Response of cull cows to different ration concentrate levels
by Felicia Ann Drumm LaMontagne

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in ANIMAL SCIENCE
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Abstract:
Four levels of energy were fed to cull cows in three trials to determine the effect of ration energy level upon weight gain and body condition as indicated by live-animal and carcass measurements.

Trial 1 was conducted for 72 days; trials 2 and 3 for 59 days.

In each trial, 48 mature, non-pregnant, non-lactating beef cows were fed barley, beet pulp, and grass hay. Alfalfa was added in trial 1. Percent grain mixture in treatments 1, 2, 3, and 4 was 8.5, 27.0, 45.0, and 60.0 in trial 1, respectively; 20, 40, 57, and 69 in trial 2; 20, 37, 53, and 67 in trial 3. Average daily consumption was 9.69, 10.42, and 10.68 kg dry matter in trials 1, 2, and 3, respectively. Cows were allotted by weight, body condition score (1 = poor, 10 = extremely fat), number of incisors, and breed and balanced among treatments accordingly. One cow died in trial 1 and associated data were removed. Weight, score, height and, in trial 1, heart girth were evaluated.

Cows were slaughtered and data were collected.

In all trials, total weight gain, 'average daily gain (ADG), and weight:height (wt:ht) increased ($P < .05$) as percent concentrate increased; in trial 3, condition score increased ($P < .05$). In trials 1 and 2, higher feed efficiency was associated with higher grain proportions ($P < .05$). In all trials, hot carcass weight was greater in treatments with more grain ($P < .01$). Rib eye area was positively affected by treatment in trial 2 ($P < .05$).

Condition score was a better predictor of carcass quality than weight:rheight and heart girth. Score was significantly ($P < .05$) correlated to carcass grade, marbling, fat at 12th rib, and kidney, pelvic, and heart fat. Cows with lower initial scores required less weight to increase condition than cows with higher scores ($P < .05$). Thin cows with lowest hip height showed greatest potential for increasing condition as measured by weight gains and condition scores.

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Signature Felicia Ann LaMontagne

Date June 17, 1981

Whom have I in heaven but Thee?
And besides Thee, I desire nothing on earth
My flesh and my heart may fail,
But God is the strength of my heart
and my portion forever.

Psalm 73:25,26

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by

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ABSTRACT

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Trial 1 was conducted for 72 days; trials 2 and 3 for 59 days. In each trial, 48 mature, non-pregnant, non-lactating beef cows were fed barley, beet pulp, and grass hay. Alfalfa was added in trial 1. Percent grain mixture in treatments 1, 2, 3, and 4 was 8.5, 27.0, 45.0, and 60.0 in trial 1, respectively; 20, 40, 57, and 69 in trial 2; 20, 37, 53, and 67 in trial 3. Average daily consumption was 9.69, 10.42, and 10.68 kg dry matter in trials 1, 2, and 3, respectively. Cows were allotted by weight, body condition score (1 = poor, 10 = extremely fat), number of incisors, and breed and balanced among treatments accordingly. One cow died in trial 1 and associated data were removed. Weight, score, height and, in trial 1, heart girth were evaluated. Cows were slaughtered and data were collected.

In all trials, total weight gain, average daily gain (ADG), and weight:height (wt:ht) increased ($P < .05$) as percent concentrate increased; in trial 3, condition score increased ($P < .05$). In trials 1 and 2, higher feed efficiency was associated with higher grain proportions ($P < .05$). In all trials, hot carcass weight was greater in treatments with more grain ($P < .01$). Rib eye area was positively affected by treatment in trial 2 ($P < .05$).

Condition score was a better predictor of carcass quality than weight:height and heart girth. Score was significantly ($P < .05$) correlated to carcass grade, marbling, fat at 12th rib, and kidney, pelvic, and heart fat. Cows with lower initial scores required less weight to increase condition than cows with higher scores ($P < .05$). Thin cows with lowest hip height showed greatest potential for increasing condition as measured by weight gains and condition scores.

Chapter 1

INTRODUCTION

Cull cows provide substantial amounts of beef to the meat industry. Approximately 9.7 billion kilograms of beef were produced in the United States in 1979, of which 1.4 billion kilograms were provided by 6 million cull beef cows. If cull cows are in thin body condition, cattle producers could hold and feed the cows to take advantage of increases in weight and carcass grade, as well as seasonal price increases.

When initial body condition differs, beef cows respond differently to feed programs designed to change body condition. Performance of beef cows during realimentation might be more accurately predicted if the weight change and feed needed to alter body condition were known and would enable producers to more effectively evaluate feeding strategies.

The objectives of this study were to:

(1) determine response of cull cows to different energy intake levels;

(2) determine the weight gain needed to increase cow body condition; and

(3) determine the feed required for the weight gains identified in (2).

Chapter 2

REVIEW OF LITERATURE

Response of beef cows to a ration has been observed in weight change and in the corresponding change in body condition. Feeding for desired changes in condition has been complicated by many factors which influence rate of gain and by difficulty in accurately measuring body condition.

Factors Influencing Weight Gain

One objective in feeding cull beef cows is to increase weight and therefore improve carcass quality. Because weight gain is desirable, energy intake must be increased above the amount needed for body maintenance. Therefore, it is necessary to understand the factors that influence maintenance requirements and weight gain. Factors considered in this study were body size, weight, condition, climatic environment, muscular activity, and dietary energy.

Body size is described as metabolic body size as an exponential function of weight. Metabolic body size has been used by researchers to determine and express maintenance requirements in terms of total digestible nutrients (Gaines, 1943; Brody, 1945; Garrett, 1959). Other researchers have expressed energy requirements of cattle in terms of net energy (Kleiber, 1961; Klosterman *et al*., 1968; Lofgreen and Garrett, 1968). The most widely accepted relationship for determining cow maintenance requirements for net energy has been:

$$\text{Net Energy}_{\text{maintenance}} = 77 \text{ Kcal/kg}^{0.75} \text{ body weight.}$$

This equation is now used by the National Research Council (NRC, 1976) to establish levels of dietary requirements.

