calf at birth was related to its capacity to consume milk. Totusek and Arnett (1965) reported correlations between total milk production and calf weight at 70, 112 and 210 days of 0.69, 0.80 and 0.88, respectively. All correlations were highly significant ($P < .01$).

The earliest milk consumption estimates were obtained at two, three, and five weeks of age by Schwulst *et al.* (1966). The correlations between the average daily gain from birth to two weeks of age and milk consumption at two, three, and five weeks were 0.36, 0.23 and 0.23, respectively; all correlations were non-significant.

Similar results were found when correlations were made from birth to three weeks and five weeks of age; however, some correlations were significant. When average daily gain and the mean of the three observations were correlated, higher and more significant values were obtained than with the individual observations. The correlation between the average milk consumption and the average daily gain from birth to two, three and five weeks were 0.41 (NS), 0.63 ($P < .01$) and 0.58 ($P < .01$). A highly significant ($P < .01$) correlation of 0.50 was obtained between the mean milk consumption and birth weight.

Gleddie and Berg (1968) reported correlations between individual milk yield estimates and the average daily gain of calves in the preceding test period. The correlation coefficients were 0.62 for first month lactation yield and average daily calf gain from birth to 30 days; 0.75 for second month lactation yield and average daily calf gain from 30 to 60 days; 0.56 for third month lactation yield and average daily calf gain from 60 to 90 days; and 0.51 for fifth month lactation yield and average daily calf gain from 90 to 150 days. Milk yield as measured in the first, second, third and fifth months of lactation was highly correlated with average daily calf gain from birth to weaning (0.73 to 0.83). The average of the four milk estimates had a similar correlation with average daily calf gain of 0.84. The correlations of average milk yield and per cent butterfat, protein, solids-not-fat and total solids were 0.19, -0.30, 0.02 and 0.14, respectively. Average milk yield accounted for 71.3% of the variance in average daily calf gain, while per cent total solids accounted for an additional 2.7% and the inclusion of percentages of protein, solids-not-fat and butterfat accounted for only an additional 0.5%.

Wilson et al. (1969), working with Angus X Holstein females, reported a ratio of daily milk yield to daily calf gain of 11.2:1. The simple correlation between calf weight gain and 12-hour milk yield was 0.46 and non-significant. Deutscher (1970) indicated that birth weight was significantly correlated ($P < .05$) with total milk in the 3/4 Angus - 1/4 Holstein calves ($r = 0.52$), while the correlation was negative (-0.44) for the Angus calves, but non-significant. A high partial correlation of total milk to May 1 (average calf age - 50 to 60 days) versus total gain to May 1 ($r = 0.60$; $P < .01$) and total milk to weaning versus total gain to weaning ($r = 0.68$; $P < .01$) in the Angus was noted as compared to 0.14 and 0.21, respectively, for the crossbreds. The low correlations may indicate that the milk supply is not the limiting growth factor in the crossbreds, but may be in the Angus. The Angus calves required 6 pounds of milk to produce a pound of gain as compared to 7.1 for the 3/4 Angus - 1/4 Holstein calves. A low non-significant position correlation (Angus, 0.16; Angus X Holstein, 0.37) was noted between total milk to May 1 and cow weight loss to May 1. Therefore it appears that the cows giving the greater quantity of milk had a tendency to sacrifice body weight for milk production. Similar results were reported by Gregory, Blunn and Baker (1960). They found a small negative correlation (-0.23) between calf weight gain from birth to weaning and gain of the cow from calving to weaning indicating that the cows which gained the least weight tended to produce the largest calves; thus, suggesting a higher priority of nutrients for increased milk production as compared to body weight gain.

Plum and Harris (1971) studied Holstein cows under range conditions. Holstein calves nursing their dams required 12.2, 12.7, 12.2

12.0, 11.6 and 11.5 pounds of milk to produce a pound of calf gain at 23.5, 51.5, 83.0, 116.5, 115.0 and 190.5 days post-calving, respectively. The mean conversion rate for the 190.5 day lactation was 12.0:1 with respect to pounds of milk per pound of calf gain.

Effect of Nutrition and Milk Production on Reproductive Performance

A calving interval of 365 days or less is generally considered the optimal reproductive rate in cattle to maximize economic profit per breeding female per year. An increased post-partum interval increases that part of the cost of the offspring which is due to the maintenance of the dam. Too short an interval between parturitions has been presumed to burden the breeding female so that eventually her breeding performance, the quality of her offspring and her milk producing ability will suffer. Cattlemen can not afford to substitute higher levels of milk production and higher weaning weights for breeding efficiency.

In an extensive review on the post-partum cow by Casida (1968), numerous observations on the interval from parturition to the first succeeding estrus were summarized. Work done by Chapman and Casida (1937), Carmen (1955), Fosgate, Cameron and MacLeod (1962) on 1826 Holstein females milked under dairy conditions revealed an average interval from calving to first estrus of 62 ± 35 days. In similar work, 667 Holstein females involved in twice daily milking (Clapp, 1937; Buch, Tyler and Casida, 1955; Menge *et al*., 1962) required an average of only 38 ± 22 days to exhibit first estrus as compared to 63 ± 32 days for three times daily milking (Casida and Wisnicky, 1936) and 69 ± 37 days for four times daily milking (Clapp, 1937). Clapp

(1937) also observed that the interval from calving to first estrus was longer for Holstein females that suckled their calves, requiring an average of 72 ± 30 days. In comparison, 318 Shorthorns (Wiltbank and Cook, 1958; Foote, Hauser and Casida, 1960) required 88 ± 35 days; 96 Angus (Wiltbank, 1955; Foote *et al.*, 1960), 73 ± 27 days and 846 Hereford (Laslay and Bogart, 1943; Warnick, 1955; Foote and Hunter, 1964; Foote and Saidudden, 1964), 60 ± 25 days.

Boyd (1967) reviewed several studies with dairy cows and concluded that high milk production does significantly affect the onset of estrus after calving. Each additional 1000 pounds of milk produced during the first 120 days of lactation resulted in a delay of 1.5 days on first estrus. No evidence indicating a positive relationship between high levels of milk production and conception rate was noted. Therefore, he concluded that high levels of production did not significantly affect reproduction except to delay the onset of first estrus. Similar results have been reported by Gaines (1927), Boyd, Seath and Olds (1954) and Olds and Seath (1953).

While it may be possible to combine high genetic potential for both growth and milk production in the cow, the feed environment under which the cow must survive may be a limiting factor. Smithson *et al.* (1964) reported that low winter feeding of bred Hereford yearlings resulted in a marked delay in rebreeding after calving. Turman *et al.* (1964) studied 80 bred Hereford heifers on two levels of winter feeding. The group that maintained their fall weight through calving returned to estrus sooner, bred back earlier and had a higher conception rate than the group that lost 20% of their fall weight. Wiltbank *et al.* (1962) fed 44 mature Hereford cows a high level of energy (nine pounds of TDN per head daily) and 44 cows a low level of energy (4.5 pounds of TDN per head daily). After calving each level was split into a high (16 pounds of TDN per head daily) and a low (eight pounds of TDN per head daily). The results indicated that the per cent of cows pregnant were 95, 95, 77, and 20 per cent for the high-high, low-high, high-low and low-low levels, respectively. These results indicate that level of energy post-calving is a very important factor for good reproductive performance. In further work, Wiltbank _et al_. (1964) found that mature cows fed 100% of the recommended energy requirements returned to estrus faster than those fed at higher or lower levels of energy. The lower energy level heifers exhibited a delay in first estrus, but were observed in estrus before the high (150%) energy group.

A significant difference in the per cent cows pregnant at 120 days post-calving was indicated among high (87%), moderate (72%) and low (64%) levels of winter feeding by Dunn _et al_. (1969). They also observed a significant difference (25% to 6%) in the onset of estrus to 40 days post-partum between the cows on high and low levels of energy before calving. Christenson _et al_. (1967) also found that heifers fed a high level of energy expressed estrus sooner (37.3 days versus 59.8 days) post-calving that heifers fed a low level of energy.

Deutscher and Whiteman (1971) reported a poor rebreeding performance for two-year-old Angus X Holstein females that nursed their calves. Of those nursing calves only three of 23 or 13% of the crossbred cows rebred during the 90-day breeding season as compared to 63% of the Angus females (17 of 27). This difference was highly significant ($P < .01$). All heifers that had been open or had lost their calves rebred. This would indicate that the feeding level was probably too low to support lactation, body growth and good rebreeding performance. More available energy was needed by all heifers for good rebreeding performance to exist, but the crossbreds were the most severely restricted because of their higher milk producing ability. McGinty _et_ _al_. (1971) also indicated poor rebreeding performance of dairy X beef crossbred females. Reporting data from the 1969-70 calf crop, the highest per cent calves born (93%) was exhibited by the Hereford cows, while only 65% of the Brown Swiss X Hereford cows calved. Instead of low conception, the main problem was the failure of the Brown Swiss X Hereford cows to express estrus. During the next year, the cows were fed 160% of the recommended N.R.C. energy requirement for beef cattle. Their rebreeding performance (96%) was excellent. A number of factors were indicated as being responsible for the increased reproductive performance: (1) all cows, in question, had produced at least their second calf; (2) natural service was used for all cows except the Brown Swiss X Hereford females which were bred artificially to a Red Angus bull; and (3) increased energy and phosphorous levels in the ration during the breeding season. In addition to the 25 pounds of roughage normally fed to the lactating cows, five pounds of milo fortified with dicalcium phosphate to provide 0.76% calcium and 0.86% phosphorous were fed. The Brown Swiss X Hereford cows were also fed 10 extra pounds of milo because of their increased milk production.

In summary, energy appears to be the most important single factor for good rebreeding performance. As level of energy increases, the number of days from calving to first estrus tend to decrease and high conception rates are realized.

CHAPTER III

MATERIALS AND METHODS

Animals, Treatment and Procedures

Forty-two Hereford, 50 Holstein and 42 Hereford X Holstein heifers approximately one-year-old were assembled at the Fort Reno Livestock Research Station in the fall of 1969, with a minimum of three herds represented in the origin of each breed group. For the ensuing year, all heifers were maintained on tallgrass native range. The native range on the Fort Reno station, classified in excellent condition, is typified by little bluestem (*Andropogon scorparius*) as the predominant species and has a carrying capacity of approximately seven to eight acres per cow-calf unit on a yearlong basis. The range forage is normally dormant from early November (first frost) to late April. Ample range forage was available at all times.

All heifers received 0.91 kilogram of soybean meal (44% crude protein) per head daily from October 25, 1969 to April 30, 1970. In addition, the Holstein heifers received 1.50 kilograms of ground milo per head daily to achieve a degree of body condition comparable to that of the Hereford and Hereford X Holstein heifers which received 0.91 kilogram of ground milo. All heifers were synchronized with CAP[1]

---

[1] 6-chloro-Δ^6-17 acetoxyprogesterone, Eli Lilly Company, Greenfield Laboratories, Greenfield, Indiana.

and artificially inseminated to a single Angus bull from February 15 to April 2, 1970. Following this period, the heifers were pasture-mated to three Angus bulls rotated among the three breed groups until May 15, 1970. All heifers diagnosed open by rectal palpation in August were removed and replaced with similar females from herds in Oklahoma. Within one week post-calving (November 2, 1970 to January 26, 1971) each female was assigned to either the range or drylot phase and to a level of winter supplementation on the basis of a preassigned calving order to equalize calving date within breed.

Three levels of winter supplementation designated as Moderate, High and Very High were fed in both the range and drylot phases. The Moderate level consisted of that amount of supplement estimated necessary to effect a weight loss (including weight loss at calving) from fall (November) to spring (April) of approximately 10% in Hereford females. This same level was fed to a group of Holstein females and to a group of Hereford X Holstein females. The High level was established by the Hereford X Holstein females and consisted of that amount of supplement considered necessary to maintain a degree of body condition and physiological activity in Hereford X Holstein females comparable to that of the Moderate Herefords. This same level was fed to a group of Hereford females and to a group of Holstein females. The Very High level was established by the Holstein females and consisted of that amount of supplement considered necessary to maintain the Holstein females in a condition comparable to Moderate Herefords and High Hereford X Holstein crossbreds. This level was fed only to a group of Holsteins.

