PRODUCTION FACTORS AND CARCASS CHARACTERISTICS OF FATTENING CALVES INFLUENCED BY RATE OF GRAIN FEEDING

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By

LESLIE GRAHAM YOUNG

AN ABSTRACT

Submitted to the School for Advanced Graduate Studies of
Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

DOCTOR OF PHILOSOPHY

Department of Animal Husbandry

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Approved E. O. Branaman

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ABSTRACT

Data are relatively scarce regarding the effect of feeding of a similar total amount of grain to weanling beef calves at varying rates, and the effect on the carcasses produced. Previously unpublished data from two experiments conducted at Michigan State University in 1940-42 were summarized.

An additional experiment was conducted in 1957-58 to secure additional information. Twenty-two steer and twenty-one heifer calves of known breeding, age and previous treatment were divided into four lots, two lots of steers and two lots of heifers. One lot of each sex was fed a "Limited" ration of one and a quarter pounds of ground shelled corn per 100 pounds body weight, adjusted bi-weekly, plus corn silage, hay and soybean meal. The other two lots ("Delayed Full-fed") were fed corn silage, hay and soybean meal for 98 days after which ground shelled corn, full-fed, was added to the ration. The cattle were removed individually from the experiment as they reached choice live grade.

The steer lots were fed for approximately the same total feeding period (average 278 days), and consumed similar total amounts of concentrates (average 2756 pounds). The final weights, slaughter dates, carcass grades and carcass analyses did not differ significantly between treatments.

Comparative results with heifers were similar to

those of the steers except "Limited-fed" heifers were finished a month earlier than "Delayed Full-fed" heifers. Heifers finished an average of 33 days sooner than steers, at 122 pounds lighter weight and on less total feed. Steers and heifers consumed approximately the same amounts of estimated total digestible nutrients for each 100 pounds gain.

There were no significant differences due to treatment or sex in slaughter grade, final carcass grade, area of rib-eye muscle, percent ether extract of the *longissimus dorsi* (rib-eye) muscle, analysis of the 9-10-11 rib cut or specific gravity measurements.

Unribbed quality, ribbed quality and final carcass grades were highly significantly correlated with each other. Final live grade and carcass conformation grade were not correlated significantly with unribbed quality, ribbed quality or final carcass grades or with each other in this experiment involving rather uniform cattle.

Specific gravity of the 7-rib wholesale cut was correlated .93 with the specific gravity of the 9-10-11 rib cut.

The following estimates of fatness were in good agreement: specific gravity of the 9-10-11 rib cut, ether extract of the boneless 9-10-11 rib cut. Prediction of ether extract of the *longissimus dorsi* muscle by the use of specific gravity was not as accurate, relatively, as predicting fatness of the 9-10-11 rib cut by specific gravity. Fat thickness over the rib-eye muscle in this study was not related to the percent ether extract of the boneless 9-10-11 rib cut. Areas of the tracings of the *longissimus dorsi* muscle, obtained before and after squaring the loin end of the 7-rib wholesale cut, were highly significantly correlated (.88). The area of the tracing obtained after squaring was .01 to 2.04 square inches smaller than the area of the tracing obtained before squaring.

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INTRODUCTION

Quality in meat has promoted discussion since the beginning of the packing industry and research studies have been in progress for four decades or more, yet there are many problems remaining to be solved. The advent of systematic carcass grading, both Federal and private, has emphasized the need for more accurate information regarding actual quality and also the yield of edible meat. At the same time economic factors in production exert a major influence on feeding methods and the grade of beef produced.

There is still a lack of data regarding the effect of different feeding treatments on carcasses of beef cattle. Numerous experiments have been conducted in which rate and efficiency of gain have been recorded, and in most cases stating the selling price of finished cattle, but in many of these experiments the detailed differences in carcasses were omitted.

There is also an important problem existing in relating desirable carcass traits to the live animal. One is unable to determine accurately the area of eye muscle or amount of marbling from visual appraisal of the live animal.

Certain subjective evaluations of the beef carcass are used by the grader to arrive at a final grade. In some cases the carcass is quartered and then the size of rib-eye, the amount of marbling and other indications of quality may influence the grader's opinion as to final grade.

The following is a review of the literature pertaining to some of these aspects of beef production and quality of the carcass.

REVIEW OF LITERATURE

EFFECT OF DELAYED VERSUS LIMITED FEEDING ON GAINS AND FEED EFFICIENCY

Mumford et al. (1917) in feeding clover hay and ground corn, observed that two-year-old steers which had been kept on a low plane of nutrition (maintenance) for 31 weeks and then allowed a full-fed grain ration for six weeks made more economical gain than steers which had been full-fed for 37 weeks. Similar steers receiving more than a maintenance but less than a full-fed ration for 31 weeks made no more economical gains when put on a full feed for six weeks than steers which had already been on full feed for 37 weeks. Skinner and King (1916) in comparing a limited feed of corn with a full feed of corn, concluded that two-year-old steers fed a limited feed of grain (5.80 pounds shelled corn per day) with corn silage, protein supplement and hay, made more economical gains than full-fed steers (9.81 pounds shelled corn per day) plus corn silage, protein supplement and hay. In the same series of experiments with two-year-old steers, these authors (1921) found that more rapid gains could be made on the same total quantity of corn if no corn was fed during the early part of the feeding period but fed according to the appetite during the latter part of the period, than if a small quantity of corn was fed during the entire period. In a summary of their work Skinner and King (1922) concluded that: a full feed of corn was most profitable, full feeding during the latter part of the period second in point of profit, no corn third and a half feed of corn during the entire period least profitable of the four feeding methods tried. Trowbridge and Fox (1924), utilizing two-year-old feeder steers, observed that in a 100 day feeding period, steers started on corn silage, legume hay and linseed meal with a full feed of corn during the last 40 days made greater average daily gains and required less corn per 100 pounds gain than steers fed similarly except they were fed a half ration of corn throughout the 100 day feeding period.

In studying the effect of rapid versus moderate rates of gain on feed efficiency of cattle fed rolled milo, cottonseed meal, dehydrated alfalfa pellets and cottonseed hulls, Pope _et al_. (1958) reported that steer calves fed to gain 365 pounds and gaining moderately throughout the feeding period required the least amount of total digestible nutrients per 100 pounds gain, whereas the lot fed to gain rapidly throughout the feeding period required the largest amount of total digestible nutrients per 100 pounds gain. In a continuation of the above studies Hendrickson _et al_. (1959a) reported that, on the basis of either pounds of feed or total digestible nutrients per pound of gain, steer calves fed to gain 200 pounds at a moderate rate then 200 pounds at a fast rate were slightly more efficient than steers fed to gain at a continuous fast rate. Those fed to gain at a moderate rate throughout were the least efficient. Summarizing three experiments Hendrickson (1959b) states that calves fed to gain moderately throughout the experiment required about 60 days longer to reach final weight and were no more efficient than full-fed calves due to a longer feeding period.

Johnson _et_ _al_. (1958) fed yearling steers corn silage, alfalfa hay and varying quantities of a concentrate mixture composed of barley, oats and dried molasses beet pulp. They reported that feeding the concentrate mixture during the last half of a 154 day feeding period resulted in less feed being required per 100 pounds gain and larger average daily gains as compared to steers fed the same total quantity of concentrate throughout the feeding period.

There is a close relation between the amount of net energy consumed and the maintenance requirement Hogan _et_ _al_. (1922). Periods of high energy intake were periods of high maintenance cost, while periods of low energy intake were accompanied by a lowered maintenance requirement. These researchers also observed no definite relation between the age of animals and their maintenance requirement. Moulton _et_ _al_. (1921) experimenting with calves and feeding for varying rates of growth for varying periods up to four years of age, found that as the level of feeding decreased the pounds of dry matter per pound of gain decreased. The scantily fed animals grew less rapidly in all respects but reached the same height at the withers in four years as the full-fed group.