Body condition has been shown to be important in accurately estimating the amount of energy needed by beef cows for maintenance. Blaxter (1962) stated that fatty tissue in cattle had a maintenance cost comparable to that of the body as a whole. Blaxter's statements are supported by the study of Klosterman et al. (1968). Klosterman reported that cows with a high degree of finish tended to gain weight while those in thin condition lost weight when fed a constant amount of feed per metabolic body weight (because fatter, heavier cows received more feed per head daily). Neville (1971) and Marshall et al. (1976) also showed that fatter cows required more energy for maintenance than thinner cows.

Body condition has been reported to be related to weight gain and fat deposition in beef cows. Thin cows required less weight gain than fatter cows to deposit the same amount of body fat (Kropp et al., 1973; Bellows et al., 1979; Long et al., 1979; Swingle et al., 1979). Riley (1978) reported that thin cows had a greater opportunity than fat cows to change body condition by increasing in weight. The greater potential for thin cows to increase their body weight beyond the gains of fatter cows was probably due to the fact that thin cows tended to be lighter in weight (Wiltbank et al., 1962; Klosterman et al., 1968; Bellows et al., 1971; Kropp et al., 1973; Long et al., 1979; Swingle et al., 1979).

Climatic environment has been shown to affect the maintenance requirements of beef cows during cold periods. Adverse winter conditions resulted in increased feed requirements by 30 to 70 percent (Jordan et al., 1968; Hironoka and Peters, 1969; Bond et al., 1970; Young and Berg, 1970; Lister et al., 1972; Young, 1975a). Increased appetites of cattle during adverse weather were noted by some researchers (Sharma and Kehar, 1961; Webster et al., 1970; Young, 1975a). Decreased average daily gains were also reported as temperature decreased (Mulligan and Christison, 1974; Young 1975b; Paine et al., 1977). Some researchers reported minimal effects of winter environment on cattle, perhaps due to large body size, increased metabolism, type of diet or housing (Graham et al., 1959; Blaxter and Wainman, 1961; Kleiber, 1961; Webster et al., 1970; Hellickson et al., 1972; Milligan and Christison, 1974; Young, 1975a, b; Christopherson, 1976). The effect of cold stress on beef cows appeared to be primarily on the energy requirement for maintenance as pregnancy, development of the conceptus and consequently calf birth weight were unaffected (Wiltbank et al., 1962; Jordan et al., 1968; Hironaka and Peters, 1969).

Muscular activity has been reported to be related to energy requirements of cattle. Increased energy requirements for maintenance were associated with cattle standing (Ritzman and Bendict, 1938; Morrison et al., 1970; Ganyou et al., 1976). Muddy conditions resulted in increased energy expenditure, increased maintenance requirements, and decreased weight gains (Bond et al., 1970; Teter et al., 1973; Riskowski et al., 1976; Mahoney et al., 1977; Long et al., 1979). The adverse effects on performance from standing and walking through mud have been reduced by increasing available feed to cattle and providing housing (Bond et al., 1970; Webster, 1970; Butchbaker et al., 1973).

The effect of dietary energy on weight gain and changes in body condition of cull cows cannot be predicted because the energy requirements for maintenance and weight gain have not been fully established. Riley (1978) reported that cows gained .74 kg of weight per day when grazing on lush brome grass pasture during spring months. Cows that grazed range forage (Northern Great Plains mixed prairie forage) gained .67 kg per day in the spring (Bellows et al., 1979). These reports indicate that roughage rations satisfied the maintenance requirements of the cows. However, cows in the breeding herd that weigh 400 to 500 kg have high maintenance requirements according to NRC (1976) and if large gains are desired, the ration must have a high percentage of grain (Riley, 1978).

Researchers have fed different amounts of concentrates to gain information on the level of performance that could be expected from cull cows when placed in a feedlot. A wide range of percent grain mixture has been fed to cull cows: 20 percent by Batterman et al. (1952); 22, 40 and 80 percent by Swingle et al. (1979); 0, 60 and 80 percent by Riley (1978); 85 and 95 percent by Howes et al. (1972); and 90 percent by Price and Berg (1979). Average daily gains were 1.21 and 1.15 kg for 20 percent (Batterman et al., 1952) and 22 percent grain (Swingle et al., 1979); 1.74, 1.20 and 1.46 kg for 80 percent (Swingle et al., 1979), 90 percent (Price and Berg, 1979), and 95 percent grain (Howes et al., 1972). The most rapid and efficient weight gains in cull cows were obtained from the higher concentrate diets (Howes et al., 1972; Riley, 1978; Swingle et al., 1979).

Studies in the past have not determined the percentage of grain that results in the greatest change in body condition. However, Swingle et al. (1979) observed that cows that consumed a higher percentage of grain (80 percent concentrate) deposited fat faster and reached the desired condition sooner than cows receiving less grain (22 and 40 percent concentrate). Improved carcass quality, grades and weights have been attained by feeding cull cows a variety of rations ranging between 20 and 95 percent concentrate (Batterman et al. 1952; Howes et al., 1972; Riley, 1978; Price and Berg, 1979; Swingle et al., 1979. However, composition of gains (e.g. proportion of lipid to protein deposition) was not influenced by concentrate level in the diet (Jesse et al., 1976; Swingle et al., 1979).

Estimating Body Condition

Body condition has been measured subjectively and objectively by many researchers. Among the live animal evaluations used were visual and palpable systems, weight:height ratio, and heart girth measurement. Certain carcass traits were also effective for evaluating condition, e.g., marbling and body fat cover at the 12th rib.

Visual and palpable methods of determining fat cover have been easy to use and yet have been very subjective. At the discretion of the appraiser, animals have been assigned a numerical score indicating the thinness or fatness. The range of scores used in the systems has varied from one to five (Klosterman et al., 1968), one to nine (Wiltbank et al., 1961), one to ten (Bellows et al., 1971), and four to twelve (Warnick et al., 1979). Palpable criteria were used with visual reference points to describe body condition by Long and Everly (1971) and Lowman et al. (1976).