Moderate Herefords, High Hereford X Holsteins and Very High

Holsteins were used as the base breed-treatment groups to establish the levels of supplementation according to N.R.C. requirements for protein for the Moderate, High and Very High levels, respectively. Cows of the mean November, 1970 weight of the three base breed-treatment groups received 1.7, 3.3 and 5.1 kilograms of supplement per head daily. Within each nutritional treatment, irrespective of breed, the quantity of supplement fed each female was increased or decreased to adjust for differences in body size on the basis of metabolic weight ($W^{.75}$). For example, an average weight Moderate Hereford and any Hereford X Holstein or Holstein female of the same weight on the Moderate level of supplementation was fed the same amount of supplement, but a lighter female received less and a heavier female received more (regardless of breed) in recognition of the fact that maintenance requirements are influenced by cow size. The supplement used was a range pellet (30% crude protein) composed of (%): soybean meal (44%), 60.1; ground milo, 30.3%; dehydrated alfalfa meal, 5.0; dicalcium phosphate, 2.9; masonex, 1.3; salt, 0.5; plus vitamin A added at a level of 22,000 I.U. per kilogram of supplement. The mean daily supplement allowance pre- and post-calving for each breed-treatment group is presented in Table I. All females on the range were individually fed the supplement five times per week for a 172-day period from November 9, 1970 to April 30, 1971. During the winter non-lactating females were maintained in three breed groups in separate pastures; however, after calving, each breed-treatment group was maintained in a separate pasture to prevent cross-nursing by calves across treatments. Cattle were rotated among pastures monthly to minimize pasture effects on performance.

Females in drylot received the same range pellet fed daily for a 136-day period from November 9, 1970 to March 25, 1971. Approximately the same total quantity of supplement for the winter was received by females in comparable treatments in both range and drylot phases. Additional roughage and grain as necessary to approximate the weight change pattern of the range females was provided. The drylot roughage ration consisted of cottonseed hulls during the winter to March 25, cottonseed hulls in decreasing quantity and chopped alfalfa hay in increasing quantity to April 30, chopped alfalfa hay to July 1 and a mixture of 63% chopped alfalfa hay, 30% dry rolled milo and 7% liquid cane molasses to October 31. All rations were analyzed for crude protein by the standard Kjeldahl procedure and DE (Kcal/kg) and DP(%) were calculated from tabular material (Crampton and Harris, 1969). Drylot females were individually fed daily with the roughage being fed <u>ad libitum</u> during approximately a three hour period along with the supplement. The mean total intake for each roughage by each breed-treatment group is presented in Table I. All cows and calves were maintained on one lot until some cross-nursing was observed; thereafter, breed-treatment groups were separated and rotated among seven drylot pens monthly.

Individual cow weights were taken monthly from November, 1970 to November, 1971. Condition scores were taken just prior to initiation (November, 1970), just after termination (May, 1971) and just before reinitiation of supplemental feeding (November, 1971). Condition scores were based on a scale of one (very thin) to nine (very fat). All calves were weighed to the nearest 0.45 kilogram and identified by ear tag within 24 hours after birth. Range calves remained with their dams on native pasture until weaning and did not receive creep feed. Drylot calves remained with their dams except when furnished a high-roughage creep-feed (chopped alfalfa hay, 60%; cottonseed hulls, 20%; whole oats, 15%; liquid cane molasses, 5%) ad libitum in individual stalls while their dams were being fed. The creep-feed was provided from March 1, 1971 to weaning. Calf weights were obtained after a six-hour shrink at monthly intervals during lactation. All calves were weaned at 240 ± 7 days of age and weights were adjusted to 240 days by interpolation (for calves over 240 days) or extrapolation from past month's rate of gain (for calves weaned under 240 days). The age-corrected weaning weights of the heifer calves were corrected to a steer equivalent by multiplying by 1.059 (Smithson, 1966).

The estimated 24-hour milk production was determined by the calf-suckle technique at monthly intervals during the 240-day lactation. The calves were weighed to the nearest 0.045 kg immediately before and after nursing. Pens and scales which facilitated rapid weighing were employed to minimize weight losses due to urination and defecation. Four six-hour estimates were combined to give a 24-hour estimate of milk yield. Milk composition of the drylot females was determined during the mean fourth, fifth, and sixth months of lactation (April, May and June). Following complete nursing, all females were isolated from their calves for six hours prior to collection of the sample. Approximately 12 grams of Promazine granules[2] per female was fed shortly before milking and 20 I.U. of oxytocin[3] was injected

---

[2] Fort Dodge Laboratories, Fort Dodge, Iowa

[3] Pituitary Solution, Posterior, Stronger, Fort Dodge Laboratories, Fort Dodge, Iowa.

intramuscularly just prior to attachment of a portable milking machine. Butterfat was determined by the standard Babcock procedure, total solids by drying a three milliliter milk sample in an aluminum dish for four hours at 100°C in a forced-air oven and solids-not-fat by difference.

The second calf crop was sired by Charolais bulls. The mating procedure was as follows: first estrus, artificial insemination (23 days); second estrus, hand mating (22 days); followed by pasture exposure (45 days). The breeding season extended from February 17 to May 17, 1971. Rebreeding performance was evaluated on the basis of date of first observed estrus, date of apparent conception and pregnancy as determined by rectal palpation approximately 90 days after the breeding season.

Statistical Analysis

The data were subjected to analysis of variance using Hereford, Holstein and Hereford X Holstein females and Moderate and High levels of winter supplementation in a 3 x 2 factorial arrangement. The Very High Holstein females were excluded from the analyses for determining breed, treatment and breed x treatment effects and were compared to other breed-treatment groups by using the Student's "t" test for samples of equal and unequal sizes (Snedecor and Cochran, 1967). Due to extremely small F values, little, if any, evidence existed for breed x treatment interactions; therefore, breed effects were examined across breeds.

Standard errors were put on the means by using:

$$s_{\bar{x}} = \sqrt{\frac{s^2}{n}}$$

where

$s_{\bar{x}}$ is the standard error of the mean

s^2 is the estimated variance (error mean square)

n is the number of observations in that particular mean.

It should be noted that the drylot standard errors apply to all breed-treatment groups since n = 5 in all cases. In the range phase, n varied from 11 to 13; therefore, the standard errors reported are termed approximate standard errors since they have been computed with n = 12.

The analysis used for testing for significant differences between means was the Student's "t" test. In the drylot phase and within breed in the range phase, equal sample numbers existed. The analysis used was as follows:

$$s_{\bar{x}_1 - \bar{x}_2} = \sqrt{\frac{2\,s^2}{n}}$$

where,

$s_{\bar{x}_1 - \bar{x}_2}$ is the standard error of difference

s^2 is the estimated variance (error mean square)

n is the common sample size

The degrees of freedom were 2n - 2.

Within unequal sample numbers, the analysis used was as follows:

$$s_{\bar{x}_1 - \bar{x}_2} = \sqrt{s^2 \left(\frac{n_1 + n_2}{n_1 n_2} \right)}$$

where

$s_{\bar{x}_1 - \bar{x}_2}$ is the standard error of the difference

s^2 is the estimated variance (error mean square)

n_1 is the number of observations in group one

n_2 is the number of observations in group two.

The degrees of freedom were $(n_1 - 1) + (n_2 - 1)$.

The "t" test was calculated from the following formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s_{\bar{x}_1 - \bar{x}_2}}$$

CHAPTER IV

RESULTS AND DISCUSSION

Feed Intake

Total winter supplement intake by breed-treatment groups were approximately equal between range and drylot (Table I). In order to provide the drylot females with a higher quality roughage (alfalfa) than cottonseed hulls by spring and also feed approximately the same amount of winter supplement, it was necessary to feed the supplement daily for a 136-day period.

In drylot, level of supplementation did not appear to influence the intake of roughage (cottonseed hulls), with one exception. Very High Holsteins received 1.3 kilogram per head daily more supplement than the High Holstein females, but consumed 3.0 kilograms per head daily less cottonseed hulls. The estimated daily DE intake of both groups was 33.5 megacals which was very near the recommended N.R.C. requirement for growth, maintenance and lactation. Intake of range forage was not measured, but cow weights suggested that increases in level of supplementation resulted in decreased forage intake, since there were less differences in body weight due to level of supplementation within breed on range than in drylot (Figure 1).

Intake of roughage and estimated DE in drylot appeared to be influenced by breed, as might be expected since the heavier milking breeds were also larger. In the range phase, the Moderate Hereford

TABLE I

MEANS OF SUPPLEMENT AND ROUGHAGE INTAKES

Item	Breed and Level of Winter Supplementation						
	Hereford		Hereford x Holstein		Holstein		
	Moderate	High	Moderate	High	Moderate	High	Very High
Range cows							
Supplement, kg							
Total winter[1]	198	332	234	401	270	430	547
Daily, winter	1.1	2.0	1.4	2.3	1.6	2.5	3.2
Daily, pre-calving	0.9	0.9	1.4	1.4	1.8	1.8	1.8
Daily, post-calving	1.2	2.2	1.4	2.5	1.5	2.6	3.5
Drylot cows							
Supplement, kg							
Total winter[2]	207	356	230	365	274	452	571
Daily, winter	1.5	2.6	1.7	2.7	2.0	3.3	4.2
Daily, pre-calving	0.9	0.9	1.4	1.4	1.8	1.8	1.8
Daily, post-calving	1.7	3.2	1.8	3.3	2.0	3.8	5.1
Roughage ration, kg							
Cottonseed hulls	938.6	958.0	1086.5	1037.5	1346.9	1423.5	1170.3
Alfalfa hay, chopped	581.7	577.5	714.5	690.3	897.0	871.8	899.8
Mixed	832.5	859.0	981.7	897.3	1203.7	1146.3	1131.7
Total	2352.8	2394.5	2782.7	2625.1	3447.6	3441.6	3201.8
Total roughage, %[3]	100	102	118	112	147	146	136
Estimated daily post-calving DE intake, Mcal	20.0	21.8	23.6	23.7	28.9	30.3	30.2
Estimated daily post-calving DP intake, kg	0.86	0.99	1.02	1.08	1.23	1.35	1.42
Drylot calves							
Creep, total, kg	246.7	249.0	307.1	274.7	281.7	245.8	351.6
Estimated daily DE intake, Mcal[4]	7.1	7.0	10.4	9.9	11.3	11.7	13.3
Estimated daily DP intake, kg[4]	0.26	0.26	0.39	0.38	0.43	0.46	0.51

[1] November 9, 1970 - April 30, 1971, 172 days.

[2] November 9, 1970 - March 25, 1971, 136 days.

[3] Expressed as percent of Moderate Herefords.

[4] Creep plus milk.