Guilbert et al. (1944), experimenting with weanling calves fed for 14 months, reported that from the standpoint of total feed required to produce a unit of product, greatest efficiency is obtained from a high plane of nutrition with continuous growth and development.

Matsushima et al. (1957) fed three levels of protein and energy to yearling steers for 211 days, the medium level being calculated to meet the recommendations of the National Research Council, the high and low levels of protein varying 18 percent and high and low levels of energy varying 10 percent from these standards. The efficiency of feed utilization increased as the level of energy and protein ration increased. The largest average daily gain was made by the group fed the high protein medium energy ration, while the lowest gain was made by the low protein-high energy fed steers. Fibre digestibility was decreased and ether extract digestibility was increased as the level of energy in the ration increased.

Langford et al. (1954) reported that wintering beef calves at a higher plane of nutrition (25 pounds corn silage, 4 pounds hay plus 2 pounds oats daily versus 20 pounds corn silage, 4 pounds hay) followed by summer grazing, resulted in 41 pounds greater gain at the end of the grazing period for the higher winter ration, but at a considerably increased feed cost.

A number of experiments have been performed (Winchester 1951, 1953, Winchester and Howe 1955, Winchester and Ellis

1956, Winchester *et al.* 1957) using identical twin calves to study the effect of energy restriction for periods varying from six months to twelve months of age followed by a liberal ration until slaughter. Liberal-fed control and experimental animals required about the same cumulative energy intake from the beginning until slaughter at about 1,000 pounds body weight or when low prime. Weight gains of retarded calves either equaled or exceeded those of controls for some time after restricted feeding ended.

An experiment was conducted utilizing rats to determine the effect of feed restriction (anonymous 1957). There was little difference in weight when all rats had consumed the same total of energy foods, although rats in the restricted groups required 6 to 13 days longer to reach their goal. In the same report identical twin beef calves were compared similarly by restricting corn to one of each pair. All the calves reached 1,000 pounds live weight on about the same amount of feed energy, but the calves on the restricted rations required 10 to 20 weeks longer to reach that weight.

Branaman (1936) in comparing self feeding versus limiting the grain ration of fattening beef calves, observed that calves fed the limited grain ration ate twice as much corn silage and one half more hay but one third less grain, as compared with the calves self-fed grain. In another series of trials reported in the same publication the author concluded that calves fed largely on silage and legume hay

so as to gain 1.2 to 1.4 pounds per day during the first third of the feeding period, and full-fed shelled corn to the finish required less grain per 100 pounds gain and more corn silage and hay than those fed more liberally on shelled corn and gaining 1.9 pounds or more per day.

Branaman et al. (1940), in five experiments, compared individual full feeding and limited feeding of heifer and steer calves from birth. The limited-fed calves ate less corn and more alfalfa hay and corn silage per 100 pounds finished weight and required approximately 100 days longer to reach choice slaughter grade. Limited-fed heifers reached choice grade at an average of 97 days later and 61 pounds heavier than full-fed heifers, while limited-fed steers at 114 days later were 132 pounds heavier than full-fed steers.

EFFECT OF DELAYED VERSUS LIMITED
FEEDING ON GRADES AND CARCASSES

Considerable, detailed, studies have been conducted by McMeeken (1940a, 1940b, 1940c, and 1941) concerning growth and development of the pig. He stated that after birth the head muscles grow proportionately least, and those of the loin and pelvis region proportionately most, with the neck and thoracic muscles falling into an intermediate position. The order of development of fat is the same as that for muscle and bone. Fat is not stored between the muscle, to any extent, until the later stages of growth, while it may be deposited subcutaneously in large amounts before this stage. A gradient from head to tail occurs in the percentage

of fat in both inner and outer layers of subcutaneous fat, the percentage fat falls as one passes backwards along the body. A similar gradient to that in fat along the backline is exhibited in the growth of intramuscular fat. The percentage of intramuscular fat in the *psoas* and *longissimus dorsi* shows a general increase with age. In another experiment of this series it was stated that the relative effect of nutrition upon the intramuscular fat is high. Pigs fed on a high plane of nutrition from birth to 16 weeks have considerably larger muscle fibres and more marbling in the *longissimus dorsi* muscle than pigs on a low plane of nutrition. The feeding of a low level of nutrition to pigs followed by a high level resulted in more fat, both subcutaneous and intramuscular, than in pigs fed a high level throughout. The former had less bone and muscle than the latter. Loin muscles from "Low-High" pigs were heavier than the "High-High" pigs. When a high level of nutrition followed an initially inadequate level as in the case of a "Low-High" group, the growth of fat in the late developing regions, as also with total fat, was tremendously increased.

Pomeroy (1941) in difference to McMeekan, states that subcutaneous fat is later developing than intermuscular fat in the pig. Restricted feeding of pigs from 110 to 200 pounds live weight increased the size of the loin eye muscle (Crampton *et al*. 1954), but part of this difference may be due to the restricted pigs being on feed approximately two weeks longer. Brunstad *et al*. (1959) fed pigs on four combinations of full and limited feeding. Pigs on a limited feed followed by a full feed had the smallest loin eye area and the greatest back fat thickness. Work reported by Lucas and Calder (1956) indicated that pigs fed a low energy-high fibre ration throughout the growing-finishing period had a significantly larger eye muscle than a high energy-low fibre ration throughout. In a second experiment, plane of feeding had no significant effect on area of eye muscle.

In sheep Palsson (1952) concluded that limited nutritive supply at any age causes greatest inhibiting effects on the tissues or those parts of any one tissue, which have the highest growth intensity at that age. Muscle was better developed in groups fed a "High-Low" or a "Low-Low" plane of nutrition than groups fed "Low-High" or "High-High", while fat, especially the subcutaneous fat, was better developed in the two latter groups. The percentage of marbling fat in the _longissimus dorsi_ muscle appeared to be more dependent on the age of the animal than on the plane of nutrition or the state of fatness of the animal. However, the plane of nutrition or the degree of fatness of the animal has a considerable influence on the marbling fat content of muscle at constant age but different carcass weight. Also ewes had more marbling fat than wethers.

Black _et al_. (1940) fed concentrates to two-year-old steers on grass for varying periods and concluded after three tests that it made little if any difference in carcass grades whether the cattle received a supplemental concentrate ration during the entire 135 day grazing period, or for only the last 79 days. The fattest cattle were those grazed for 135 days followed by feeding concentrate in drylot for 56 days. The differences in intramuscular fat content of the carcasses were not great and apparently were not closely related to the rations fed to the cattle.

In an experiment with cattle reported previously (Guilbert _et al_. 1944), evidence was obtained that high planes of nutrition speed up the development of thickness growth generally, especially in later maturing parts such as the loin and hindquarters. Thus a high plane of nutrition early in life followed by a lower plane results in carcasses higher in lean and lower in fat than when the reverse occurs, even though the same final weight at the same age is obtained.

Hedrick _et al_. (1954) and anonymous (1955) wintered yearling steers on three levels of nutrition followed by summer grazing and finished in dry lot to the choice grade. Carcasses from cattle on the low plane of winter nutrition (-0.4 pound daily gain) had more separable fat, less separable lean and less fat in the rib-eye than carcasses from the lots on a higher plane of winter nutrition (1.0 or 1.5 pounds daily gain). Research at Missouri (anonymous 1952-53) indicated steers gaining more during the winter had more marbling in the rib-eye.