Although none of the scoring systems cited earlier have been examined in terms of predictive potential, researchers have attempted to subjectively estimate carcass characteristics. Jeremiah et al. (1970) reported that predictions of carcass grade based on visual appraisal of 1710 live steers were significantly correlated with actual carcass grades. In contrast, other researchers note that systematic subjective evaluations have had limited accuracy in ranking cattle according to carcass quality (Gregory et al., 1962; Gregory et al., 1964; Wilson _et al._, 1964). Crouse _et al._ (1974) had less success estimating quality grade than quantitative characteristics such as fat thickness and yield grade. Lewis _et al._ (1969) explained that the difficulty in estimating quality grades has been due to the appraisers' inability to estimate marbling. In an attempt to estimate marbling score based on fat thickness within breed types, Jeremiah, Smith and Hiller (1970) found a low association between subcutaneous fat thickness and marbling score. They noted that levels of fat thickness and live weight in each breed were not associated with concomitant increases in marbling scores. Clearly more work is needed to establish an accurate method of predicting carcass merit and quality grade in the live animal.

Weight:height ratio is an objective measurement and may be useful in describing body condition (Klosterman _et al._, 1968). The vertical distance from the highest point of the withers or hips is measured and the ratio of weight in kilograms to height in centimeters (wt:ht ratio) is calculated. The wither and hip height measurements have been highly repeatable and considered to be equivalent (Lush, 1928; Yao _et al._, 1953; Kidwell, 1955; Williams _et al._, 1979). However, hip height may be a more accurate measurement than wither height (Lush, 1928; Tallis _et al._, 1959) and easier to obtain, since it is measured away from the animal's head (Williams _et al._, 1979).

Using the wt:ht ratio, it may be possible to select cattle which possess desirable carcass characteristics. Wt:ht was found to be positively and significantly correlated with dressing percentage, area of ribeye, and fat at the 12th rib by Tallis et al. (1959). Although Wooten et al. (1979) used wt:ht to select cows for slaughter, no correlations were given between wt:ht and carcass characteristics. The wt:ht ratio was significantly correlated with carcass grade in 1938 (Black et al.) but succeeding studies correlated only wither height with carcass grade. Cook et al. (1951) and Yao et al. (1953) reported a negative and significant correlation between height and quality grade. However, in another study, Cook et al. (1951) and Kidwell et al. (1955) showed a nonsignificant relationship. Because of the lack of information which shows that wt:ht is an accurate indicator of condition, wt:ht has not been used extensively to predict carcass quality.

Heart girth has been a highly repeatable, objective measure of condition (Tallis et al., 1959). The measurement is taken with a nonelastic tape at the smallest heart girth circumference. The possibility of error exists because the measurement can be affected by tautness of the tape and manure on the chest of cows. Kidwell (1955) showed that heart girth was significantly correlated with carcass grade. However, a review of the literature does not lend great support for the use of heart girth as a quantitative indicator of carcass characteristics as reported by Hultz (1927), Lush (1932), Black et al. (1938), Cook et al. (1951), Kohli et al. (1951), White and Green (1952), Yao et al. (1953), Orme et al. (1959), Crouse et al. (1974).

Body fat cover and marbling of the ribeye muscle measured at the 12th rib, indicate actual fat deposition and are important criteria in assigning carcass grades. The amount of external fat on a carcass is evaluated in terms of thickness of this fat over the ribeye muscle at the 12th rib, measured perpendicular to the outside surface at a point three-fourths of the length of the ribeye from its chine bone end (U.S.D.A., 1975). Marbling is determined in the ribeye muscle of a properly chilled carcass. Marbling scores range from devoid (1) to abundant (10) by increments of one; more marbling is needed for higher quality grades than lower grades.

Chapter 3

EXPERIMENTAL PROCEDURE

Four levels of energy were fed to cull cows in three trials to determine the effect of ration energy level upon weight gain and body composition as indicated by live-animal and carcass measurements. In each trial, 48 mature, non-pregnant, non-lactating beef cows were fed in a concrete drylot at the Montana Agricultural Experiment Station, Bozeman, Montana. The drylot was protected by windbreaks and had partial roof cover over fenceline feed bunks. The pens provided each cow with an area of 7.5 m^2 and .89 m of bunk space. Weather data were collected at the Bozeman, Montana State University Climatological Station.

Cows were group-fed twice daily and had access to water and trace mineralized salt. Daily feed consumption per pen was recorded. Proximate analysis of feeds were determined according to methods described by the A.O.A.C. (1970).

In trial 1 cows were fed for 72 days (January 11 to March 23, 1979) four rations which consisted of barley, beet pulp, grass hay and alfalfa (table 1). From day 0 to 36, ration energy levels were 60, 65, 70, and 75 percent total digestible nutrients (TDN) for treatments 1, 2, 3, and 4, respectively. The energy levels were attained by increasing grain by .91 kg per head every two days and

TABLE 1. PROXIMATE ANALYSIS[a] AND METABOLIZABLE ENERGY[b] OF DIETS.

Diet	Dry Matter	Crude Protein	Ash	Ether Extract	Crude Fiber	Nitrogen Free Extract	Metabolizable Energy
Trial 1:							
Barley, grain, grnd	90.4	12.4	2.8	2.2	7.4	75.0	3.15
Beet pulp, dehy	90.6	9.4	8.8	0.1	17.4	64.3	2.77
Native grass hay, chopped	87.8	6.7	6.8	4.2	34.0	48.3	2.10
Alfalfa hay, s-c, mature	89.9	11.4	9.9	1.9	31.8	44.8	1.89
Trials 2,3:							
Barley, grain, grnd	91.5	13.7	2.6	1.7	2.1	79.6	3.21
Beet pulp, dehy	94.0	11.8	6.7	0.9	17.1	63.5	2.80
Native grass hay, chopped	87.8	6.7	6.8	4.2	34.0	48.3	2.10

[a]Percent composition on dry matter basis.

[b]Mcal/kg dry matter intake.

decreasing hay accordingly. Average dry matter consumption by cows in light-weight replications as 8.73 kg per day and 9.82 kg per day by cows in heavy-weight replications (Appendix table 5). Due to cold stress, energy intake was raised 5 percent on day 36 and maintained from days 37 to 72 at 65, 70, 75, and 80 percent TDN in treatments 1, 2, 3, and 4, respectively. Daily dry matter intake was increased to 9.55 and 10.67 kg per head for light-weight and heavy-weight replication, respectively. The feeding regime resulted in an average grain content of 8.5, 27.0, 45.0, and 60.0 percent for treatments 1 through 4. One cow died on day 36 in treatment 2 (heavy replication); feed was adjusted for five animals in that pen.