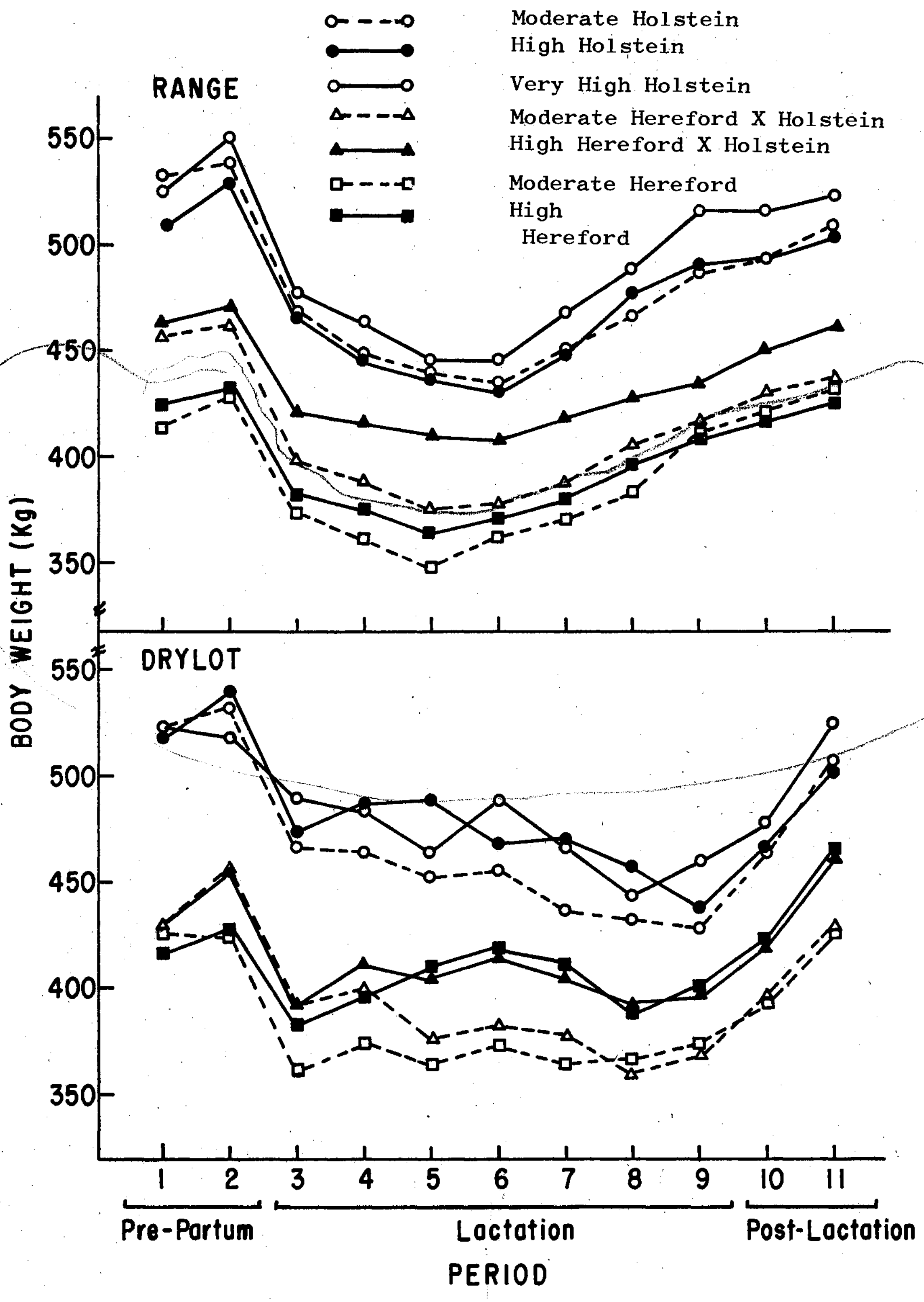

Figure 1. Average Body Weight Curves

females gained the most body weight, whereas the Moderate Hereford X Holstein and Moderate Holstein females gained the least during the year; therefore, it appears that heavy milking range females do not consume sufficient roughage to compensate for inadequate supplementation to meet their higher energy requirements. All females received more than the calculated daily digestible protein requirement for growth, maintenance and lactation, but received less than the calculated daily digestible energy requirement as suggested by N.R.C. The DE deficiency ranged from 6.0 megacals per head daily for the High Hereford females to 11.8 megacals per head daily for the Moderate Hereford X Holstein and Moderate Holstein females. However, the N.R.C. energy requirements for lactating beef cows are based on maintaining the cow weight without weight gain or loss. It has been shown that beef females under range conditions can maintain a high level of reproductive performance even though deficient in energy as indicated by considerable body weight loss (Pinney *et al.*, 1962b).

The range calves weaned considerably heavier than the drylot calves, primarily because of reduced forage intake since milk consumption in both phases was almost identical within breed-treatment groups. The high roughage creep-feed provided the drylot calves contained sufficient DE (kcal/kg) and DP (%) for adequate gains had anticipated consumption been realized. Poor creep-feed intakes were attributed to lack of sufficient knowledge of eating habits of the calves, individual feeding and fineness of grind and dustiness of the ration.

Weight and Condition of Cows

All females in both phases lost considerable weight during the wintering period in addition to weight loss due to calving, suggesting some sacrifice of body tissue for milk production (Table II). Both on range and in drylot, the amount of weight loss decreased as level of winter supplementation increased, resulting in a significant ($P < .01$) treatment effect for winter weight loss. The range Holstein females lost significantly more ($P < .01$) weight during the supplementation period than the Hereford females, but a significant breed effect was not noted in drylot ($P > .05$) probably because of the small number of animals in the drylot phase.

Summer weight gain was significantly ($P < .05$) affected by winter supplementation in drylot. Summer gains increased as level of winter supplementation decreased and winter weight loss increased. The Moderate females apparently had the ability to compensate for previous growth restrictions when adequate nutrition was available. This inverse relationship has been observed by numerous workers (Jourbet, 1954; Nelson _et_ _al_., 1954; Zimmerman, 1960; Clanton and Zimmerman, 1970; Hughes, 1971). On the range only the Moderate Hereford females made compensatory summer gains. Apparently in cows with greater genetic potential for milk production, nutrient demands for lactation have priority over compensatory body weight gain under range conditions. No significant breed differences were noted for the drylot females ($P > .05$), but on the range, the Holstein and Hereford females gained significantly more ($P < .05$) than the Hereford X Holstein females during the summer. The reason is not apparent.

For the entire year, all females gained weight except the Moderate Hereford X Holstein females managed under drylot conditions and the Moderate Hereford X Holstein and Moderate Holstein females on the range; these females only maintained their initial weight. The Hereford females gained the most in both phases, but only significantly more ($P < .01$) than the Hereford X Holstein and Holstein females on the range. The females increased from two to three years of age during this study, an interval during which they should increase in weight if accomplishing a "normal growth curve." The failure of the higher milking females particularly those on the lowest level of supplementation, to increase substantially in weight may result in poorer performance later (Johnson, Moxon and Smith, 1952). A significant ($P < .01$) treatment effect was noted on range with the High females gaining more than the Moderate females. The lower milking Herefords provided an exception; those on the Moderate level received adequate supplementation to meet all demands for production and increased in body weight as much as those in the High level.

Condition scores closely followed the weight change patterns. The mid-lactation condition scores decreased as level of supplementation decreased and the Moderate females exhibited a compensating effect (larger increases than the High females) when adequate nutrition was available (Table II). A significant ($P < .01$) treatment effect for spring condition score existed in both phases with females on the High treatments exhibiting a higher condition than those on the Moderate treatments.

The cow weights by period, including pre-partum, lactation and post-lactation periods, are presented graphically in Figure 1. All breed-treatment groups in both phases tended to increase in body weight until calving and then showed a drastic reduction in weight corresponding to calving loss after period two. All range females

TABLE II

MEANS AND STANDARD ERRORS OF WEIGHT, WEIGHT CHANGE AND CONDITION

	Breed and Level of Winter Supplementation							
	Hereford		Hereford x Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE[1]
Range								
Weight (kg)								
Fall (pre-calving)	402^{c}	411^{c}	449^{b}	453^{b}	523^{a}	495^{a}	508^{a}	12
Spring (mid-lactation)	342^{c}	358^{c}	370^{bc}	401^{ab}	430^{a}	418^{a}	434^{a}	12
Fall (post-lactation)	448^{b}	447^{b}	451^{b}	480^{b}	524^{a}	525^{a}	545^{a}	13
Weight change (kg)								
Winter[3]	-60^{ab}	-53^{a}	-79^{cd}	-52^{a}	-93^{d}	-77^{cd}	-74^{bc}	6.1
Summer	106^{ab}	89^{c}	81^{c}	79^{c}	94^{bc}	107^{ab}	111^{a}	5.7
Year[3]	46^{a}	36^{a}	2^{b}	27^{a}	1^{b}	30^{a}	37^{a}	6.7
Weight change (%)								
Winter	-15	-13	-18	-11	-18	-16	-15	
Summer	31	25	22	20	22	26	26	
Year	11	9	0	6	0	5	7	
Condition Score[2]								
Fall (pre-calving)	6.17^{a}	6.33^{a}	5.00^{b}	5.08^{b}	4.27^{c}	3.55^{c}	4.27^{c}	0.25
Spring (mid-lactation)[3]	4.83^{b}	5.58^{a}	3.85^{c}	4.77^{b}	2.09^{e}	2.09^{e}	3.09^{d}	0.27
Fall (post-lactation)	5.25^{a}	5.58^{a}	4.38^{b}	4.69^{b}	3.36^{d}	3.00^{d}	3.73^{c}	0.20
Drylot								
Weight (kg)								
Fall (pre-calving)	407^{c}	405^{c}	449^{bc}	439^{c}	500^{ab}	507^{a}	498^{ab}	41
Spring (mid-lactation)[4]	351^{b}	400^{ab}	357^{b}	399^{ab}	419^{a}	449^{a}	453^{a}	42
Fall (post-lactation)	446^{b}	467^{b}	448^{b}	475^{ab}	536^{a}	531^{a}	530^{a}	48
Weight change (kg)								
Winter[3]	-56^{bc}	-5^{a}	-92^{c}	-40^{ab}	-81^{bc}	-58^{bc}	-45^{ab}	16
Summer[4]	95^{ab}	67^{b}	91^{ab}	76^{b}	117^{a}	82^{ab}	77^{b}	29
Year	39^{ab}	62^{a}	-1^{b}	36^{ab}	36^{ab}	24^{ab}	32^{ab}	32
Weight change (%)								
Winter	-14	-1	-20	-9	-16	-11	-9	
Summer	27	17	25	19	28	18	17	
Year	10	15	0	8	7	5	6	
Condition Score[2]								
Fall (pre-calving)	5.80^{a}	5.80^{a}	4.20^{bc}	4.60^{b}	3.60^{c}	4.00^{bc}	4.20^{bc}	0.33
Spring (mid-lactation)[5]	4.60^{b}	6.80^{a}	3.60^{bc}	4.60^{b}	2.60^{c}	4.00^{b}	4.60^{b}	0.46
Fall (post-lactation)	5.60^{ab}	6.60^{a}	4.60^{bc}	4.60^{bc}	3.60^{c}	4.40^{c}	4.40^{c}	0.40

[1] Approximate standard error: range, n = 12; drylot, n = 5.

[2] Condition score: very fat = 9, . . . very thin = 1.

[3] Significant treatment effect ($P < .01$).

[4] Significant treatment effect ($P < .05$).

[5] Significant treatment effect ($P < .001$).

[a,b,c,d,e] Means on the same line with differing superscripts differ significantly ($P < .05$).

continued to lose weight during the wintering period and reached their lowest weight during the fifth or sixth periods (March or April on the average), after which a steady increase in weight until weaning was noted. Weight curves for the three breeds remained dispersed throughout the year, although the Moderate Hereford X Holstein curve approached that of the Herefords. There was no significant treatment effect within any breed for any period ($P > .05$).

Calf Growth

At birth, the range Angus X Holstein calves were significantly heavier ($P < .001$) than the Angus X Hereford X Holstein and Angus X Hereford calves, while the drylot Angus X Holstein calves were only significantly ($P < .05$) heavier than the Angus X Hereford calves (Table III). These differences were probably due to the larger body size of the Holstein females since they weighed significantly ($P < .01$) more than the Hereford X Holstein and Hereford females both on range and in drylot.