Winchester and Howe (1955), in their experiments with identical twin calves, fed one of the pair a liberal ration whereas the other calf was limited to 50 to 75 percent of the energy in the liberal ration from six to twelve months of age, followed by a liberal ration to slaughter at about 1,000 pounds body weight. In five of six pairs the eye of the rib cut was fatter in the animal that was fed the limited ration, and in four of the six pairs the remainder of the edible portion of the 9-10-11 rib cut was fatter. Part of the difference may be accounted for by the fact that the limited-fed calves were slaughtered 10 to 20 weeks later than the controls.

In another similar experiment (Winchester and Ellis 1956), no evidence was observed that carcass grades, meat quality, or proportion of lean meat to fat were lowered by a delay in growth (submaintenance).

The effect of feeding steers a full or restricted feed of concentrates on pasture or in dry lot was studied by Palmer _et al_. (1957). Limited feeding lowered carcass grade, marbling, area and ether extract of the _longissimus dorsi_ muscle. According to Callow (1949), rapid fattening of beef cattle leads to the same level of fatness being reached at lower carcass weights than is the case with fattening at a slower rate. In addition with carcasses containing more than 28 percent of the fatty tissue, rapid fattening may be expected at the same level of fatness, to produce carcasses with a slightly smaller percentage of muscular tissue and a slightly greater percentage of bone than is the case with carcasses which have been fattened

more slowly.

Robertson and Baker (1933) studied the histological differences in the muscles of full, half and roughage-fed steers. Muscle fibres of the full-fed animals were larger in diameter than those of the half-fed animals. Joubert (1956) stated that the level of nutrition in sheep influenced muscle fibre diameter appreciably at all ages, higher levels of nutrition resulting in larger muscle fibres.

The effect of levels of nutrition on performance and carcass characteristics of yearling steers slaughtered after making an average gain of 350 pounds was studied by Dilley _et al_. (1959), who observed a greater area of fat in the rib-eye of cattle fed 60 percent of a full feed as compared to a full feed. Also the area of the eye muscle was larger and the rind thickness less in the 60 percent of full-fed group as compared to the full-fed group. Part of these differences may be due to the two month longer feeding period of the limited-fed group.

In three experiments on steer calves fed to gain a total of 365 or 400 pounds conducted at Oklahoma State University, referred to previously (Pope _et al_. 1958, Hendrickson _et al_. 1959a, 1959b), steers fed to gain rapidly throughout the feeding period had higher carcass grades than those fed to gain moderately or combination of feeding for high and moderate gain. Moderate gaining calves had less external fat and marbling, but contained about six percent more lean (based on 9-10-11 rib cut physical separation) than fast gaining calves. Altering the rate of gain during the last half of the feeding period gave results similar to calves fed for the same rate of gain throughout.

SPECIFIC GRAVITY

Yapp (1923) determined the specific gravity of the body, as a whole, of cattle. Rathbun and Pace (1945) obtained the specific gravity of the eviscerated bodies of 50 normal guinea pigs and derived an equation which would express the percent of fat in the carcass based on specific gravity. In rats, Da Costa and Clayton (1950) determined the specific gravity of the total carcasses. Their results showed an inverse relationship between carcass fat (ether extract) and specific gravity, and a direct relationship between carcass water and specific gravity. They concluded that specific gravity was as good an index of the water content of the whole animal as it was of the fat content.

Numerous researchers have used specific gravity in pork carcasses (Brown et al. 1951, Whiteman et al. 1953, Pearson et al. 1956 and Price et al. 1957), in an effort to determine carcass leanness or fatness.

Garrett et al. (1959) found a high negative correlation between the specific gravity of the dressed sheep carcass and percent chemical carcass fat. Using specific gravity they developed an equation for the estimation of percent carcass fat. According to Knight et al. (1959), the specific gravity of the pork shoulder furnished a good

estimate of whole carcass specific gravity. Also, a highly significant correlation between chemically determined fat and specific gravity of the 12th rib was obtained.

The specific gravity of veal carcasses, produced by different feeding methods, did not vary significantly (Bray et al. 1959). These authors suggested that specific gravity as a measure of fatness may not be critical enough for measuring very low quantities of fat in veal carcasses.

In thirty steers and heifers with a wide range in weight and fatness, Kraybill et al. (1951-52) observed a highly significant correlation between the specific gravity of the 9-10-11 rib cut and the specific gravity of the carcass. An equation was given for the estimation of separable fat of the 9-10-11 rib cut from the specific gravity of the cut. Lofgreen and Garrett (1954) developed an equation for the estimation of proportion of separable fat in a cut if the specific gravity of the whole cut is known. They obtained a high correlation between separable fat determined by mechanical separation and as calculated from the equation.

Using 24 steers ranging in carcass grade from high good to low prime, Breidenstein et al. (1955) observed little relationship between subjective evaluation of marbling and specific gravity of the rib-eye, but the following indices of carcass fatness were in excellent agreement; specific gravity of the wholesale rib cut, physical separation of the wholesale rib, determination of ether extract of separable lean and fat of the wholesale rib. Results of a study by Cole _et al_. (1957) of the eye muscle from 9-10-11 rib section of beef ribs ranging in grade from prime to commercial cow, indicated that specific gravity may be correlated to quality factors in beef of similar age. Kelly _et al_. (1959) determined the specific gravity of 10 wholesale cuts of steers from different levels of nutrition. They observed that from their data it appeared that specific gravity for the estimation of fat, moisture and protein in meat was not reliable in cuts of beef with very low fat content. Godbey _et al_. (1959) observed a difference in specific gravity of the 9-10-11 rib cut due to the level of nutrition fed fattening steers. In correlating specific gravity of the 9-10-11 rib cut of beef cattle with its components, Kropf (1959) obtained the highest correlation between specific gravity of the 9-10-11 rib cut and percent bone and a lesser relationship between specific gravity of the 9-10-11 rib cut and percent fat. Orme _et al_. (1957) and Orme (1958) determined the specific gravity of the _longissimus dorsi_ muscle from the 9-10-11 rib cut of 51 ribs, ranging in grade from good to low prime. They found highly significant correlations between specific gravity and percent fat and percent water of the _longissimus dorsi_ muscle.

The effect of chilling time on specific gravity of hog carcasses was determined by Kline _et al_. (1955). The specific gravity of the carcasses increased from zero to 72 hours of chilling time. The correlations between specific gravity and live probe, back-fat and lean cuts were maximal at 24 hours and then decreased to values at 72 hours approximating those at zero hours.

UNPUBLISHED RESEARCH AT MICHIGAN STATE UNIVERSITY 1940-1942

Certain research was undertaken at Michigan State University in cooperation with the United States Department of Agriculture in 1940-42 from which there were not considered to be sufficient data to warrant conclusions and publication. Those results will be analyzed here in conjunction with a further experiment conducted by the author along the same general plan.

Two experiments were conducted during the years 1940-41 and 1941-42 under the supervision of G.A. Branaman, O.G. Hankins, G.A. Brown and R.L. Hiner, in which limited grain feeding was compared with delayed full feeding. Five pairs of weanling steer calves approximately six months old were fed to choice live grade in each experiment. They were fed individually twice daily, one calf of each pair receiving a "Limited ration" of three-quarters of a pound of cracked corn and one-quarter of a pound of linseed meal per 100 pounds live weight daily, plus a full feed of mixed alfalfa, hay and of corn silage.

The other calf of the pair was fed a "Delayed Full-fed ration" consisting of a full feed of both corn silage and alfalfa mixed hay for the first 120 days followed by a full feed of cracked corn, corn silage, alfalfa mixed hay plus one-quarter pound of linseed meal per 100 pounds live weight. The calves were slaughtered when they individually reached choice live grade.