In trial 2, cows received rations of barley, beet pulp, and grass hay (table 1) for 59 days (November 26, 1979 to January 24, 1980). The experimental design called for feeding 20, 40, 60, and 80 percent concentrate in treatments 1, 2, 3, and 4, respectively. Energy intake increased from treatments 1 through 4 (table 2). Desired percent concentrate was attained by increasing grain .91 kg per head every two days and reducing hay accordingly. Daily feed intake per head was 13.61 kg (as fed basis) on day 39 and was maintained at that level for the remainder of the trial. The feeding regime resulted in average percent concentrate intakes of 20, 40, 57, and 60 for treatments 1, 2, 3, and 4, respectively (table 2). Bloat guard was added to the grain mixture at a rate of .18 kg per head per day.

TABLE 2. AVERAGE DAILY METABOLIZABLE ENERGY[b] AND FEED[a] INTAKE BY TRIAL AND TREATMENT

	Treatment			
	1	2	3	4
<u>Trial 1</u>				
Concentrate, %, Avg.	8.5	27.0	45.0	60.0
Energy	21.44	23.67	25.35	27.43
Feed	9.48	9.68	9.70	9.89
<u>Trial 2</u>				
Concentrate, %, Avg.	20.0	40.0	57.0	69.0
Energy	23.43	26.18	28.63	29.85
Feed	10.10	10.38	10.64	10.56
<u>Trial 3</u>				
Concentrate, %, Avg.	20.0	37.0	53.0	67.0
Energy	23.86	26.25	28.83	30.83
Feed	10.34	10.53	10.85	11.01

[a]Mcal ME/cow/kg dry matter intake.

[b]Kg dry matter/cow.

In trial 3, barley, beet pulp, and grass hay (table 1) were fed to cows for 59 days (February 4 to April 3, 1980). The feeding regime of trial 3 replicated trial 2 (tables 1 and 2) with two exceptions: daily feed intake per head was 13.61 kg (as fed basis) on day 30 and average percent grain mixtures were 20, 37, 53, and 67 percent for treatments 1 through 4.

The 48 cows in each trial were assigned to treatment according to weight, body condition, breed, and number of incisor teeth as follows:

(1) Cows were first separated by weight into light and heavy groups. Animals below the median of the intial weight were assigned to the light feed group and those above were assigned to the heavy feed group.

(2) Within each weight group, the cows were ranked according to body condition and assigned sequentially to one of four groups beginning with the lowest ranked cows. However, assignment of cows by body condition did not maintain balance with respect to breed and teeth. Therefore, animals that were essentially equal in all traits except breed and number of teeth were interchanged between groups, which gave a simulance of balance among groups (Appendix tables 1, 2, 3).

(3) Four feed treatments were randomly assigned to the four light and four heavy groups; this assignment resulted in a

light and heavy replication of each feed treatment. The treatments were then randomly distributed among eight feedlot pens.

In each trial, cows were allotted by weight; initial, interim, and final body weights were taken according to the time schedule as shown in Figure 1. Individual cow weights were taken prior to the morning feeding, after the cows had been restricted from feed and water overnight. A dial scale with a capacity of 727 kilograms (1600 pounds) was used to weigh all cows; weights were recorded to the nearest pound and converted to kilograms for analyses. In order to reduce error, the scale was balanced after every 12th animal.

Cow body condition was evaluated by three technicians using a palpable and visual scoring system (Figure 2) before allotment and at each weigh date. Two technicians scored cows in all three trials and one technician was replaced in the last two trials. The condition scoring system used six reference points described by Long and Everly (1971). Evaluation criteria were developed using criteria described by Lowman _et al_. (1976) and Spitzer (1977). Cows were palpated at the point of the shoulder, the ribs, and spinal processes while they stood on the scale. Each cow was then moved to a pen to permit visual examination of the brisket, tailhead, and twist. Each technician independently assigned condition scores (Figure 2) which ranged from one (thin) to ten (fat).

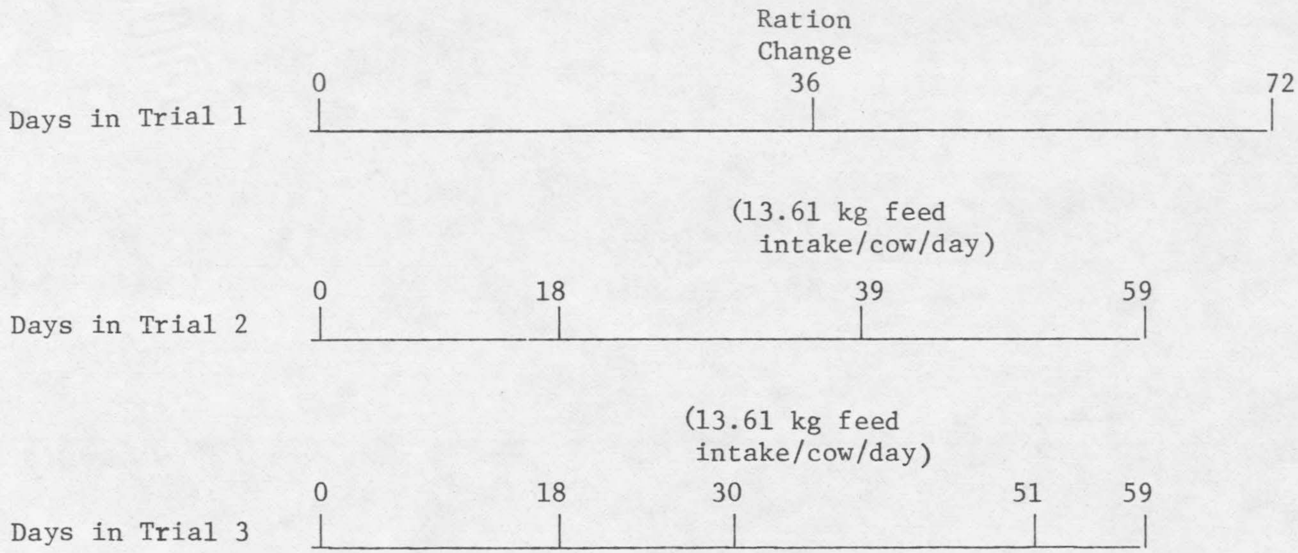

FIGURE 1. SCHEDULE OF PERIODIC BODY MEASUREMENTS TAKEN IN TRIALS 1, 2, AND 3.