At weaning, the range Angus X Holstein calves weighed 26 kilograms more ($P < .01$) than the Angus X Hereford X Holstein calves (Table III). The Angus X Hereford X Holstein calves weaned 24 ($P < .01$) and 42 kilograms ($P < .01$) heavier than the Angus X Hereford calves on range and in drylot, respectively. The Angus X Holstein calves weaned 50 ($P < .01$) and 63 kilograms ($P < .001$) heavier than the Angus X Hereford calves on range and in drylot, respectively. There was no significant treatment difference within breed for 240-day sex-corrected weaning weight ($P < .05$). The Very High Angus X Holstein calves were significantly ($P < .01$) heavier than the Moderate and High Angus X

TABLE III

MEANS AND STANDARD ERRORS OF CALVING AND WEANING DATA

	Breed and Level of Supplementation							
	Hereford		Hereford x Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE[1]
Range								
No. of calves	12	12	13	13	11	11	11	
Male	5	6	6	6	4	4	9	
Female	7	6	7	7	7	7	2	
Calving date (day of year)	364^a	364^a	353^a	353^a	356^a	358^a	354^a	6.4
Birth weight (kg)	29.1^b	29.2^b	31.3^b	29.2^b	36.2^a	37.2^a	37.1^a	1.1
Adjusted weaning weight(kg)	230^c	227^c	250^b	256^b	275^a	282^a	288^a	6.6
Drylot								
No. of calves	5	5	5	5	5	5	5	
Male	1	0	4	3	0	2	4	
Female	4	5	1	2	5	3	1	
Calving date (day of year)	353^a	355^a	356^a	355^a	354^a	354^a	360^a	9.8
Birth weight (kg)	29.4^c	28.4^c	34.3^{abc}	30.0^{bc}	34.9^{ab}	35.6^a	35.1^{ab}	1.9
Adjusted weaning weight(kg)	179^c	196^c	230^b	229^b	249^{ab}	253^{ab}	261^a	8.8

[1] Approximate standard error: range, n=12; drylot, n=5

[a,b,c] Means on the same line with differing superscripts differ significantly (P ∠ .05).

Hereford X Holstein and Hereford calves in both phases as would be expected since they received more milk and had greater genetic potential for growth.

Milk Production

In both the range and drylot phases, the Holstein females produced the greatest entire lactation milk yield, followed by the Hereford X Holstein and Hereford females (Table IV). All differences among breeds were highly significant ($P < .001$). The estimated daily milk yield of 11.0 kilograms for Holstein females in both range and drylot phases agrees with estimates of Plum and Harris (1971). The range and drylot Hereford X Holstein females produced 8.3 kilograms of milk daily which agrees with reports of Gillooly *et al.* (1967) and Wilson *et al.* (1969), but is higher than reports of Walker and Pos (1963), Deutscher and Whiteman (1971) and Hendrix (1971); however, most beef x dairy milk estimates in the literature have been with Angus X Holstein females. The daily milk yield of Hereford females ranged from 4.8 (drylot) to 5.7 kilograms (range). These results are supported by Caldwell *et al.* (1962), Melton *et al.* (1967 a,b), Gleddie and Berg (1968), Dickey *et al.* (1970) and Rutledge *et al.* (1971).

Lactation curves for the three breed groups remained dispersed throughout the lactation in both the range and drylot phases, indicating that three different milk production potentials had indeed been established by the three breed groups used in this experiment (Figure 2). It should be noted that the range Holstein females actually produced as much milk during late lactation as during early

TABLE IV

MEANS AND STANDARD ERRORS OF MILK PRODUCTION AND MILK COMPOSITION DATA

	Breed and Level of Supplementation							
	Hereford		Hereford x Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE[1]
Range								
Total lactation yield(kg)	1308	1402	1884	2107	2566	2673	2700	
Daily yield (kg)[2]	5.45^{d}	5.84^{d}	7.85^{c}	8.78^{b}	10.69^{a}	11.14^{c}	11.25^{a}	0.34
Drylot								
Total lactation yield(kg)	1135	1162	1985	1997	2395	2722	2810	
Daily yield (kg)	4.73^{d}	4.84^{d}	8.27^{c}	8.32^{c}	9.98^{b}	11.34^{a}	11.71^{a}	0.38
Butterfat (%)[3]	2.57^{c}	2.78^{bc}	3.01^{ab}	3.15^{a}	2.84^{bc}	3.23^{a}	3.25^{a}	0.10
Total solids (%)[3]	11.40^{c}	11.64^{abc}	11.54^{bc}	11.95^{a}	11.36^{c}	11.83^{ab}	11.80^{ab}	0.13
Solids-not-fat	8.84^{a}	8.86^{a}	8.53^{b}	8.80^{a}	8.52^{b}	8.60^{b}	8.54^{b}	0.072

[1] Approximate standard error: range, n = 12; drylot, n = 5.

[2] Significant treatment effect ($P < .05$).

[3] Significant treatment effect ($P \angle .01$).

[a,b,c,d] Means on the same line with differing superscripts differ significantly ($P \angle .05$).

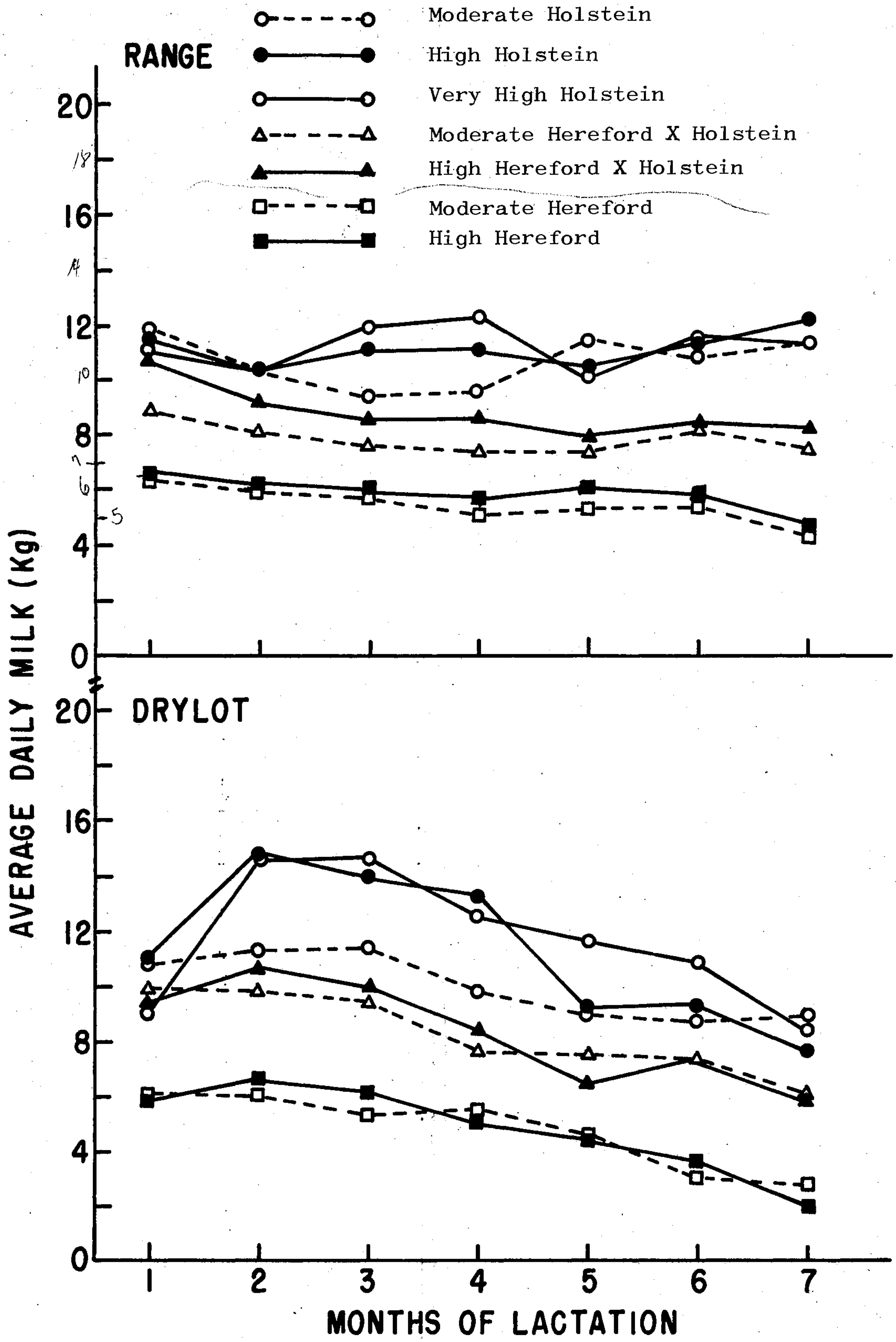

Figure 2. Average Daily Milk Yield

lactation, while the drylot Holstein females produced somewhat lower milk yields than were expected when compared to the other breed groups during the first period. The lower early lactation yields may have been caused by the limited capacity of the calf for milk. Plum and Harris (1971), working with Holsteins under beef cattle management, reported that the amount of milk available for the calf was practically constant throughout the lactation, but the calves were unable to consume all of the milk during the first three months.

The range lactation curves observed were much flatter than many previously reported, possibly due to the availability of spring grass at the time when milk yields normally decline as well as the generally excellent grass conditions throughout the summer 1971 grazing season.

From a comparison of the range and drylot lactation curves, it appears that the ad libitum consumption of cottonseed hulls in drylot was superior in providing protein and energy than the low quality pasture forage during the winter, but the alfalfa and high energy roughage ration (alfalfa: milo: molasses) was definitely inferior to spring and summer grass.

Milk production was definitely influenced by winter supplementation level in both the range and drylot phases. Significant ($P < .05$) treatment effects were noted in the drylot phase during periods 2, 3, and 4 (February, March and April) and in the range phase during periods 3 and 4 (March and April). Milk yields increased as level of supplementation increased within breed during the wintering period; however, the Moderate females in both phases tended to show a greater response to higher quality forage in the spring and summer by producing higher quantities of milk. Reduced protein and/or energy have been shown to result in reduced milk yields but females wintered at the lower levels generally exhibit an increase in milk production when forage of much higher quality becomes available (Harris et al., 1962, 1965; Furr and Nelson 1964; Bond et al., 1964; Huber et al., 1964; Dunn et al., 1965; Lamond et al., 1969 ; Gillooly et al., 1967; Wilson et al., 1969).

In the range phase, no treatment appeared to be superior or inferior in milk yield than the other treatments within the Holsteins except for periods 3 and 4 (March and April), during which the Moderate Holstein females produced significantly less ($P < .01$) milk than the Very High Holstein females. However, when considering the entire lactation yield no significant differences were noted ($P > .05$). The High Hereford X Holstein females produced significantly ($P < .05$) more milk than the Moderate Hereford X Holstein females during the first period (January) and continued to produce higher yields during the remainder of the lactation; however, the differences in the last six periods were non-significant ($P > .05$). Due to the first period significance and greater production during the remainder of the lactation, the High Hereford X Holstein females produced significantly more ($P < .05$) milk for the entire lactation than the Moderate crossbred females. The High Hereford females tended to produce somewhat higher quantities of milk throughout the lactation than the Moderate Hereford females; however, the differences were non-significant ($P > .05$) for any period and for the entire lactation.

In the drylot phase, the Moderate Holstein females produced significantly less ($P < .01$) milk that the High or Very High Holstein females during periods 2, 3 and 4. Due to these significant period differences and the tendency of the Moderate Holstein females to yield less milk throughout the lactation than the other two Holstein treatments, a significant ($P < .05$) treatment difference for the entire lactation yield was noted. No trend existed for treatment superiority in either the Hereford X Holstein or Hereford females for any period during the lactation or entire lactation yield.

It should be noted that all significant period differences, except the range Hereford X Holstein first period difference, occurred during late winter when level of supplementation should have had its greatest effect. Digestible energy intakes and body weight changes suggest a tendency for increased roughage intakes to compensate for decreased supplementation and a higher priority of nutrients for lactation than body gain. However, the digestible energy and protein intakes by the Moderate Holstein females were too low to support maintenance, growth and lactation; therefore, resulting in reduced milk yields and increased weight losses.