The second experiment was designed similarly except the "Limited-fed" calves received slightly more corn, being fed one pound of cracked corn per 100 pounds live weight daily and soybean meal replaced linseed meal. During the last 56 days of the experiment these calves received approximately one and a half pounds of cracked corn per 100 pounds live weight daily. The "Delayed Full-fed" calves received one pound of soybean meal daily with silage and hay for the first 112 days and corn was full-fed thereafter. Each set of calves was group fed during the last 85 days of the experiment to try to induce greater feed consumption. Corn silage and mixed hay were full-fed all calves. The calves were slaughtered at the end of a 352 day feeding period.

Table 1 gives a summary of the two experiments including feed data.

Analysis of variance of total gain and average daily gain revealed no significant differences due to treatment, but there was a significant interaction between treatment and year for total gain. This interaction indicates that the two treatments didn't respond the same between experiments, as can be seen from the Table 1.

In the first experiment the "Limited-fed" calves made the largest total gain (579.00 pounds vs. 527.25 pounds) while in the second experiment the results were reversed and the "Delayed Full-fed" calves made the largest total gain (542.4 pounds vs. 572.4 pounds). This occurred despite the

TABLE 1. WEIGHTS GAINS AND FEED CONSUMPTION OF CALVES IN 1940-41 AND 1941-42 EXPERIMENTS

	1940-41		1941-42	
	Limited-fed	Delayed Full-fed	Limited-fed	Delayed Full-fed
Av. initial wt.	363.80	371.75	398.85	368.20
Av. final wt.	942.80	899.00	941.20	940.60
Av. total gain	579.00	527.25	542.40	572.40
Av. days on feed	333	328	352	352
Av. daily gain	1.74	1.61	1.54	1.63
Av. daily gain on full feed[1]	1.81	2.11	1.72	2.06
Av. feed per head				
Cracked corn	1484.6	1983.5	2311.0	2436.8
Protein supplement	541.8	379.5	563.6	549.0
Corn silage	4343.6	3120.8	3393.4	3051.4
Hay	1034.2	1123.0	904.2	905.0
Av. feed consumption per cwt. gain				
Cracked corn	256.7	376.2	425.9	425.8
Protein supplement	90.2	72.1	103.8	95.8
Corn silage	750.4	590.0	625.6	533.1
Hay	179.1	213.4	166.7	158.1
Estimated T.D.N. consumption per cwt. gain[2]				
Cracked corn	205.62	301.34	341.15	341.07
Protein supplement	68.10	54.44	81.07	74.82
Corn silage	128.17	107.97	114.48	97.56
Hay	90.09	107.34	83.85	79.52
Total	491.98	571.09	620.55	592.97

1. Average daily gain during the period that the "Delayed full-fed" calves were on full feed.

2. Morrison, Frank B. Feeds and Feeding, 22nd Edition, Morrison Publishing Co. 1956.

Corn #2	80.1
Corn silage (recent analysis)	18.3
Soybean meal (all analysis)	78.1
Hay	50.3

fact that in the second experiment the "Limited-fed" calves received more corn per 100 pounds live weight than in the first experiment.

In each experiment the two lots were fed a similar number of days. When the "Delayed Full-fed" calves were put on a full feed, they gained approximately .30 pounds more per day than did the "Limited-fed" calves.

For each 100 pounds of gain in live weight in the first experiment the "Delayed Full-fed" calves consumed an average of 119.5 pounds of corn more than did the "Limited-fed" calves, but consumed approximately 260 pounds less of corn silage. In the second experiment the calves on the two treatments consumed approximately the same amounts of corn and hay but the "Limited-fed" calves consumed slightly more protein supplement and corn silage per 100 pounds gain.

On the basis of estimated total digestible nutrients consumed per 100 pounds of gain the lots varied inversely as compared to average total gain. That is, in the first experiment the "Limited-fed" calves which made the largest total gain required less total digestible nutrients per 100 pounds gain as compared to the "Delayed Full-fed" calves. In the second experiment the "Delayed Full-fed" calves made the largest average total gain and required the least amount of total digestible nutrients per 100 pounds gain.

In Table 2 the summary of carcass data is reported. There was little difference in dressing percentage due to treatment in the first experiment, in the second experiment

TABLE 2. DRESSING PERCENTAGE GRADES AND 9-10-11 RIB CUT ANALYSES OF EXPERIMENTS 1940-41 AND 1941-42

	1940-41		1941-42	
	Limited-fed	Delayed Full-fed	Limited-fed	Delayed Full-fed
Cold dressing percent	59.48	60.11	59.89	58.76
Slaughter grade[1,2]	9.2	8.0	10.0	11.2
Carcass grade[1,2]	9.2	10.0	10.0	8.8
Physical separation right 9-10-11 rib				
Fat percent	30.27	31.39	31.52	34.19
Total edible percent	82.97	83.41	79.64	81.58
Bone percent	17.03	16.59	20.36	18.42
Chemical analysis of total edible portion right 9-10-11 rib				
Water percent	42.91	48.44	47.04	45.43
Fat percent	35.56	36.84	37.88	39.83
Rib eye from 9-10-11 rib				
Water percent	72.86	73.86	73.23	73.58
Fat percent	4.70	4.06	3.58	2.80

1. High choice = 9 Av. choice = 10 Low choice = 11

2. Graded by Animal Husbandry staff.

the "Limited-fed" calves dressed approximately one percent higher than the "Delayed Full-fed" calves. In both years the slaughter grades of the "Limited-fed" calves averaged the same as their average carcass grades. With respect to the "Delayed Full-fed" calves in the first experiment their average slaughter grade was two thirds of a grade above the carcass grade whereas in the second year this was reversed. Grading was done by the Animal Husbandry Department staff using Federal grading system in effect prior to 1950.

There was no consistent difference in grade due to treatment for the two years, as grade tended to vary directly with total gain.

The "Delayed Full-fed" calves had more separable fat and total separable lean in the 9-10-11 rib cut than the "Limited-fed" calves. As would be expected, the percent bone varied inversely with the above two. The percent fat by chemical analysis of the total edible portion varied in a similar manner as that obtained by physical separation. The percent water of the total edible portion varied inversely as the percent chemical fat of the same tissues.

With respect to percent fat in the longissimus dorsi (rib-eye) muscle, the "Limited-fed" calves had an average of .71 percent more fat (4.14% vs. 3.43%) than the "Delayed Full-fed" calves although this difference was not statistically significant. The calves in the first experiment had a statistically significant larger amount of fat in the rib-eye than those from the second experiment.

OBJECTIVES

Considering the review of literature and the previous experiments at Michigan State University, the following objectives were established:

1. To evaluate the effects of time and rate of grain feeding on production efficiency of steer and heifer calves.
2. To evaluate the effect of time and rate of grain feeding on Federal carcass grades, muscle development and fat deposition in the carcass.
3. To study the relationship of live animal grades, carcass grades and certain objective measurements.

EXPERIMENTAL PROCEDURE
1957-1958

SOURCE OF CATTLE

Twenty-four steers and twenty-two heifers of Angus, Hereford and Angus X Hereford breeding were obtained from the University experimental herd. The calves were sired by four Hereford bulls and two Angus bulls and out of choice and fancy grade cows.

TREATMENT OF LIVE ANIMALS

After weaning, these calves were fed corn silage, supplement and alfalfa mixed hay until the start of this experiment. They were not creep fed at any time. The calves were then divided as equally as possible into four lots, two lots of steers and two lots of heifers, on the basis of breeding, age, weight and feeder grade.