SCORE	1	2	3	4	5	6	7	8	9	10
	Poor	V.Thin	Thin	Borderline	Moderate	Mod-Good	Good	Fat	Extremely Fat	
PALPABLE — Shoulder	Very sharp	Fairly sharp →		Rounded →	→	→		Rounded and smooth		Bulging
PALPABLE — Ribs	Very sharp	Fairly sharp →	(Only slightly prominent)	Easily felt (no longer seen individually)		Spongy fat →		Folds of fat developing: large deposits		Great folds of fat
PALPABLE — Spinous Processes	Very sharp	Fairly sharp →		Rounded →		Felt with firm pressure by fingertips		Cannot be felt →		
VISUAL — Brisket	Folds of skin only Lower surface of breastbone 1/4 the distance down on forearm to knee.		Some fat →		Lower surface of solid brisket 1/2 the distance down on forearm to knee			Fat despoits becoming larger-lengthening		Knee length
VISUAL — Tail Head	No fat →		Some tissue cover on top (prominence depends on conformation)		Fat cover on both sides of tailhead (easily felt)		Slight fat "rounds" (soft to touch)		Almost completely buried	Completely buried
VISUAL — Twist	"Cut up" Skin only Narrow stance →	→		Some tissue →		Moderate fat depth		Full of fat Broad stance Beginning to fat down to hocks →		Fatted down to hocks (mobility impaired)

FIGURE 2. PALPABLE AND VISUAL BODY CONDITION SCORING SYSTEM

Teeth and breed were recorded before allotting cows to feed treatments. Approximate cow ages were determined by examination of permanent incisor teeth (Watts, 1965). Cows with sets of permanent teeth (whether or not the teeth were broken and/or worn) were considered at least four years of age and mature. The number of incisor teeth was counted and recorded. "Full", "missing some", and "smooth" designated mouths with all incisors present, one or more broken incisors, and all incisors absent, respectively. Angus, Hereford-Angus, and Hereford were the predominant breeds. Also included were Charolais-Angus in trial 2 and Hereford-Shorthorn in trial 3.

Additional measurements were taken but not used in allotting cows to feed treatments. In all trials, hip height was determined for use in the ratio of weight in kilograms to height in centimeters (weight: height ratio) as an objective measurement of body condition (Klosterman et al., 1968). Cows stood on the scale while hip height was measured to the nearest .5 cm. A steel caliper was used which hung over the cow and extended downward from a pre-set height to the lumbar vertebrae midway between the tuber coxae. In trial 1, heart girth was also measured; the measurement was not taken in trials 2 and 3 due to manure padding on chests of cows. Animals were held in a squeeze chute while heart girth was measured. A nonelastic tape was drawn snugly around the body in a plane perpendicular to the long axis of the body at the smallest circumference just behind the front legs. Heart girth was recorded to the nearest .5 inch and converted to centimeters for analyses.

At the termination of each trial, shrunk weights and final measurements were taken prior to shipment for slaughter. The cows were transported a distance of 193 km to Midland Packing Company, Billings, Montana. Slaughter occurred within 12 hours of arrival at the packing plant. The carcasses were processed according to U.S.D.A. standards (1975), weighed, and chilled for 2.5 days prior to data collection.

A federal grader evaluated all carcasses and quality grades were assigned in third intervals (U.S.D.A., 1975). Degree of marbling was evaluated at the 12th rib. Slaughter grade and marbling score were assigned numerical values for statistical analyses (A.M.S.A., 1977). Fat thickness was measured to the nearest .1 inch at the 12th rib and then converted to centimeters. Ribeye area was obtained by planimeter measurement of a tracing of the L. dorsi muscle sectioned between the 12th and 13th ribs. In trials 2 and 3, percent kidney, pelvic, and heart fat was also evaluated.

Treatment effects were analyzed for differences by analysis of variance using Statistical Packages for the Social Sciences (Nie et al., 1975) with statistical procedures from Snedecor and Cochran (1967).

Chapter 4

RESULTS AND DISCUSSION

Data were analyzed to determine the effects of feed treatment, weight groups (light- and heavy-weight), and two-way interactions. Initial condition score was included as a covariate. Treatment effects were analyzed for differences by analysis of variance (Nie et al., 1975) with statistical procedures according to Snedecor and Cochran (1967). The response of cows to feed treatment was expected to have a linear order because ration energy increased from treatments 1 through 4. Therefore, a test for linear effect of feed treatment was applied to the data and considered more valid than analysis of variance. Cow breed, teeth, and age were not included as main effects because they were nonsignificant in preliminary analyses (Harvey, 1975).

Weight. Cows initially weighed an average of 437.0, 402.8, and 402.9 kg in trials 1, 2, and 3, respectively (appendix tables 7, 8, and 9). Average final weights were 476.7, 448.8, and 459.8 kg in trials 1, 2, and 3, respectively. Within each trial, initial and final weights did not differ ($P > .05$) among feed treatments (table 3). Initial and final weights differed significantly between light and heavy replications in all trials (appendix tables 7, 8, and 9).

In all trials, feed treatment had a positive effect ($P < .05$;

TABLE 3. WEIGHTS AND FEED/GAIN RATIOS; TRIALS 1, 2, AND 3.