Milk Composition

No significant breed effect was noted for per cent total solids; however, the Holstein and Hereford X Holstein females yielded significantly higher ($P < .01$) per cent butterfat than the Hereford females (Table IV). When considering the yields of solids-not-fat, the Hereford females produced significantly higher ($P < .05$) yields than the Holstein females.

Significant treatment effects ($P < .05$) were noted for all three composition components with the High females producing greater per cent of each component than the Moderate females. Graves _et_ _al_. (1940)

noted that Holstein females produced lower butterfat percentages when alfalfa hay and pasture were provided ; whereas, Flux and Patchell (1954), Huber et al. (1964) and Huber and Bowan (1966) reported that reduced energy levels increased per cent butterfat of dairy females. Gillooly et al. (1967) and Wilson et al. (1969), studying Angus X Holstein females, and Arnett (1963), studying beef females, reported that energy differences had no significant effect on per cent butterfat. Lamond et al. (1969) noted a reduction in butterfat percentages when females were provided poor quality (low energy) pasture. Therefore, it appears that energy levels derived from alfalfa hay and poor quality pasture may result in reduced butterfat yields which may account for the low values obtained in this experiment. Also the short time (6 hours) between complete nurse out and milk sampling may have reduced butterfat percentages.

The per cent solids-not-fat increased as energy levels increased which agrees with results reported by numerous workers (Flux and Patchell, 1954; Huber et al., 1964; Gillooly et al., 1967; Wilson et al., 1969).

Reproductive Performance

Breed effects for days to first observed estrus and days to apparent conception were non-significant ($P > .05$) in both phases (Table V).

In drylot, significant treatment effects were noted for days to first observed estrus ($P < .001$) and days to apparent conception decreased as level of supplementation increased. On range, treatment differences in these reproductive traits were smaller and non-signifi-

TABLE V

MEANS AND STANDARD ERRORS OF REPRODUCTIVE PERFORMANCE DATA

	Breed and Level of Supplementation							
	Hereford		Hereford x Holstein		Holstein			
Item	Moderate	High	Moderate	High	Moderate	High	Very High	SE[1]
Range								
No. of cows exhibiting estrus	12-12	12-12	13-13	13-13	8-11	9-11	11-11	
Days to first observed estrus[2]	71^{a}	62^{a}	82^{a}	68^{a}	83^{a}	71^{a}	65^{a}	8.5
Days to apparent conception[3]	78^{ab}	75^{a}	100^{b}	94^{ab}	89^{ab}	90^{ab}	77^{ab}	8.5
No. of cows bred	12	12	13	13	8	9	11	
Drylot								
No. of cows exhibiting estrus	5-5	5-5	5-5	5-5	4-5	5-5	5-5	
Days to first observed estrus[2,4]	101^{d}	57^{c}	79^{cd}	56^{c}	108^{d}	56^{c}	55^{c}	10.0
Days to apparent conception[3,5]	118^{d}	74^{c}	107^{cd}	75^{c}	108^{cd}	96^{cd}	83^{c}	12.0
No. of cows bred	5	5	4	5	3	5	5	

[1] Approximate standard error; range, n = 12; drylot, n = 5.

[2] Analysis on only those females to exhibit estrus.

[3] Analysis on only those females that apparently conceived.

[4] Significant treatment effect ($P < .001$).

[5] Significant treatment effect ($P < .01$).

[a,b] Means on the same line with differing superscript differ significantly ($P < .05$).

[c,d] Means on the same line with differing superscript differ significantly ($P < .01$).

($P > .05$), but the same trends were noted.

In the range phase, all Hereford and Hereford X Holstein females at both levels of supplementation and all Very High Holstein females rebred during the 90-day breeding season. Three of 11 (27%) of the Moderate Holsteins and two of 11 (18%) of the High Holsteins failed to rebreed; the open females were never observed in estrus during the breeding season. In the drylot phase, all Herefords at both supplement levels, all High Hereford X Holsteins and all High and Very High Holsteins rebred, while one of five Moderate Hereford X Holsteins and two of five Moderate Holsteins failed to rebreed. One Moderate Holstein female that did not conceive had been observed in estrus and apparently bred; however, the other two females were never observed in estrus.

Considering both range and drylot, 100% conception was attained by Moderate Herefords, High Herefords, High Hereford X Holsteins and Very High Holsteins, while 94% (17 of 18) of the Moderate Hereford X Holsteins, 87% (14 of 16) of the High Holsteins and 69% (11 of 16) of the Moderate Holsteins rebred.

These results suggest that, to support reproduction in addition to maintenance, growth and lactation in two-year-old range females, the Moderate, High and Very High levels of supplementation are adequate for low (Hereford), intermediate (Hereford X Holstein) and high (Holstein) levels of milk production, respectively. The Moderate level was adequate, or nearly so, for Hereford X Holsteins, but definitely inadequate for Holstein females. Furthermore, the High level appeared inadequate for Holsteins.

Decreased post-partum interval and improved conception due to higher levels of supplementation of range cows have also been observed by Wiltbank _et al_. (1962, 1964),Smithson _et al_. (1964), Turman _et al_. (1964), Christenson _et al_. 1967), Dunn _et al_. (1969) and Clanton and Zimmerman (1970). Deutscher and Whiteman (1971) and McGinty _et al_. (1971) have reported poor reproductive performance by beef X dairy crossbreds managed under beef cattle conditions. Apparently, even in the Moderate level of supplementation, the nutritional environment in this study was more adequate, since the Moderate Hereford X Holstein females weaned heavier calves and rebred almost as well as the Moderate Herefords.

CHAPTER V

SUMMARY

The productivity as two-year-olds of 48 Holstein, 36 Hereford X Holstein and 34 Hereford females was compared under tallgrass range and drylot confinement conditions. Hereford and Hereford X Holstein females were fed at two levels of winter supplementation, while the Holstein females were fed at three levels. The levels were designated as Moderate, High and Very High. The base breed-treatment groups were the Moderate Hereford, High Hereford X Holstein and Very High Holstein females which were fed an average of 1.7, 3.4 and 5.0 kg/head/day of a 30% crude protein range supplement, respectively. Within each nutritional treatment, the quantity of supplement fed each female was adjusted for differences in body size on the basis of metabolic weight ($W^{.75}$). The drylot feeding program consisted of the same supplement used on range, plus additional roughage and grain as necessary to approximate the weight change pattern of the females on grass. All heifers were bred to Angus bulls as yearlings and exposed to Charolais bulls as two-year-olds. Cow and calf weights were taken at monthly intervals and cow condition was determined at pre-calving, mid-lactation and post-lactation intervals. All calves were weaned at 240 ± 7 days and adjusted for age and sex. Daily milk production was estimated at monthly intervals by the calf-nursing technique. Conception rate was determined by rectal palpation approximately

90 days after termination of the breeding season.

In the range and drylot phases, the amount of cow body weight loss during the winter decreased as level of supplementation increased, resulting in a significant ($P < .01$) treatment effect. The Moderate females exhibited larger summer gains; thereby, compensating for growth restrictions when adequate nutrition was available. Condition scores closely followed the trends of winter weight losses and summer weight gains.

A definite trend existed for increased birth weights of the Angus X Holstein calves. The 240-day sex-corrected weaning weights in the range phase were 229, 253 and 279 kilograms for Angus X Hereford, Angus X Hereford X Holstein and Angus X Holstein, respectively. In the drylot phase, the Angus X Hereford, Angus X Hereford X Holstein and Angus X Holstein calves weighed 188, 230 and 251 kilograms, respectively at weaning. There were no significant treatment differences within breed for 240-day sex-corrected weaning weight.

The Holstein females produced the greatest mean daily milk yield (11.0 kilograms daily), followed, respectively, by the Hereford X Holstein (8.3 kilograms daily) and the Hereford females (5.2 kilograms daily). All differences among breeds were highly significant ($P < .001$). For entire lactation yield, no significant differences between treatments within breed were noted, except for the range Hereford X Holstein and drylot Holstein females. In the range phase, the High Hereford X Holstein females produced significantly more ($P < .05$) milk than the Moderate crossbred females. In the drylot phase, the Moderate Holstein females produced significantly less ($P < .05$) milk than the High and Very High females. Significant ($P < .01$) treatment effects were noted on range during periods 3 and 4 (March and April) and in the drylot phase during periods 2, 3, and 4 (February, March and April) when level of supplementation should have had its greatest effect; milk yields increased as level of supplementation increased.

The number of days from calving to first observed estrus and days from calving to apparent conception tended to decrease as level of supplementation increased. Considering both range and drylot phases, 100% conception was attained by Moderate Hereford, High Herefords, High Hereford X Holstein and Very High Holsteins, while 94% (17 of 18) of the Moderate Hereford X Holstein, 87% (14 of 16) of the High Holstein and 69% (11 of 16) of the Moderate Holsteins rebred.

The results of this study indicate that two-year-old Hereford X Holstein females are capable of producing more milk and weaning heavier calves with comparable reproductive performance on the same level of winter supplementation as Hereford females when ample forage is available, but due to their larger body size require more forage (acres) per cow-calf unit. The Holstein females were superior to the other breeds in this study in milk yield and calf weaning weights, but were at some disadvantage due to increased forage (acreage) requirement per cow-calf unit, poor reproductive performance at low levels of winter supplementation and high supplement costs at the Very High Level which may represent the level of winter supplementation necessary for two-year-old Holsteins under range conditions.

LITERATURE CITED

Anthony, W. B., P. F. Parks, E. L. Mayton, V. L. Brown, J. G. Starling and T. B. Patterson. 1959. A new technique for securing milk production data for beef cows nursing calves in nutrition studies. J. Anim. Sci. 18:1541. (Abstr.).

Arnett, D. W. 1963. Studies with twin beef females. I. Some effects of level of nutrition. II. Milk production techniques. Ph.D. Thesis. Oklahoma State University, Stillwater Oklahoma.

Baker, T. A. and A. E. Tomhave. 1944. The intensity of feeding as related to milk production. Del. Agr. Exp. Sta. Bull. 248.

Bond, J., J. N. Wiltbank, E. J. Warwick, R. P. Lehmann and T. B. Kinney. 1964. Feed intake and milk production of beef cows. J. Anim. Sci. 23: 901. (Abstr).

Boyd, L. J., D. M. Seath and Durward Olds. 1954. Relationship between level of milk production and breeding efficiency in dairy cattle. J. Anim. Sci. 13: 89.

Boyd, L. J. 1967. Does production affect breeding efficiency. Hoards Dairyman 112:1276.

Broster, W. H., Valerie J. Tuck and C. C. Balch. 1964. Experiments on the nutrition of the dairy heifer. J. Agri. Sci. 63:51.

Broster, W. H. and Valerie J. Tuck. 1967. The effect on milk production of the level of feeding during the last six months of pregnancy and first eight weeks of lactation. J. Agri. Sci. 69:465.

Brumby, P. J., D. K. Walker and R. M. Gallagher. 1963. Factors associated with growth in beef cattle. New Zeal. J. Agr. Res. 6:256.

Caldwell, J., T. B. Patterson and W. B. Anthony, 1962. Influence of total milk production, butterfat, protein, total solids, change in cow weight and their interrelationships in beef cows. J. Anim. Sci. 21:381. (Abstr.).

Casida, L. E. 1968. Studies on the post-partum cow. Wis. Agri. Exp. Sta. Res. Bull. 270.

Chow, G., J. K. Riggs and L. M. Schake. 1967. Frequency of milking and milk yield of beef cows. J. Anim. Sci. 26:202. (Abstr.).

Christenson, R. K., D. R. Zimmerman, D. C. Clanton, L. E. Jones, R. L. Tribble and R. Sotomajor. 1967. Effect of pre-calving energy levels on performance of beef heifers. J. Anim. Sci. 26:916. (Abstr.).