The cattle were fed in an open barn with concrete yards. They were group fed and had free access to automatic waterers and a mixture of trace mineral salt and dicalcium phosphate. All cattle were fed twice daily, receiving soybean meal at the rate of one-fourth pound per 100 pounds body weight, and hay at the rate of two pounds per head daily. During the last month of the experiment when only ten animals remained on test, the feeding of corn silage was discontinued and replaced by hay. One lot of steers (Lot 1) and one lot of heifers (Lot 3) received a "Limited-fed" ration of ground shelled corn at the rate of 1.25 pounds per

100 pounds body weight, plus corn silage full-fed throughout the experiment. The estimated lot weight of the cattle was obtained by adding one half of the previous two week's gain to the present live weight. This estimated lot weight was the basis for calculating the amount of corn daily to feed per 100 pounds body weight for the next two week period. The remaining lot of steers (Lot 2) and of heifers (Lot 4) ("Delayed Full-fed lots") received corn silage full-fed for the first 98 days in addition to protein supplement and hay as fed in Lots 1 and 3. Thereafter they were brought up gradually to a full feed of ground shelled corn with silage being fed according to appetite, this ration continuing until time of slaughter. The supplement, corn and corn silage, were mixed together in the manger at each feeding for each lot.

All cattle were individually weighed starting at one o'clock on three consecutive days, December 17, 18 and 19, 1957. The average of these three weights was taken as the initial weight. The cattle were individually weighed every two weeks during the experiment.

A panel of six members of the Animal Husbandry Department graded the live animals individually at approximately monthly intervals commencing in June of 1958. Those cattle grading Low choice or higher were selected for slaughter after each grading. The first group was slaughtered on July 22, 1958.

Final feed-lot weights were obtained by averaging individual weights obtained on three consecutive days previous to the day of slaughter.

Cattle to be slaughtered were removed from the experiment following the last weighing and prior to the evening feed. They were then trucked to the adjacent University Meat Laboratory where they had access to water but no feed up until time of slaughter the following morning. Slaughter weights, to the nearest pound, were obtained immediately prior to slaughter.

LIVE ANIMAL MEASUREMENTS

Two days prior to the day of slaughter all animals were measured as they stood naturally on a level concrete floor. All linear measurements were obtained by the use of metal calipers. The height measurement was taken using the 180 centimeter bar to the nearest centimeter, while the width measurements were taken to the nearest centimeter using the 100 centimeter bar. Circumference measurements were taken using a steel tape graduated in centimeters. All circumference measurements were taken to the nearest centimeter except the circumference of the cannon bone which was taken to the nearest fourth of a centimeter.

Each measurement was taken twice and the average of the two measurements was used in the data.

Height Measurement

Height of Withers: This was the distance from the floor to the highest point of the shoulder

Width Measurements

Width of Shoulder: Width of the shoulder was taken at the widest point of the shoulder. In order that the width measurements would be obtained the same distance from the topline of each animal, a wooden "T" was slipped on the caliper when obtaining the crop and loin measurements. Thus the measurements were taken eight inches down from the topline.

Width of Crops: This measurement was taken over the crops region.

Width of Loin: Width of loin measurement was obtained midway between the 13th rib and the tuber coxae (hooks). The arms of the calipers were pressed firmly against the loin in obtaining this measurement.

Width through Thighs: Width through thigh measurement was obtained through the thigh area with the calipers held vertically.

Circumference Measurements

Heart Girth: This circumference was measured by encircling the steel tape around the animal immediately behind the elbow.

Circumference of Middle: This was the greatest distance around the barrel of the animal at a point just anterior to the pizzle or navel.

Circumference of Hind Flank: The distance encircling the body of the animal at the highest point of the hind flank and immediately posterior to the tuber coxae.

Circumference of Cannon Bone of Fore Leg: This was the smallest circumference of the metacarpal bone taken approximately half way between the knee and the pastern joint.

SLAUGHTER AND CARCASS DATA

Slaughter Procedure

The slaughter procedure recommended by Deans (1951) was followed. Slaughter weights immediately before slaughter were obtained. Weights of the full and empty stomach, full intestines and caul fat were recorded. The spinous processes were not "scored" on the right side of the carcasses. All carcasses were weighed, shrouded and placed in a chilling room for 48 hours after which the shrouds were removed and chilled weights to the nearest one-half pound were obtained.

Carcass Data

Carcasses were graded to the nearest third U.S.D.A. grade by a Federal meat grader, who evaluated each carcass with regards to (1) conformation grade (2) unribbed quality grade (3) ribbed quality grade and (4) final overall carcass grade.

The right side of the carcasses was divided between the 12th and 13th rib. The wholesale 7-rib cut was removed according to the procedure of Hankins _et al._ (1946) and a tracing was obtained of the rib cut at the point of separation from the loin. The same end of the rib cut was then squared according to Figure 1. A second tracing of the eye muscle was then obtained.

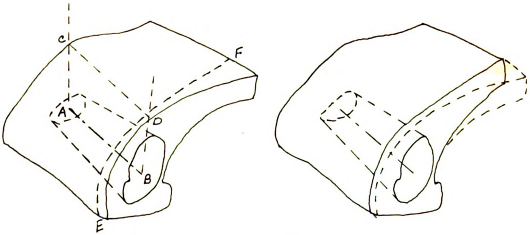
The 9-10-11 rib cut was removed from the wholesale 7-rib cut according to Hankins _et al._ (1946), the _longissimus dorsi_ (rib-eye) muscle was excised, the remainder was separated into fat, lean and bone and weighed to the nearest gram. Samples of the fat and lean together minus the _longissimus dorsi_ were obtained for chemical analysis as described later.

SPECIFIC GRAVITY

All specific gravity determinations were made four days after slaughter, except that the specific gravity determinations of the first five and next 14 carcasses were made 13 days and seven days, respectively, after slaughter, using the apparatus in Figure 2.

The specific gravity of each of three cuts was determined prior to removal of any portion for subsequent specific gravity determination. The 7-rib wholesale cut, after squaring, and the 9-10-11 rib cut were weighed to the nearest gram in air and the nearest 0.1 gram in water. The eye muscle from the 9-10-11 rib cut, with superficial facia removed, was weighed to the nearest 0.1 gram in air and the

FIGURE 1. METHOD OF SQUARING 7-RIB WHOLESALE CUT

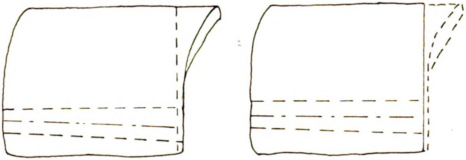


Perspective view of twelfth rib end

AB central axis of <u>longissimus</u> <u>dorsi</u> muscle

CD projection of central axis of <u>longissimus</u> <u>dorsi</u> muscle on surface of rib cut

EF line perpendicular to CD along which the cut was made



Outside surface view

FIGURE 2. APPARATUS FOR THE DETERMINATION OF SPECIFIC GRAVITY

A. Scale weighs to .01 gram
B. Scale weighs to .1 gram
C. Scale weighs to 1 gram
D. Barrel containing distilled water

nearest 0.01 gram in water.

The meat was kept in a 30-36° F. cooler prior to the specific gravity determinations. Distilled water at 36-40° F. temperature was used for the determinations. The specific gravity determinations were made in a cold (36-40° F.) corridor, thus the temperatures were nearly equal during the determinations.

Specific gravity was calculated according to the formula given by Brown *et al*. (1951).

Preparation and Chemical Analysis

After weighing in water, the *longissimus dorsi* muscle was blotted to remove excess moisture and ground five times through a 5/64 inch grinder plate. Approximately 40 gram aliquot was placed in a glass jar, sealed and frozen for subsequent analysis. The other separable fat and lean from the 9-10-11 rib cut was treated similarly.

In preparation for analysis the sample was thawed in a jar, with the lid on, mixed thoroughly and a three to five gram sample was placed in a dry tared disposable aluminum moisture dish and weighed. The sample was then placed in an oven at 75° C. and 28 to 30 inches of vacuum for 24 hours, removed, cooled in a desiccator and weighed. The percentage moisture was calculated from the loss in weight of the sample.

The samples along with the disposable aluminum dishes were placed in an alundum cup and extracted for four hours with anhydrous ethyl ether in a Goldfisch extraction apparatus.