	Treatment			
Item	1	2	3	4
Trial 1:				
Concentrate, Avg. %	8.5	27.0	45.0	60.0
Average Weights, kg:				
Initial	444.4	449.5	426.3	429.0
Final	469.8	481.1	476.8	479.4
Total Gain	25.4^{a}	31.6^{a}	50.5^{b}	50.4^{b}
Daily Gain	0.35^{a}	0.44^{ab}	0.70^{b}	0.70^{b}
Energy, Mcal/Gain, kg	61.1^{a}	53.6^{a}	36.1^{b}	39.1^{b}
Feed, Kg Dry Matter/Gain, kg	27.0^{a}	22.0^{a}	13.8^{b}	14.1^{b}
Trial 2:				
Concentrate, Avg. %	20.0	40.0	57.0	69.0
Average Weights, kg:				
Initial	399.3	399.3	410.8	401.6
Final	428.8	452.5	461.7	452.0
Total Gain	29.5^{a}	53.2^{b}	50.9^{b}	50.4^{b}
Daily Gain	0.50^{a}	0.90^{b}	0.86^{b}	0.85^{b}
Energy, Mcal/Gain, kg	46.9^{a}	29.0^{b}	33.1^{b}	34.9^{b}
Feed, Kg Dry Matter/Gain, kg	20.2^{a}	11.5^{b}	12.3^{b}	12.4^{b}
Trial 3:				
Concentrate, Avg. %	20.0	37.0	53.0	67.0
Average Weights, kg:				
Initial	404.3	392.7	409.8	404.9
Final	453.1	444.8	467.6	473.8
Total Gain	48.8	52.1	57.8	68.8
Daily Gain	0.83	0.88	0.98	1.17
Energy, Mcal/Gain, kg	28.8	29.7	29.4	26.4
Feed, Kg Dry Matter/Gain, kg.	12.5	11.9	11.1	9.4

^{a,ab,b}Means in same row with different superscript letters are significantly different, $P < .05$.

table 4) on weight gain (table 3). In trial 1, gains were 25.4, 31.6, 50.5, and 50.4 kg in treatments 1, 2, 3, and 4, respectively. In trial 2, weight gains in treatments 1 through 4 were 29.5, 53.2, 50.9, and 50.4 kg. Weight gains in trial 3 were 48.8, 52.1, 57.8 and 68.8 kg in treatments 1 through 4. By comparison, cows in trial 3 tended to gain more weight than cows in trials 1 and 2 although trial 3 was 59 days in length in comparison to 72 days in trial 1.

Average daily gains were affected (P < .05) in a linear order (table 4) by percent concentrate in the rations in all trials. In trial 1, average daily gains were .35, .44, .70, and .70 kg in treatments 1, 2, 3, and 4, respectively. Daily gains in trial 2 were .50, .90, .86, and .85 kg in treatments 1 through 4. In trial 3, average daily gains were .83, .88, .98, and 1.17 kg in treatments 1, 2, 3, and 4, respectively.

Rations with the most grain produced most efficient weight gains (P < .05) in cows in trials 1 and 2. In trial 1, cows in treatments 1 and 4 required 27.0 and 14.1 kg dry matter per kg weight gain. Metabolizable energy was 61.1 versus 39.1 Mcal for treatments 1 and 4, respectively. In trial 2, cows in treatments 1 and 4 required 20.2 and 12.4 kg dry matter per kg weight gain. Cows in treatment 1 required 46.9 Mcal versus cows in treatment 4 required 34.9 Mcal metabolizable energy per kg weight gain. Feed treatment did not significantly influence feed efficiency in trial 3 as indicated by

TABLE 4. SUMMARY OF STATISTICAL TESTS[a] FOR EFFECTS[b] OF FEED TREATMENTS; TRIALS 1, 2 AND 3.

Test	Degrees of Freedom Numerator / Denominator	Total Weight Change	Average Daily Gain	Total Score Change	Total Wt:HT Change	Total Heart Girth Change	Hot Carcass Weight	Carcass Quality Grade	Marbling Score	Fat at 12th Rib	Rib Eye Area	Kidney, Pelvic, Heart Fat
Trial 1:												
Linear	1/38	**	**	NS	**	NS	NS	NS	NS	NS	NS	--
ANOV	3/38	*	*	NS	*	NS	NS	NS	NS	NS	NS	--
Trial 2:												
Linear	1/39	*	*	NS	*	--	**	NS	NS	NS	*	NS
ANOV	3/39	*	*	NS	*	--	NS	NS	NS	*	*	NS
Trial 3:												
Linear	1/39	*	*	*	*	--	**	NS	NS	NS	NS	NS
ANOV	3/39	NS	NS	*	NS	--	**	*	NS	NS	NS	NS

[a]"Linear" specifies a 1 degree of freedom test for a linear effect of feed treatment. "ANOV" specifies a 3 degrees of freedom analysis of variance based test for effect of feed treatment.

[b]NS = no significant differences between means (P > .05).
*Differences between means were significant (P < .05).
**Differences between means were highly significant (P < .01).

the similar feed/gain and energy/gain ratios among treatments.

The fact that cows in trial 1 tended to gain weight less efficiently may have been due to the additional energy needed to maintain cow body processes during winter stress. Cows in trial 1 were exposed to more cold and wet days than cows in trials 2 and 3 (table 5).

Body condition score. Initially, cows tended to have more fat cover in trial 2 than cows in trials 1 and 3 as evidenced by higher condition scores in trial 2. Cows had average initial scores of 4.1, 4.8, and 4.0 in trials 1, 2, and 3 respectively (appendix tables 11, 12, 13). Within each trial, initial cow condition was not significantly different among feed treatments (table 6), which was expected since cows were balanced within treatments according to initial condition scores (appendix tables 11, 12, 13). However, light-weight cows tended ($P > .05$) to have less condition than heavy-weight cows in all trials, as shown by the condition scores (3.6, 4.5, and 3.6 versus 4.7, 5.0, and 4.4; appendix tables 11, 12 and 13).

Average final cow condition was similar between trials as indicated by final scores 5.3, 6.0, and 6.0 in trials 1, 2, and 3, respectively (appendix tables 11, 12, 13).

In trial 3, final body condition and change in condition were significantly greater in treatments with more energy

TABLE 5. SUMMARY OF WEATHER CONDITIONS IN TRIALS 1, 2, AND 3.