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

Clanton, D. C. and D. R. Zimmerman. 1970. Symposium on pasture methods for maximum production in beef cattle: Protein and energy requirements for female beef cattle. J. Anim. Sci. 30: 122.

Cole, L. J. and I. Johansson. 1948. Inheritance in crosses of Jersey and Holstein-Friesian with Aberdeen-Angus cattle. Amer. Natur. 82:265.

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

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

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

Dickey, J. R., M. Koger, D. E. Franke and W. C. Burns. 1970. Milk production in beef cattle. J. Anim. Sci. 30: 317. (Abstr.).

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

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

Dunn, T. G., J. E. Ingalls, D. R. Zimmerman and J. N. Wiltbank. 1969. Reproductive performance of two-year-old Hereford and Angus heifers as influenced by pre-and post-calving energy intake. J. Anim. Sci. 29:719.

Elliott, G. M. 1959. The effect of milk yield of the length of milking intervals used in twice a day milking, twice and three times a day milking and incomplete milking. A review. Dairy Sci. Abstrs. 21:481.

Flux, D. S. and M. R. Patchell. 1954. The effect of undernutrition after calving on the quantity and composition of the milk produced by dairy cattle. J. Agr. Sci. 45:246.

Flux, D. S. and M. R. Patchell. 1957. The effect of short periods of undernutrition after calving on the establishment of lactation in dairy cows. New Zeal. J. Sci. Tech. 38:689.

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

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

Gaines, W. L. 1927. Milk yield in relation to recurrence of conception. J. Dairy Sci. 10:117.

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

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. (Abstr.).

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

Gowen, J. W. 1918. Studies in inheritance of certain characters of crosses between dairy and beef breeds of cattle. J. Agr. Res. 15:1.

Graves, R. R., G. Q. Bateman, J. B. Shepherd and G. B. Carni. 1940. Milk and butterfat production by dairy cows on four different planes of feeding. U.S.D.A. Tech. Bull. 724.

Gregory, K. E., C. T. Blunn and M. L. Baker. 1950. A study of some of the factors influencing the birth and weaning weights of beef calves. J. Anim. Sci. 9:338.

Harris, R. R., W. B. Anthony and V. L. Brown. 1962. Effect of winter feeding level of beef cows upon milk production and calf performance. J. Anim. Sci. 21:385. (Abstr.).

Harris, R. R., V. L. Brown, W. B. Anthony, J. G. Starling, E. L. Mayton and L. A. Smith. 1963. Milk production potentials for beef type cows. Feed Bag 39:40 (Dec.).

Harris R. R., V. L. Brown and W. B. Anthony. 1965. Effect of plane of nutrition upon performance of beef cows and their calves. J. Anim. Sci. 24:280. (Abstr.).

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

Holland, G. L. 1961. The influence of excessive body fatness on the performance of beef females. Ph.D. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Holloway, J. W. 1971. The influence of preweaning plane of nutrition on growth, lactation and reproduction of the beef female. M. S. Thesis. Oklahoma State University, Stillwater, Oklahoma.

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.

Huber, J. T. and R. L. Bowan. 1966. Effect of grain level and protein content of the grain for grazing cows on milk composition and yield and certain blood and rumen constituents. J. Dairy Sci. 49:395.

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

Johnson, L. E., A. L. Moxon and R. L. Smith. 1952. Wintering beef cows on South Dakota ranges. S. Dak. Agri. Exp. Sta. Bull. 419.

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

Klett, R. H., T. R. Mason and J. K Riggs. 1962. Preliminary studies on milk production of beef cows. Tex. Agr. Exp. Sta. Misc. Pub. 591:79.

Klett, R. H., T. R. Mason and J. K. Riggs. 1965. Milk production of beef cows and its relationship to the weaning weight of their calves. J. Anim. Sci. 24:586. (Abstr.).

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.

Koch, R. M. 1969. Influence of dam's environment on offspring phenotype. J. Anim. Sci. 29:108. (Abstr.).

Konkoly, T. H. S. and G. Barczy. 1954. The milk production of cows which suckled their calves and that of cows milked without suckling. Anim. Breed. Abstrs. 23:135.

Lakshmanan, S., J. C. Shaw, R. E. McDowell, M. F. Ellmore and M. F. Fohrman. 1958. Short-interval milking as a physiological technique. I. Effect of frequent milking with the aid of oxytocin on milk and milk fat production. J. Dairy Sci. 41:1601.

Lam, C. F. Jr., D. R. Lamond, J. R. Hill, Jr. and C. B. Loadhelt. 1969. Three techniques for estimating milk production of beef cows. J. Anim. Sci. 29:109.

Lamond, D. R., J. H. G. Holmes and K. P. Haydock. 1969. Estimation of yield and composition of milk produced by grazing beef cows. J. Anim. Sci. 29:606.

Linnerud, A. D., E. V. Caruoio, G. E. Miller, G. D. Marx and J. D. Donker. 1966. Lactation studies. X. Total daily production as affected by number of times milked, number of times stimulated and method of stimulation. J. Dairy Sci. 49: 1529.

Mangus, W. L. and J. S. Brinks. 1971. Relationships between direct and maternal effects in growth in Herefords. I. Environmental factors during preweaning growth. J. Anim. Sci. 32:17.

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

Melton, A. A., T. C. Cartwright and L. A. Nelson. 1967b. Cow size as related to efficiency of calf gain. J. Anim. Sci. 26:206. (Abstr.).

McGinty, D. D., H. I. Essig and Maurice Belew. 1971. Factors affecting performance of beef cattle in confinement. Arizona Cattle Feeders Day. Series P-23. 9:9.

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

Nelson, A. B., O. B. Ross, A. E. Darlow, W. D. Campbell and R. W. MacVicar. 1954. Studies on winter rations for commercial beef cows. Okla. Agri. Exp. Sta. Bull. B-418.

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

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

N.R.C. 1966. Nutrient Requirements of Domestic Animals, No. 3. Nutrient Requirements of Dairy Cattle. National Research Council, Washington, D.C.

N.R.C. 1970. Nutrient Requirements of Domestic Animals, No. 4. Nutrient Requirements of Beef Cattle. National Research Council, Washington, D.C.

Olds, Durward and D. M. Seath. 1953. Repeatability, heritability and the effect of level of milk production on the occurrence of first estrus after calving in dairy cattle. J. Anim. Sci. 12:10.

Patchell, M. R. 1957. The influence of undernutrition of dairy cows on the yield and composition of milk. New Zeal. J. Sci. Tech. 38:681.

Peterson, W. E. 1942. New developments in the physiology and biochemistry of lactation, a review. J. Dairy Sci. 25:71.

Peterson, W. E. and T. V. Rigor. 1932. Relation of pressure to rate and quality of milk secreted. Proc. Soc. Exp. Biol. Med. 30:254.

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

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

Pinney, D. O., L. S. Pope, C. Van Cotthem and K. Urban. 1962a. Effect of winter plane of nutrition on the performance of three - and four-year-old beef cows. Okla. Agri. Exp. Sta. Misc. Pub. 67:50.

Pinney, D. O., L. S. Pope, D. Stephens and L. M. Henderson. 1962b. Lifetime performance of beef cows wintered each year on three different levels. Okla. Agr. Exp. Sta. Misc. Pub. 67:63.

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

Pope, L. S., L. Smithson, D. F. Stephens, D. O. Pinney and M. Velasco. 1963. Factors affecting milk production of range beef cows. Okla. Agri. Exp. Sta. Misc. Pub. 70:69.

Renbarger, R. E., L. J. Smithson, D. F. Stephens and L. S. Pope. 1964. Effect of nutrition before and after calving on performance of beef heifers. J. Anim. Sci. 23:293. (Abstr.).

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

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

Serwanja, J. C., J. A. Welch and H. E. Kidder. 1969. Dam's milk yield and composition on growth of Angus calves. J. Anim. Sci. 29:198. (Abstr.).

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

Smithson, L., S. A. Ewing, R. E. Renbarger and L. S. Pope. 1964. Effects of high or low winter feed levels in alternate years on growth and development of beef heifers. Okla. Agr. Exp. Sta. Misc. Pub. 74:78.

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

Swanson, E. W. 1956. Effect of nursing calves on milk production of identical twin heifers. J. Dairy Sci. 39:73.

Swanson, E. W. 1957. The effect of fattening dairy heifers upon the growth and lactation. J. Dairy Sci. 40:611. (Abstr.).

Swanson, E. W. and T. R. Spann. 1954. The effect of rapid growth with fattening upon lactation in cattle and rats. J. Anim. Sci. 13:1032. (Abstr.).

Totusek, Robert. 1968. Early weaning vs. normal weaning vs. creep feeding of heifer calves. Okla. Agr. Exp. Sta. Misc. Pub. 80:72.

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

Turman, E. J., L. Smithson, L. S. Pope R. E. Renbarger and D. F. Stephens. 1964. Effect of feed level before and after calving on the performance of two-year-old heifers. Okla. Agr. Exp. Sta. Misc. Pub. 74:10.

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

Walker, D. E. K. and H. G. Pos. 1963. Milk porduction of beef beef heifers. New Zeal. J. Agr. 107 (4):277.

Wilson, L. L., J. E. Gillooly, M. C. Rugh, C. E. Thompson and H. R. Purdy. 1969. Effects of energy intake, cow body size and calf sex on composition and yield of milk by Angus-Holstein cows and preweaning growth rate of progeny. J. Anim. Sci. 28:798

Wiltbank, J. N., W. W. Rowden, J. E. Ingalls, K. E. Gregory and R. M. Koch. 1962. Effect of energy level on reproductive phenomena of mature Hereford cows. J. Anim. Sci. 21:219.

Wiltbank, J. N., W. W. Rowden, J. E. Ingalls and D. R. Zimmerman. 1964. Influence of post-partum energy level on reproductive performance of Hereford cows restricted in enery intake prior to calving. J. Anim. Sci. 23:1049.

Zimmerman, J. E. 1958. Effect of different levels of wintering and different ages at first calving upon performance of beef cows. M. S. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Zimmerman, J. E. 1960. Part I. Effect of plane of nutrition on growth and reproductive performance of beef heifers. Part II. Effect of nutrient restriction on weight gains, feed utilization and body composition of male rats. Ph.D. Thesis, Oklahoma State University, Stillwater, Oklahoma.

PART II. RANGE BEHAVIOR OF HEREFORD, HOLSTEIN AND HEREFORD X HOLSTEIN HEIFERS

CHAPTER VI

INTRODUCTION

Studies of the grazing behavior of range cattle can help explain their response to the environment as well as give an insight toward their needs in relation to their requirements. Due to the almost total reliance of cattle on pasture and the great variaility of the forage due to seasons, all effort should be spared to investigate animal reactions (Hancock, 1950). Numerous behavioral studies have been conducted with beef cattle and lactating dairy cows; however, little or no information is available on the behavior of non-lactating dairy and beef X dairy crossbred females as compared to beef females under range conditions. The investigations reported herein were undertaken to obtain information on the behavior of non-lactating Hereford, Holstein and Hereford X Holstein heifers on tallgrass range.

CHAPTER VII

LITERATURE REVIEW

Many early workers studied the grazing behavior of cattle; however, no observations were made during the night on the assumptions that once the animals laid down in the evening they continued to rest until morning or sunrise. Furthermore, much of the published data on grazing behavior is difficult to evaluate because only a few animals were observed on a limited number of days.

Hein (1935) reported data collected over three 24-hour periods on the grazing behavior of beef steers. Abundance of forage appeared to be the limiting factor in determining the total time spent grazing. As the amount of forage increased, the time spent grazing tended to decrease. The peak grazing periods were between 5:00 p.m. and 8:00 p.m. in the evening and 5.00 a.m. and 8:00 a.m. in the early morning. A period of grazing was noted at twilight or during the night if moonlight was available.