The ether extract was collected in a tared beaker, the excess ether evaporated and the beaker and extract dried for one hour at 100° C. in a forced draft oven. The beakers plus extract were then placed in a desiccator to cool for one hour after which they were weighed. The per-cent ether extract was calculated on the basis of increased weight of the beaker and the original moist weight of the sample.

RESULTS

The results are presented in five general sections. The first section dealing with the feeding period, the second section dealing with slaughter and carcass data, the third section dealing with specific gravity, the fourth section dealing with live animal measurements, and the fifth section with relationships of live animal and carcass attributes.

FEEDING PERIOD

An analysis of variance of starting weights of the steers and heifers showed there was no statistically significant difference between the average starting weights among the four lots.

Data regarding days on experiment, initial weights and average gains are presented in Table 3.

Examination of this table reveals that for the entire trial, the "Delayed Full-fed" lots were fed a longer period of time than the "Limited-fed" lots (271 days and 253 days respectively for steer and heifer lots combined) (P.05). Heifers were fed for an average of 33 days less than steers (P.01). The "Limited-lot" of steers gained an average of 69 pounds per head more during the first 98 days of the experiment than the "Delayed-lot" of steers receiving no corn. From the 98th day until the end of the experiment the trend was reversed and the "Delayed-lot" of steers which

TABLE 3. AVERAGE LIVE WEIGHTS, GAINS AND DAYS ON EXPERIMENT

	Steer Calves		Heifer Calves	
	Lot 1 Limited-fed corn	Lot 2 Delayed Full-fed Corn	Lot 3 Limited-fed corn	Lot 4 Delayed Full-fed Corn
No. per lot[1]	11	11	11	10
Av. days on experiment	275	282	231	260
Av. initial wt., lbs. (Dec. 19)	405	396	382	381
Av. wt., lbs.[2] March 27 (98 days)	612	534	563	510
Av. final wt. lbs.	1013	980	864	887
Av. gain per head lbs.				
First 98 days	207	138	181	129
98 days to slaughter	401	446	301	377
Total period	608	584	482	506
Av. daily gain per head lbs.				
First 98 days	2.11	1.41	1.85	1.32
98 days to slaughter	2.27	2.42	2.26	2.33
Total period	2.21	2.07	2.09	1.95

1. One animal in each of Lots 1, 2 and 4 died. Weight and feed removed from data.

2. "Delayed Full-fed" lots started on ground corn.

were then full-fed exceeded the "Limited-lot" by 45 pounds per head. Similar figures for heifers were 52 pounds per head for the first 98 days and 76 pounds per head from the 98th day until the end of the experiment. The difference in gain during the first 98 days was highly significant between treatments and significant between sexes. There was a highly significant difference in total gain for the experiment due to sex but no difference due to treatment. Analysis of variance of the average daily gains showed similar results as were obtained for average total gain throughout the experiment, except there was no significant difference due to treatment or sex for average daily gain at the time of slaughter.

Feed data could not be treated statistically due to lot feeding. "Limited-fed" steer calves consumed an average of 220 pounds more corn per head than "Delayed-fed" steer calves (Table 4). This trend was reversed in the heifers, in that the "Delayed-lot" consumed 55 pounds more corn per head than the "Limited-lot". Steers consumed an average of 510 pounds more corn than heifers. "Delayed-lots", both steers and heifers, consumed slightly more corn silage per head during the experiment than the "Limited-lots", the greatest difference being 233 pounds between the heifer lots. There was no consistent trend in soybean meal consumption due to treatment, the "Limited-lot" of steers consumed an average of 14 pounds more per head than the "Delayed-lot". The "Delayed-lot" of heifers consumed an average of 45 pounds more than the "Limited-lot", due principally to the longer average feeding period. The steers ate considerably more soybean meal than heifers due to longer feeding period and greater average weight. Hay was fed at a definite daily rate, thus the total amount consumed varied with the length of time on feed.

TABLE 4. RATIONS AND FEED CONSUMPTION

	Steer Calves		Heifer Calves	
	Lot 1 Limited-fed corn	Lot 2 Delayed Full-fed Corn	Lot 3 Limited-fed corn	Lot 4 Delayed Full-fed Corn
Av. total feed per head				
Gr. shelled corn	2392	2172	1745	1800
Soybean meal	481	467	352	397
Corn silage	4145	4248	3732	3975
Hay	575	628	459	545
Av. daily rations				
Gr. shelled corn				
1st phase 98 days	5.7	0	5.5	0
2nd phase (98-day end)	10.4	11.8	9.0	11.1
Total period	8.7	7.5	7.5	6.9
Soybean meal - total period	1.8	1.7	1.5	1.5
Corn silage				
1st phase	17.4	25.2	16.8	23.6
2nd phase	13.8	9.7	15.6	10.2
Total period	15.1	15.0	16.1	15.3
Hay - total period	2.1	2.2	2.0	2.1
Feed per cwt. gain				
Gr. shelled corn - total period	393	372	362	355
Soybean meal - total period	79	80	73	78
Corn silage - total period	681	728	775	785
Hay - total period	95	108	95	108

When calculated on the basis of average daily ration over the total feeding period, the "Limited-lots" consumed more corn and corn silage than the "Delayed-lots". Approximately the same amount of soybean meal and hay were consumed by the two treatments within sex.

"Delayed-lots" consumed less corn per 100 pounds gain (steers 21 pounds, heifers 7 pounds) than "Limited-lots", but ate slightly more corn silage (steers 47 pounds, heifers 10 pounds.) Hay consumption per 100 pounds gain was identical within treatment but the "Delayed-lot" of heifers consumed five pounds more soybean meal per 100 pounds gain than did the "Limited-lot" of heifers. The heifers consumed an average of 24 pounds less corn but 76.5 pounds more corn silage per 100 pounds gain than did the steers.

When the average amount of corn and soybean meal per 100 pounds gain were added together the "Limited-lot" of steers required 20 pounds more than the "Delayed-lot" whereas in the case of heifers this difference was three pounds. Steers ate an average of 28 pounds more total concentrate per 100 pounds gain than heifers.

The estimated total digestible nutrients (T.D.N.) were calculated and are presented in Table 5. On the basis of T.D.N. consumption per head at the termination of the experiment there was no consistent trend due to treatment. In the case of steers the "Limited-lot" consumed 142 pounds more T.D.N. per head than the "Delayed-lot" whereas the

TABLE 5. ESTIMATED TOTAL DIGESTIBLE NUTRIENT CONSUMPTION*

	Steer Calves		Heifer Calves	
	Lot 1 Limited-fed corn	Lot 2 Delayed Full-fed Corn	Lot 3 Limited-fed corn	Lot 4 Delayed Full-fed Corn
Av. total T.D.N. per head				
Gr. shelled corn	1916	1740	1398	1442
Soybean meal	376	365	275	310
Corn silage	759	777	683	727
Hay	289	316	231	274
Av. total	3340	3198	2587	2753
T.D.N. per cwt. gain				
Gr. shelled corn - total period	315	298	290	284
Soybean meal - total period	62	62	57	61
Corn silage - total period	125	133	142	144
Hay - total period	48	54	48	54
Av. total	550	547	537	543

*Morrison, Frank B. Feeds and Feeding, 22nd Edit. Morrison Publishing Co. 1956.

Corn #2	80.1
Corn silage (recent analysis)	18.3
Soybean meal (all analysis)	78.1
Hay	50.3

"Delayed-lot" of heifers consumed 166 pounds more T.D.N. per head than the "Limited-lot" of heifers. The average difference due to treatment amounted to only 12 pounds T.D.N. per head in favor of the Delayed-lots". Heifers ate an average of 599 pounds less T.D.N. per head than steers. Calculation of T.D.N. per 100 pounds gain revealed only small differences due to treatment within sex (steers 3 pounds, heifers 6 pounds). Heifers required an average of 8.5 pounds less T.D.N. per 100 pounds gain than steers.