Trial	Total Days in Trial	Precipitation Total number of days	% of total number of days cows were wet	Average maximum temp. °C	Average minimum temp. °C	Mean Temp. °C	Number of days -17.8 °C or less
1	72	46	63.9	38.0	13.4	25.7	14
2	59	25	42.4	37.6	17.0	27.3	10
3	59	35	59.3	39.4	20.9	30.2	4

TABLE 6. AVERAGE BODY CONDITION SCORES[1]; TRIALS 1, 2, AND 3.

Item	Treatment 1	2	3	4
Trial 1:				
Concentrate, Avg. %	8.5	27.0	45.0	60.0
No. Observations	12	11	12	12
Initial Scores	4.3	4.1	4.0	4.0
Final Scores	5.5	5.0	5.2	5.7
Score Change	1.2	0.9	1.2	1.7
Trial 2:				
Concentrate, Avg. %	20.0	40.0	57.0	69.0
No. Observations	12	12	12	12
Initial Scores	4.7	4.7	4.8	4.8
Final Scores	5.6	6.0	6.3	6.0
Score Change	0.9	1.3	1.5	1.2
Trial 3:				
Concentrate, Avg. %	20.0	37.0	53.0	67.0
No. Observations	12	12	12	12
Initial Scores	4.1	3.8	4.0	4.0
Final Scores	5.7[a]	6.2[b]	5.8[a,b]	6.3[b]
Score Change	1.6[a]	2.4[c]	1.8[a,b]	2.3[b,c]

[1] Condition scores based on a ten-point system; 1 = poor, 2 = very thin, 3 = thin, 4 = borderline, 5 = moderate, 6 = moderate-good, 7 = good, 8 = fat, 9 and 10 = extremely fat.

[a,b,c] Means in same row with different superscript letters are significantly different, $P < .05$.

than treatments with less energy (table 6). Final condition scores were 5.7, 6.2, 5.8, and 6.3 in treatments 1, 2, 3, and 4, respectively. Score changes were 1.6, 2.4, 1.8, and 2.3 in treatments 1 through 4. Treatment did not significantly affect final condition score or score changes in trials 1 and 2.

Weight:height ratio. Average cow heights in trials 1, 2, and 3 were 118.7, 116.5, and 119.4 cm, respectively (appendix tables 14, 15, 16). Although cow height did not differ ($P > .05$) among feed treatments (table 7), light-weight cows were significantly shorter than heavy-weight cows in trials 1 and 2. Average cow height of light-weight groups was 116.1, 114.3, and 119.0 cm versus 121.4, 118.7, and 120.0 cm for cows in heavy groups in trials 1, 2, and 3, respectively (appendix tables 14, 15, 16).

Weight:height ratios in table 7 were calculated after height measurements were averaged within each trial. Initial weight:height was 3.7, 3.5, and 3.4 kg/cm for trials 1, 2, and 3 (appendix tables 14, 15, 16). Within each trial, initial weight:height was not significantly different among feed treatments (table 7). This was expected since cows were allotted and balanced with respect to body condition in the treatments (appendix tables 1, 2, 3).

Final weight:height ratios in trials 1, 2, and 3 were 4.0, 3.8, and 3.9 kg/cm (appendix tables 14, 15, 16) and total increases in weight:height were .3, .4, and .5 kg/cm, respectively. The final

TABLE 7. AVERAGE HEIGHT (CM) AND WEIGHT:HEIGHT RATIOS; TRIALS 1, 2, AND 3.

Item	Treatment 1	2	3	4
Trial 1:				
Concentrate, Avg. %	8.5	27.0	45.0	60.0
No. Observations	12	11	12	12
Avg. Height, cm	118.2	119.6	118.9	118.3
Inital wt:ht, kg/cm	3.8	3.8	3.6	3.6
Final wt:ht, kg/cm	4.0	4.0	4.0	4.0
Wt:ht change, kg/cm	.2[a]	0.2[a]	0.4[b]	0.4[b]
Trial 2:				
Concentrate, Avg. %	20.0	40.0	57.0	69.0
No. Observations	12	12	12	12
Avg. Height, cm	115.7	116.7	116.6	117.2
Initial wt:ht, kg/cm	3.4	3.4	3.5	3.4
Final wt:ht, kg/cm	3.7	3.9	4.0	3.9
Wt:ht change, kg/cm	.3[a]	.5[b]	.5[b]	.5[b]
Trial 3:				
Concentrate, Avg. %	20.0	37.0	53.0	67.0
No. Observations	12	12	12	12
Avg. Height, cm	120.3	117.8	118.3	121.4
Initial wt:ht, kg/cm	3.4	3.3	3.5	3.3
Final wt:ht, kg/cm	3.8	3.8	4.0	3.9
Wt:ht change, kg/cm	.4	.5	.5	.6

[a,b]Means in same row with different superscript letters are significantly different, $P < .05$.

TABLE 8. MEANS OF HEART GIRTH MEASUREMENT, CM; TRIAL 1

Heart Girth	Treatment 1	2	3	4
Concentrate, Avg.%	8.5	27.0	45.0	60.0
No. Observations	12	11	12	12
Initial, cm	178.1	184.5	180.9	178.8
Final, cm	185.2	200.3	188.2	193.9
Total change, cm	7.2	15.8	7.3	15.1

TABLE 9. MEAN CARCASS MEASUREMENTS; TRIALS 1, 2, AND 3.

Item	Treatment 1	2	3	4
Trial 1:				
Concentrate, Avg. %	8.5	27.0	45.0	60.0
No. Observations	12	11	12	12
Hot Carcass Weight, kg	239.7	257.5	250.8	253.1
Quality Grade[1]	3.8	5.1	4.6	4.5
Marbling Score[2]	3.6	4.2	4.4	3.8
Fat Thickness, cm.	.71	.82	.98	.89
Rib Eye Area, $cm.^2$	66.3	70.9	68.0	67.1
Trial 2:				
Concentrate, Avg. %	20.0	40.0	57.0	69.0
No. Observations	12	12	12	12
Hot Carcass Weight, kg	212.1	224.6	230.4	229.4
Quality Grade[1]	5.3	6.5	6.3	7.4
Marbling Score[2]	3.5	4.1	3.8	3.8
Fat Thickness, cm	.78[ab]	.61[a]	.70[a]	.95[b]
Rib Eye Area, cm^2	53.4[a]	64.1[ab]	68.2[b]	67.8[ab]
Kidney, Pelvic, Heart, Fat, %	1.01	.89	1.00	1.00
Trial 3:				
Concentrate, Avg. %	20.0	37.0	53.0	67.0
No. Observations	12	12	12	12
Hot Carcass Weight, kg	224.5[a]	225.3[a]	238.3[ab]	242.6[b]
Quality Grade[1]	3.9[a]	5.1[b]	4.2[ab]	5.0[ab]
Marbling Score[2]	3.3	3.9	3.8	4.1
Fat Thickness, cm	.58	.56	.77	.77
Rib Eye Area, cm^2	64.4	63.9	67.1	66.9
Kidney, Pelvic, Heart Fat, %	.83	1.00	.92	1.20

[a,ab,b] Means in same row with different superscript letters are significantly different, $P < .05$.