Johnston-Wallace and Kennedy (1944) studied the grazing habits of beef cows over continuous 24-hour periods during July, August and September. Four trials were conducted, but only one animal was observed in each trial. During each 24-hour period,approximately seven to eight hours was spent grazing with only five hours actually spent gathering forage. On the average, 60 per cent of the grazing time was during the daylight hours. They also concluded that the time spent grazing was poorly related to forage intake since dry matter intake fluctuated from 32 to 10 pounds per cow, but grazing time remained almost constant.

Moorefield and Hopkins (1951) reported that the average time spent grazing was 9 hours and 54 minutes, 10 hours and 21 minutes and 10 hours and 25 minutes by a steer, heifer and cow, respectively.

Dwyer (1960) studied the grazing behavior of beef cows on true native Oklahoma prairie. Approximately 9.67 hours were spent in grazing with 82% occurring during the daylight. The total rumination time was 10.47 hours of which 57.8% occurred during darkness. The cattle preferred to ruminate in the lying position; as compared to standing (62.1 vs. 37.9%). Peak grazing times during early morning around sunrise and late evening were noted. A reduction in daylight grazing was noted when temperatures increased; however, the cattle failed to compensate for time lost in grazing by increasing their night-time grazing.

In a similar study, Furr (1962) reported three primary periods of grazing: (1) soon after the cattle arose in the morning (around daybreak); (2) sometime during the afternoon and/or evening; and (3) around midnight. Time between these periods was devoted primarily to ruminating and idling. A greater proportion of the rumination occurred during the nighttime. The cattle spent (on the average) 42, 37 and 19 per cent of their time grazing, ruminating and idling, respectively. Temperature changes and quality of forage appeared to alter per cent grazing time. Apparently, the cattle preferred to ruminate in the lying position and idle in the standing position.

Also in the study, a comparison was made between continuous observations and observations taken at 15-, 30- and 60- minute intervals. Reasonably accurate estimates of major activites were obtained using the 15-minute intervals; however, estimates of minor activities such as walking, sleeping, drinking, etc., did not appear adequate.

In an extensive review on grazing behavior, Hancock (1953) reported that day-to-day variations made the term "normal behavior" almost meaningless. Temperatures of the range encountered in the temperate zones appeared to have little effect on the time cattle spent grazing. Higher temperatures stimulated the cows to start grazing earlier in the day or caused a reduction of grazing during the mid-afternoon, but the cattle tended to increase their nightime grazing in order to compensate for time lost.

Cattle preferred to graze in daylight and only when the hours of light become very short as in winter or when the daytime temperatures are very hot as in summer do cattle spend an appreciable part of their grazing time in darkness.

Considering the effect of quality of pasture on grazing times, Hancock concluded that, if the quantity of the pasture is ample, the grazing times are long when the quality of the forage is mixed, intermediate when the quality is good and short when the quality is poor.

In summarizing, very little research has been done with pregnant heifers as the experimental animal in a grazing study. Most studies have employed too few animals for proper evaluation of behavior habits. Perhaps the main conclusion that can be drawn is that cattle, given time, will change their habits in order to meet the changes in their environment. Feed intake data also appears to be an essential tool in the proper evaluation of grazing studies.

CHAPTER VIII

MATERIALS AND METHODS

The behaviorial studies were conducted at the Fort Reno Research Station. The native range on the Fort Reno Station, classified in excellent condition, consists largely of little bluestem (Andropogon scorparius, big bluestem (Andropogon gerardi), switchgrass (Panicum virgatum), Indian grass (Sorghastrum nutans) and sideoats grama (Bouteloua curtipendula), and has a carrying capcacity of approximately seven acres per cow-calf unit on a yearlong basis. The range forage is normally dormant from early November (first frost) to late April. Ample forage was available at all times. The pastures used during the tests were approximately 160 acres in size. Only 10 animals per pasture were observed; therefore, stocking rate and forage were not limiting factors.

A total of 42 Hereford, 50 Holstein and 42 Hereford X Holstein heifers formed the animal pool from which 10 animals of each breed group were randomly selected prior to each seasonal observation. The same 10 heifers were used for both observational days within a season, then re-entered the animal pool before the random selection of observation heifers for the next season. Therefore, some of the heifers may have been observed during different seasons. Large numerals were painted with enamel paint on both sides of each cow and large numbered ear tags were used for identification purposes. This facilitated the identification of individuals from almost any angle of observation.

Eight 24-hour observations (two per season) were conducted during the study, namely: Winter- February 6-7 and March 13-14, 1970; Spring - May 26-27 and June 28-29; Summer - July 25-26 and August 28-29; and Fall - November 8-9 and December 4-5.

Each 24-hour period was divided into four six hour intervals: (1) 12 am - 6 am; (2) 6 am - 12 pm; (3) 12 pm - 6 pm; and (4) 6 pm - 12 am. This division was made in order to study day and night differences among breeds and to facilitate observor changes.

The observations were made by a team of six persons. One person was randomly assigned to each of three pastures. The observors watched and recorded activities for one interval (six hours) and then rested for six hours while the other three observors took their place. Therefore, during a given 24 hour period, observors watched for 12 hours and rested for 12 hours. It should be noted that observor was confounded with interval; however, every attempt was made to eliminate major observor effects by adopting a common nomenclature used to describe activities during all observations. All activities were observed and then recorded at the end of each 15 minute interval over the 24 hour period. Vehicles, generally pickup trucks, were used to follow the cattle in the pastures. Movement of the vehicles did not appear to disturb the herd at any time. Observors were generally at a distance of 80-100 and 40-50 yards from the cattle during the daytime and nighttime, respectively. During the day, field glasses were employed to identify the cattle and at night, it was usually necessary to employ a hand lamp to determine particular activities such as rumination and sleeping. Disturbance resulting from the use of the lamps appeared to be negligible.

The major activities studied were grazing, standing ruminating, lying ruminating, standing idle, lying idle and minor activities were sleeping, walking, drinking, and feeding. The following nomenclature was used during this study:

1. Grazing - time spent actually grazing plus short periods of walking while selecting suitable areas to be grazed.
2. Ruminating - time spent (either standing or lying) in regurgitation, mastication, swallowing of ruminal ingesta, and short time periods between boluses.
3. Idling - time spent (either standing or lying) neither grazing nor ruminating. Included time spent sleeping, walking, drinking and feeding.

In the analyses of these statistical data, which follows, the error mean squares(EMS) for determining breed, day, interval and interval x day effects were approximately equal in magnitude within activity and were pooled for determining significance.

Due to significant ($P < .01$) F tests for breed x day, breed x interval, day x interval and breed x day x interval in all major activities, tests for main effect significance had little meaning; therefore, no standard errors have been placed on these data.

Interval effects were the most pronounced source of variation in grazing, lying ruminating and lying idle. Definite time patterns existed for these activities, resulting in large mean square values for interval effects. Standing ruminating and standing idle were rather low percentage activities and exhibited less differences due to time of day.

TABLE VI

STATISTICAL ANALYSIS

The analysis of variance for each activity was as follows:

Variance Source	d.f.	ss	ms
Corrected Total	959		
Breed	2		
Cow	9		error A
Cow x Breed	18		error A
Day	7		
Breed x day	14		
Cow x day	63		error B
Cow x Breed x Day	126		error B
Interval	3		
Breed x Interval	6		
Cow x Interval	27		error C
Cow x Breed x Interval	54		error C
Day x Interval	21		
Breed x Day x Interval	189		error D
Cow x Breed x Day x Interval	378		error D

Breed effects accounted for only a small portion of the total corrected sum of squares and were the least pronounced source of variation.

CHAPTER IX

RESULTS AND DISCUSSION

General Activities

Data will be presented as yearly means (the average of all eight days) and seasonal means (the average of the two days within a season). Daily minimum and maximum temperatures were taken and the average of the two days is presented as the seasonal mean in Table VII. It should be noted that temperature appeared to have little, if any, effect on the total per cent of any major activity; however, on days of extreme hot temperatures, an additional period of drinking during mid-afternoon and a slight delay in the initiation of the afternoon grazing was noted.

Grazing

There appeared to be very little difference among breed for yearly grazing time (Table VIII). The average time spent grazing among breeds was 42.4% per 24 hour period which agrees with many workers (Hein, 1935; Moorefield and Hopkins, 1951; Dwyer, 1960; Furr, 1962).

The breed X day interaction can easily be seen in seasonal grazing percentage since no general trend existed for one breed grazing more than another breed across seasons. The actual time spent grazing must have been poorly related to forage intake and thus, weight gain, since during each season, the breed with the smallest weight gain

TABLE VII

ONSERVATION DATES AND TEMPERATURES

Date		Ave. Temperature (°F)	
		Min.	Max.
February 6-7	Winter	37	59
March 13-14			
May 26-27	Spring	67	89
June 28-29			
July 25-26	Summer	68	95
August 28-29			
November 8-9	Fall	40	72
December 4-5			

TABLE VIII

GRAZING PERCENTAGES

Item	Holstein	Hereford x Holstein	Hereford
Yearly grazing, percent[1]	41.2	41.5	43.9
Seasonal grazing, percent[1]			
Winter	36.4	34.4	42.5
Spring	38.7	38.3	41.8
Summer	44.6	42.9	41.2
Fall	45.1	50.4	50.0
Daily grazing, percent[1]			
February 6-7	35.4	34.6	35.7
March 13-14	37.4	34.2	49.2
May 26-27	45.3	39.3	42.0
June 28-29	32.1	37.3	41.7
July 25-26	47.6	44.8	44.9
August 28-29	41.7	40.9	37.4
November 8-9	44.5	47.6	56.9
December 4-5	45.7	53.1	43.1

[1] Percentage of 24 hours.

had the highest per cent grazing time. Johnston - Wallace and Kennedy (1944) found that, while dry matter intake fluctuated from 32 to 10 pounds, the grazing times remained almost constant. Hancock (1953) concluded that within a herd a distinct relationship between grazing time and feed requirement does exist, but individual differences in feed intake per unit of time and day-to-day variation in grazing time are of sufficient importance to obscure such relationship unless a great number of cattle are observed several times at close intervals.

Feed intake per unit of time may be the greatest factor which eliminated major differences in yearly and seasonal grazing time among breeds. The number of bites per minute and size of each bite may be very important, but little information is available on these factors.

From many research papers, it seems fairly well established that, if the quantity of pasture offered to cattle is ample, the grazing times are long when the quality of the forage is mixed, intermediate when the quality is good and short when the quality is poor. This pattern existed for seasonal grazing time among breeds, since a definite trend existed for an increase in the per cent grazing time as the year progressed from winter to fall. The increase in per cent grazing time was probably due to the quality of forage as well as an increased nutrient requirement for pregnancy and maintenance of larger body weight.

The yearly and seasonal interval grazing percentages are presented in Table IX. The breed x interval interaction existed since no general pattern for one breed grazing more in all intervals than another breed was noted.