SLAUGHTER AND CARCASS DATA

Slaughter and carcass data are presented in Table 6. There was no statistically significant difference in slaughter weights due to treatment but there was a highly significant difference due to sex, the steers averaging 122 pounds heavier than the heifers. There was a range of 1.4 percent in average dressing percent between lots, the "Limited-lot" of steers having the highest dressing percentage and "Delayed-lot" of steers the lowest dressing percentage (62.5 percent and 61.1 percent respectively), but there was no significant difference due to treatment or sex. There was a significant interaction between treatment and sex on dressing percentage.

Steer carcasses graded significantly higher (P.05) in conformation than did heifers. No statistically significant difference due to treatment or sex was observed in the following items in grading: slaughter grade, unribbed quality, ribbed quality and final carcass grade. Although the difference was not significant the "Delayed Full-fed" heifers tended to grade highest of all lots in the ribbed quality and final carcass grade.

Heifers had significantly less average weight of caul fat (greater omentum) (P.01) than steers (20.7 pounds and 25.4 pounds respectively) but there was no significant difference due to treatment. When the weight of caul fat was expressed as a percent of chilled carcass, there was no

TABLE 6. SLAUGHTER DATA AND CARCASS GRADES

	Steer Calves		Heifer Calves	
	Lot 1 Limited-fed corn	Lot 2 Delayed Full-fed Corn	Lot 3 Limited-fed corn	Lot 4 Delayed Full-fed Corn
Av. Slaughter wt.	985	946	829	858
Av. dressing percent	62.5	61.1	61.5	61.8
Av. slaughter grade[1]	19.6	19.2	19.3	19.3
Av. carcass grade[1,2]				
Conformation	21.2	21.1	19.7	19.8
Unribbed quality	19.3	19.4	18.6	19.3
Ribbed quality	19.0	18.9	19.0	19.5
Final grade	19.0	18.9	19.1	19.4
Av. wt. of caul fat	25.4	25.3	20.5	20.8
Av. percent caul fat of chilled carcass	4.18	4.34	4.02	3.95

1. High choice = 21, Av. choice = 20, Low choice = 19, High good = 18.

2. Federal grades

significant difference due to treatment or sex.

The area of <u>longissimus dorsi</u> (rib-eye) muscle was approximately .62 square inches larger in steers than heifers (11.02 square inches and 10.40 square inches respectively) (Table 7), but this difference was not statistically significant. There was no significant difference in rib-eye area due to treatment.

The average thickness of fat over the rib-eye muscle was significantly less (P.05) for heifers than it was for steers (19.6 mm. and 22.4 mm. respectively). There was

TABLE 7. AREA OF RIB-EYE AND CARCASS FAT MEASUREMENTS

	Steer Calves		Heifer Calves	
	Lot 1 Limited-fed corn	Lot 2 Delayed Full-fed Corn	Lot 3 Limited-fed corn	Lot 4 Delayed Full-fed Corn
Av. area of rib-eye (sq. inches)	10.96	11.08	10.41	10.38
Av. fat thickness over rib-eye muscle (mm.)	24.2	20.5	19.6	19.5
Av. percent ether extract in rib-eye muscle	5.84	6.19	6.53	6.94
Av. percent ether extract in composite[1]	57.31	56.24	58.23	57.16
Av. percent ether extract in 9-10-11 rib cut (boneless)	41.64	40.15	41.44	41.04
Physical analysis av. percent fat 9-10-11 rib cut (bone in)	43.67	41.60	42.68	42.02
Av. percent fat 9-10-11 rib cut (boneless)	49.52	47.56	48.09	47.55
Av. percent moisture 9-10-11 rib cut (boneless)	35.56	35.94	35.42	36.15

1. Separable fat and lean minus longissimus dorsi muscle of 9-10-11 rib combined.

no statistically significant difference due to treatment or sex in percent ether extract of the rib-eye muscle, but the two "Delayed-lots" averaged 0.36 percent higher than "Limited-lots" and the heifers averaged 0.72 percent higher than the steers.

Physical and chemical analyses of the 9-10-11 rib cut, with or without the bone or rib-eye, revealed no significant difference in percent bone, moisture, separable fat or ether extract due to treatment or sex.

SPECIFIC GRAVITY

The average specific gravities of the 7-rib wholesale cut, 9-10-11 rib cut and the <u>longissimus</u> <u>dorsi</u> (rib-eye) muscle from the 9-10-11 rib cut are presented in Table 8.

TABLE 8. AVERAGE SPECIFIC GRAVITY DETERMINATIONS

	Steer Calves		Heifer Calves		Range
	Lot 1 Limited-fed corn Av.	Lot 2 Delayed Full-fed Corn Av.	Lot 3 Limited-fed corn Av.	Lot 4 Delayed Full-fed Corn Av.	
7-rib cut	1.0472	1.0485	1.0487	1.0490	1.0386-1.0613
9-10-11 rib cut	1.0412	1.0438	1.0434	1.0441	1.0283-1.0545
Rib eye	1.0630	1.0638	1.0623	1.0618	1.0565-1.0684

The ranges in specific gravity of the various cuts were: 7-rib wholesale cut 1.0386 to 1.0613; 9-10-11 rib cut 1.0283 to 1.0545 and rib-eye from 9-10-11 rib cut 1.0565 to 1.0684. There was no statistically significant difference due to treatment or sex in the specific gravity measurements. The rib-eye of the heifers tended to have a lower specific gravity whereas the rib cuts of heifers tended to have a higher specific gravity than corresponding cuts from the steers.

LIVE ANIMAL MEASUREMENTS

The average live animal measurements are presented in Table 9. In no case was there a statistically significant difference due to treatment. The following live measurements differed significantly (P.01) between sexes: height at withers, heart girth, circumferences of belly, hind flank and cannon bone, and the width of shoulders and width through the thigh region. In all of the above mentioned cases the heifer measurement was smaller than the steer measurement.

RELATIONSHIP OF CERTAIN LIVE ANIMAL AND CARCASS ATTRIBUTES

Live Animal Measurements and Live Weight

Correlation coefficients between live weight and ten live animal measurements were calculated and shown in Table 10. All the correlations were highly significant (P.01) except the correlation between live weight and width

TABLE 9. AVERAGE LIVE ANIMAL MEASUREMENTS[1]

	Steer Calves		Heifer Calves	
	Lot 1 Limited-fed corn	Lot 2 Delayed Full-fed Corn	Lot 3 Limited-fed corn	Lot 4 Delayed Full-fed Corn
Av. height at withers	113	112	108	110
Av. circumference				
Heart girth	190	187	177	180
Belly	218	218	206	208
Hind flank	187	183	178	180
Cannon bone	19.50	19.25	17.50	18.00
Av. width				
Shoulders	54	54	51	51
Crops	41	39	40	39
Loin	34	33	32	33
Hooks	45	45	44	44
Thighs	53	53	52	51

1. Measurements are in centimeters.

TABLE 10. SIMPLE CORRELATIONS OF LIVE ANIMAL MEASUREMENTS WITH LIVE WEIGHT, RIB-EYE AREA AND FINAL CARCASS GRADE

	Live Weight r	Rib-Eye Area[1] r	Final Carcass Grade r
Height at withers	.84**	.27	-.16
Heart girth	.84**	.45**	.29
Circumference of belly	.73**	.27	.15
Circumference of hind flank	.85**	.39*	.01
Circumference of cannon bone	.67**	.33*	.25
Width of shoulders	.61**	.32*	.24
Width of crops	.09	-.04	.33*
Width of loin	.61**	.36*	.01
Width of hooks	.84**	.16	.03
Width of thighs	.54**	.30	.17
Live weight	---	.44**	.09

* significant at P = .05

** significant at P = .01

1. Not adjusted for live weight

of crops, which was non-significant. Height at the withers, heart girth, circumference of hind flank and width of hooks had the highest correlations with live weight of .84, .84, .85 and .84 respectively.