[1] Carcass quality grade: 3 = low utility, 4 = average utility, 5 = high utility, 6 = low standard, 7 = average standard, 8 = high standard.

[2] Marbling score: 3 = traces, 4 = slight, 5 = small, 6 = modest.

less than carcasses from heavy-weight cows (appendix table 18).

Average carcass quality grades were utility-minus in trials 1 and 3 and utility-plus in trial 2 (4.5 and 6.4, appendix table 18). Carcass grades differed significantly between the light- and heavy-weight groups in trial 2 (7.5, commercial-minus versus 5.4, utility-average). However, carcass grade did not differ (P > .05) among initial weight groups in trials 1 and 3. As percent concentrate increased, there was no significant response in quality grade. This is indicated by the nonsignificant linear component of carcass grade in all trials (table 4).

Carcasses in all trials averaged "slight" marbling as indicated in appendix table 18 by marbling scores 4.0, 3.8, and 3.8 for trials 1, 2, and 3, respectively. Marbling was significantly different in trial 2 for the light and heavy groups of cows even though the carcasses had "traces" to "slight" marbling. The light-weight group scores 3.9 and the heavy-weight group scored 3.7. Carcasses within each trial, had "slight" marbling and was not significantly different among feed treatments.

Fat at the 12th rib was .85, .76, and .67 cm in carcasses in trials 1, 2, and 3, respectively (appendix table 19). Carcass fat did not have a linear relation to the amount of energy in the ration among treatments (P > .05). This is shown by the insignificant linear component of fat in all trials (table 4). Heavy-weight cows in trial 2 had significantly more fat than light-weight cows (.65 and .87 cm, respectively), although there were no differences ($P > .05$ in trials 1 and 3 (appendix table 19).

Area of the rib eye muscle for trials 1, 2, and 3 was 68.0, 63.4 and 65.6 cm^2, respectively. In trial 2, feed treatment had a positive linear effect ($P < .05$) on rib eye: rib eye area was larger in cows that had consumed more energy (table 4). Rib eye area in carcasses in treatments 1, 2, 3, and 4 was 53.4, 64.1, 68.2, and 67.8, respectively. Feed did not significantly affect rib eye area in trials 1 and 3. Rib eye areas were smaller ($P < .05$) in light-weight cows in trial 1 than heavy-weight cows (appendix table 19). Average rib eyes were 63.5 and 72.8 cm^2 in light and heavy replications, respectively.

Kidney, pelvic, and heart fat (KPH) was 99 percent in trials 2 and 3 (appendix table 19). Feed treatment did not significantly affect KPH in either trial (table 9). There were no significant differences among light- and heavy-weight cows within trials 2 and 3.

Conclusions. As ration energy increased, total weight gain, average daily gain, condition scores (trial 3) and weight:height significantly increased. Cows utilized high concentrate rations more efficiently than lower concentrate rations in trials 1 and 2.

Percent concentrate in the ration significantly influenced hot carcass weight and rib eye area. However, there were no significant differences as a result of feed treatment in carcass quality grade, degree of marbling, fat thickness at the 12th rib, and kidney, pelvic, and heart fat. Jones et al. (1978) reported that bulls consuming higher roughage rations had to be 150 kg heavier to attain the same carcass grade as animals on concentrate rations. In addition, Price (1978) reported that slow fattening animals consuming low dietary energy increased weight with little or no increase in carcass fat thickness. Guenther et al. (1965) found that cattle of similar origin, fed to same final weight, on different planes of nutrition produced similar gains of fat and lean. However, greater differences in these carcass traits might have occurred if cows were fed for a longer period of time. Wooten et al. (1979) reported that fat at the 12th rib and marbling appeared closely associated with length of time cows were fed rather than level of concentrate in the diet. The findings that marbling increased in cows with increased time on feed agrees with Howes et al. (1972) and Dinius and Cross (1978). Price and Berg (1979) found that after nine weeks of feeding, cull cows had heavier carcasses, greater dressing percent, more fat, and larger rib eye area than cows slaughtered at culling time.

Weight Gain Required to Change Body Condition

Average weight change by initial body condition score of cows that changed 0, 1, 2, and 3 scores is depicted in figure 3. In order to facilitate examination of the data, groups of cows with few numbers were not included in the figure. The weight changes of all cows by initial condition score and score change is in appendix table 20.

Cows with higher initial body condition scores gained more weight without experiencing a change in condition score than cows with lower initial condition socres. Cows with initial scores 5, 6, and 7 gained 39.7, 41.0, and 38.5 kg; cows with initial scores 3 and 4 changed -2.7 and 14.8 kg.

Among cows changing condition, less weight was required by cows with lower scores than cows with higher scores. Cows with initial score 3 gained an average of 30.6, 49.1, and 56.9 kg to change body condition by 1, 2, and 3 scores (figure 3). Cows with initial scores 4, 5, and 6 gained 36.0, 43.2, and 53.8 kg to change 1 condition score. Animals with initial scores 4 and 5 gained 63.0 and 53.0 kg to change 3 scores and 64.3 and 50.5 kg to change 3 scores. Riley (1978) also reported that thin cows had a greater potential than fat cows for large weight gains and changes in body condition. These findings were consistent with Kropp et al. (1973), Bellows et al. (1979), Long et al. (1979), and Swingle et al. (1979), who showed that cows of low condition experienced more weight and condition change than