The highest per cent interval grazing times were noted during intervals 2 and 3 or 6 am to 6 pm. It has been well established that

TABLE IX

INTERVAL GRAZING PERCENTAGES

Item	Holstein	Hereford x Holstein	Hereford
Yearly interval grazing, percent[1]			
1. 12 a.m. - 6 a.m.	11.7	14.1	25.6
2. 6 a.m. - 12 p.m.	55.0	51.5	60.8
3. 12 p.m. - 6 p.m.	54.8	62.4	53.0
4. 6 p.m. - 12 a.m.	43.4	38.0	35.9
Seasonal interval grazing, percent[1]			
Winter			
1. 12 a.m. - 6 a.m.	20.0	20.2	44.2
2. 6 a.m. - 12 p.m.	35.8	25.6	53.1
3. 12 p.m. - 6 p.m.	53.5	52.1	53.5
4. 6 p.m. - 12 a.m.	36.3	39.6	19.0
Spring			
1. 12 a.m. - 6 a.m.	1.3	1.0	20.8
2. 6 a.m. - 12 p.m.	66.7	66.9	61.3
3. 12 p.m. - 6 p.m.	37.9	44.8	31.5
4. 6 p.m. - 12 a.m.	49.0	40.4	53.8
Summer			
1. 12 a.m. - 6 a.m.	10.3	14.0	12.3
2. 6 a.m. - 12 p.m.	56.5	47.5	57.9
3. 12 p.m. - 6 p.m.	48.5	62.7	47.1
4. 6 p.m. - 12 a.m.	63.5	47.2	47.3
Fall			
1. 12 a.m. - 6 a.m.	15.6	21.0	25.2
2. 6 a.m. - 12 p.m.	60.8	65.8	71.0
3. 12 p.m. - 6 p.m.	79.2	90.0	80.0
4. 6 p.m. - 12 a.m.	24.8	24.6	23.8

[1] Percentage of 6 hours.

cattle prefer to graze during the daylight. However during spring and summer, considerable grazing time existed for interval 4 or 6 pm to 12 am. The increased hours of light during late spring and summer and the tendency of the cattle to graze in darkness during periods of hot afternoon temperatures were the primary factors responsible. The small per cent grazing time during interval 1 was mainly due to a short period of grazing around midnight.

Ruminating

There appeared to be very little difference among breed for per cent yearly ruminating time (Table X). It should be noted that the cattle preferred to ruminate in the lying position during all season of the year.

Again the breed x day interaction can be seen since no general pattern existed for one breed ruminating more than another breed across seasons. It is well established that the nutritive value of native forage decreases with increased maturity, usually involving an increase in fiber content and a decrease in protein content. Since an increase in fiber content generally is accompanied by an increase in rumination, we would expect the per cent ruminating time to increase as the per cent grazing time increased through summer and fall. However, spring rumination showed a considerable increase over summer rumination. Similar results were reported by Furr (1962). He concluded that since grazing time increased and ruminating time decreased, possibly the animals became more selective in the forage grazed as the quality of the forage decreased; thus, increasing their grazing time in relation to their ruminating time.

TABLE X

RUMINATING PERCENTAGES

Item	Holstein	Hereford x Holstein	Hereford
Yearly ruminating, percent[1]			
Total	31.2	29.7	32.2
Standing	5.4	4.8	5.3
Lying	25.8	24.9	26.9
Seasonal ruminating, percent[1]			
Winter, total	22.7	30.1	29.4
Standing	4.3	3.0	4.1
Lying	18.4	27.1	25.3
Spring, total	35.1	33.4	37.1
Standing	5.7	7.9	10.1
Lying	29.2	25.5	27.0
Summer, total	28.8	21.9	33.3
Standing	2.5	4.7	5.0
Lying	26.3	17.2	28.3
Fall, total	36.9	33.3	29.1
Standing	7.8	3.6	2.1
Lying	29.1	29.7	27.0

[1] Percentage of 24 hours.

The yearly and seasonal interval ruminating percentages are presented in Table XI. An exact opposite picture to interval grazing was noted. The highest per cent interval ruminating times occurred during intervals 1 and 4 or 6 pm to 6 am with most of the ruminating occurring from 12 am to 6 am in the lying position. The per cent ruminating time during intervals 2 and 3 was attributed to short periods of ruminating during mid-morning and afternoon following periods of intense grazing.

Idling

Very little difference was noted for yearly idling time among breeds (Table XII). Again the breed x day interaction is easily noted since no pattern existed for one breed idling more than another breed across seasons. The cattle tended to prefer idling in the lying position; however, the trend was not as evident as in rumination.

The yearly and seasonal interval idling percentages are presented in Table XIII. Interval 1 or 12 am - 6 am was the predominant period of idling as would be expected. Very little difference was noted among the other intervals.

TABLE XI

INTERVAL RUMINATING PERCENTAGES

Item	Holstein	Hereford x Holstein	Hereford
Yearly interval ruminating, percent[1]			
1. 12 a.m. - 6 a.m.	48.4	47.7	49.8
2. 6 a.m. - 12 p.m.	14.5	16.6	13.4
3. 12 p.m. - 6 p.m.	23.9	17.4	23.8
4. 6 p.m. - 12 a.m.	38.2	39.1	42.0
Seasonal interval ruminating, percent[1]			
Winter			
1. 12 a.m. - 6 a.m.	31.1	49.4	42.1
2. 6 a.m. - 12 p.m.	9.3	18.9	12.9
3. 12 p.m. - 6 p.m.	13.1	10.0	11.9
4. 6 p.m. - 12 a.m.	36.0	42.1	50.9
Spring			
1. 12 a.m. - 6 a.m.	57.1	45.0	51.1
2. 6 a.m. - 12 p.m.	11.5	17.7	16.4
3. 12 p.m. - 6 p.m.	41.4	32.3	49.6
4. 6 p.m. - 12 a.m.	30.2	38.5	31.2
Summer			
1. 12 a.m. - 6 a.m.	49.4	38.5	63.6
2. 6 a.m. - 12 p.m.	18.3	12.5	16.0
3. 12 p.m. - 6 p.m.	28.8	14.4	26.6
4. 6 p.m. - 12 a.m.	24.6	22.3	27.1
Fall			
1. 12 a.m. - 6 a.m.	54.8	58.0	42.5
2. 6 a.m. - 12 p.m.	18.8	17.3	8.3
3. 12 p.m. - 6 p.m.	12.3	4.6	6.9
4. 6 p.m. - 12 a.m.	61.9	53.5	58.8

[1] Percentage of 6 hours.

TABLE XII

IDLING PERCENTAGES

Item	Holstein	Hereford x Holstein	Hereford
Yearly idling, percent[1]			
Total	27.6	28.8	23.9
Standing	7.3	7.4	8.7
Lying	14.8	15.0	9.7
Other	5.5	6.4	5.5
Seasonal idling, percent[1]			
Winter	40.9	35.5	28.1
Standing	12.4	12.6	12.2
Lying	20.7	13.5	7.4
Other	7.8	9.4	8.5
Spring	26.2	28.3	21.1
Standing	8.5	5.8	9.6
Lying	11.8	14.0	7.8
Other	5.9	8.5	3.7
Summer	26.6	35.2	25.5
Standing	5.2	8.0	10.0
Lying	15.9	21.8	11.2
Other	5.5	5.4	4.3
Fall	18.0	16.3	20.9
Standing	3.2	3.2	3.0
Lying	10.9	10.8	12.2
Other	3.9	2.3	5.7

[1] Percentage of 24 hours.

TABLE XIII

INTERVAL IDLING PERCENTAGES

Item	Holstein	Hereford x Holstein	Hereford
Yearly interval idling, percent[1]			
1. 12 a.m. - 6 a.m.	39.9	38.2	24.6
2. 6 a.m. - 12 p.m.	30.5	31.9	25.8
3. 12 p.m. - 6 p.m.	21.3	20.2	23.2
4. 6 p.m. - 12 a.m.	18.4	22.9	22.1
Seasonal interval idling, percent[1]			
Winter			
1. 12 a.m. - 6 a.m.	48.9	30.4	13.7
2. 6 a.m. - 12 p.m.	54.9	55.5	34.0
3. 12 p.m. - 6 p.m.	33.4	37.9	34.6
4. 6 p.m. - 12 a.m.	27.7	18.3	30.1
Spring			
1. 12 a.m. - 6 a.m.	41.6	54.0	28.1
2. 6 a.m. - 12 p.m.	21.8	15.4	22.3
3. 12 p.m. - 6 p.m.	20.7	22.9	18.9
4. 6 p.m. - 12 a.m.	20.8	21.1	15.0
Summer			
1. 12 a.m. - 6 a.m.	40.3	47.5	24.1
2. 6 a.m. - 12 p.m.	25.2	40.0	26.1
3. 12 p.m. - 6 p.m.	22.7	22.9	26.3
4. 6 p.m. - 12 a.m.	11.9	30.5	25.6
Fall			
1. 12 a.m. - 6 a.m.	29.6	31.0	32.3
2. 6 a.m. - 12 p.m.	20.4	16.9	20.7
3. 12 p.m. - 6 p.m.	8.5	5.4	13.1
4. 6 p.m. - 12 a.m.	13.3	21.9	17.4

[1] Percentage of 6 hours.

CHAPTER X

SUMMARY

Ten each of Hereford, Holstein and Hereford X Holstein heifers were observed during eight 24-hour periods (two per season) on tall grass range. Each 24-hour period was divided into four six-hour intervals: (1) 12 am--6 am; (2) 6 am-- 12 pm; (3) 12 pm--6 pm; and 6 pm--12 am. The observations were made by a team of six persons (one per pasture every six hours). Therefore, observor was confounded with interval, but major observor effects were reduced by using common nomenclature for the description of activities. All activities were observed every 15 minutes. The major activities studied were grazing, rumination and idling.

Due to significant ($P < .01$) F tests for breed x day, breed x interval and breed x day x interval in all major activities, tests for main effect significance had little meaning. Interval effects were the most pronounced source of variation, while breed was the least source of variation.

Temperature appeared to have little, if any, effect on the total per cent of any major activity. Very little difference existed among breeds for per cent grazing time. The average time spent grazing among breeds was 42.4% per 24-hour period. A definite trend existed for an increase in the per cent grazing time from winter to fall. This increase was probably due to the quality of forage and increased nutrient requirement for pregnancy and growth. The highest per cent interval grazing times were noted during intervals 2 and 3 or 6 am to 6 pm.

No large breed difference was noted for ruminating or idling time among breeds. The cattle appeared to be very selective in their grazing habits during spring since grazing time increased and ruminating time decreased. The major ruminating and idling intervals were 1 and 4 or 6 pm to 6 am. Lying was the preferred position for ruminating and idling; however, the trend was not as evident in idling as in rumination.

LITERATURE CITED

Dwyer, Don D. 1960. Activities and grazing preferences of cows with calves in northern Osage County, Oklahoma. Ph.D. Thesis. Texas Agri. and Mech. University, College Station, Texas.

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

Hancock, John. 1953. Grazing behavior of cattle. Animal Breed. Abstr. 21:1.

Hein, M. H. 1935. Grazing time of beef steers on permanent pasture. J. Am. Soc. Agron. 27:675.

Johnstone-Wallace, D. B. and K. Kennedy. 1944. Grazing management practices and their relationship to the behavior and grazing habits of cattle. J. Agr. Sci. 34:190.

Moorfield, J. C. and H. H. Hopkins. 1951. Grazing habits of cattle in a mixed - prairie pasture. J. Range Mgmt. 4:151.

VITA

Johnnie Robert Kropp

Candidate for the Degree of

Master of Science

Thesis: I. THE PERFORMANCE ON RANGE AND IN DRYLOT OF TWO-YEAR-OLD HEREFORD, HOLSTEIN AND HEREFORD X HOLSTEIN FEMALES AS INFLUENCED BY LEVEL OF WINTER SUPPLEMENTATION

II. RANGE BEHAVIOR OF HEREFORD, HOLSTEIN AND HEREFORD X HOLSTEIN HEIFERS

Major Field: Animal Science

Biographical:

Personal Data: Born in Plainview, Texas, March 3, 1947, the son of Paul and Beth Kropp; married Susan Marie Barr, August 16, 1968; the father of one child, Paul David.

Education: Graduated from Lockney High School in 1965. Received the Bachelor of Science degree from Oklahoma State University with a major in Animal Science in January, 1970; completed the requirements for the Master of Science degree at Oklahoma State University in May, 1972.

Professional Experience: Raised and worked on a registered livestock and cotton and grain farm in northwestern Texas; Research and Teaching Assistant in the Department of Animal Science and Industry, Oklahoma State University, Stillwater, Oklahoma, 1970-72.

Professional Organizations: Member of American Society of Animal Science and Alpha Zeta.