<u>Longissimus dorsi</u> muscle area unadjusted for live weight was highly significantly correlated (P.01) with live weight and heart girth (.44 and .45 respectively) and

significantly correlated (P.05) with circumference of hind flank (.39), circumference of cannon bone (.33), width of loin (.36) and width of shoulders (.32).

The only live animal measurement obtained which was significantly correlated with the final carcass grade was the width of crops which had a correlation of .33 (P.05).

Factors Related to Area of Eye Muscle

The coefficient of correlation between the areas obtained from the first tracing of the rib-eye made before squaring the 7-rib wholesale cut and the second tracing of the rib-eye made after squaring the 7-rib wholesale cut was .88, which was highly significant (P.01) (Table 11). There was a highly significant negative correlation (P.01) of -.39 between the area of the rib-eye and percent ether extract in the boneless 9-10-11 rib cut. Weight of the rib-eye muscle and percent lean of the 9-10-11 rib cut were also highly significantly correlated (P.01) with area of the rib-eye muscle (.41 and .42 respectively). Fat thickness over the rib-eye muscle, percent ether extract of rib-eye muscle and final grade were not significantly correlated with area of the rib-eye muscle.

Specific Gravity Relationships

A highly significant correlation of .93 (P.01) was obtained between specific gravity of the 7-rib wholesale cut and that of the 9-10-11 rib cut (Table 12). There was no

TABLE 11. SIMPLE CORRELATIONS OF CARCASS FACTORS WITH RIB-EYE AREA[1]

	r
Rib-eye area tracing 2	.88**
Percent ether extract of 9-10-11 rib (boneless)	-.39**
Percent ether extract of rib-eye muscle	-.03
Percent lean of 9-10-11 rib	.42**
Fat thickness over rib-eye muscle	.11
Weight of rib-eye muscle	.41**
Final grade	.15

1. Rib-eye area obtained from tracing one, not adjusted for liveweight

** significant at P = .01

TABLE 12. CORRELATIONS BETWEEN SPECIFIC GRAVITIES

	7-rib cut	9-10-11 rib cut
7-rib cut	-----	.93**
Rib-eye muscle	-.02	.29

** Significant at P = .01

significant correlation between the specific gravity of the rib-eye muscle and either the 7-rib wholesale cut or the 9-10-11 rib cut.

Specific gravity of the 9-10-11 rib cut was correlated (P.01) with percent ether extract (-.84), percent fat physical analysis (-.79), percent moisture (.78), percent lean (.71) and percent bone (.44) of the 9-10-11 rib cut. (Table 13). The specific gravity of the rib-eye was correlated (P.01) with percent ether extract (-.65) and percent moisture (.53) of the rib-eye.

TABLE 13. CORRELATION OF SPECIFIC GRAVITY WITH MOISTURE, FAT, BONE AND LEAN

	Fat		Moisture	Lean	Bone
	Ether Extract	Physical Separation			
9-10-11 rib cut	-.84**	-.79**	.78**	.71**	.44**
Rib-eye	-.65**		.53**		

** Significant at P = .01

Grade Relationship

Correlation coefficients between various items in grading were calculated and are presented in Table 14. Neither final live grade or carcass conformation grade were significantly correlated with the other carcass grades or with each other. The unribbed quality grade was significantly correlated (P.01) with ribbed quality grade and final carcass grade (.58 and .62 respectively). Ribbed

TABLE 14. CORRELATION OF GRADES

	Carcass Conformation Grade	Unribbed Quality Grade	Ribbed Quality Grade	Final Carcass Grade
Final live grade	.25	.26	.15	.18
Carcass conformation grade		.11	.21	.25
Unribbed quality grade			.58**	.62**
Ribbed quality grade				.98**

** Significant at P = .01

quality grade had a very high correlation with the final carcass grade of .98 (P.01).

The ribbed quality grade had a correlation of .73 with the percent ether extract of rib-eye (Table 15), this correlation was significant at P.01. However, no significant correlation was found between fat thickness over the rib-eye or area of the rib-eye muscle and ribbed quality grade, in fact the values for the correlations are nearly zero. All specific gravity measurements taken were significantly correlated (P.01) with the ribbed quality grade. The specific gravity of the rib-eye having the highest correlation (-.59) followed by the specific gravity of the 7-rib wholesale cut (-.57) and specific gravity of the 9-10-11 rib cut (-.46).

TABLE 15. CORRELATION OF RIBBED QUALITY GRADE WITH CERTAIN CARCASS MEASUREMENTS

	r
Percent ether extract of rib-eye	.73**
Fat thickness over rib-eye	.00
Area of rib-eye muscle	.03
Specific gravity of 9-10-11 rib cut	-.46**
Specific gravity of the 7-rib wholesale cut	-.57**
Specific gravity of rib-eye muscle	-.59**

** Significant at P = .01

<u>Relationship of Various Measures of Fatness</u>

Specific gravity of the 9-10-11 rib cut was correlated -.84 (P.01) with percent ether extract of the boneless 9-10-11 rib cut (Table 16). The correlation between the specific gravity of the 9-10-11 rib cut and percent fat, determined by physical separation and including the bone, was -.79. The percent ether extract of the rib-eye was correlated -.65 (P.01) with specific gravity of the rib-eye. There were non significant correlations of .20 and -.10 between fat thickness over the rib-eye and percent ether extract in the 9-10-11 rib cut and percent ether extract in the rib-eye respectively. A highly significant correlation of .88 (P.01) was obtained between the percent fat in the 9-10-11 rib cut (bone included) determined by physical separation and the percent fat in the 9-10-11 rib

TABLE 16. CORRELATION BETWEEN CERTAIN MEASURES OF FATNESS

	Percent Ether Extract 9-10-11 rib (boneless)	Percent Fat 9-10-11 Rib Physical Analysis (bone in)	Percent Ether Extract in Rib Eye
Specific gravity of 9-10-11 rib	-.84**	-.79**	
Specific gravity of rib-eye muscle			-.65**
Fat thickness over rib-eye muscle (cm.)	.20		-.10
Percent fat 9-10-11 rib physical analysis (with bone)	.88**		
Percent fat 9-10-11 rib physical analysis (minus bone)	.86**		
Percent ether extract 9-10-11 rib (with bone)			.37*

* Significant at P = .05
** Significant at P = .01

cut (excluding the bone) determined by ether extraction. A similar correlation of .86 was obtained when the percent fat determined by physical analysis was calculated excluding the bone.

A significant correlation of .37 was observed between percent ether extract in the boneless 9-10-11 rib cut and percent ether extract in the rib-eye muscle.

DISCUSSION

The experiment was designed such that the two treatments within sex, using similar total amounts of grain, would result in cattle of similar finish and grade at approximately the same weight and market date. That three of these conditions were approached is shown by analysis of variance of total gain, slaughter grade and fatness measures which revealed no significant difference due to treatment. Although there was a significant difference in length of total feeding period due to treatment, the difference between steer lots in average days on experiment was only seven days whereas it was 30 days between heifer lots.

Although there was no statistically significant difference in average daily gain due to treatment, the "Limited-lots" made slightly greater average daily gain (steers 2.21, heifers 2.09) than did the "Delayed-lots" (steers 2.07, heifers 1.95).

The "Limited-lot" of steers consumed approximately 10 percent more total ground shelled corn per head when compared with the "Delayed-lot" whereas the corresponding figure between the heifer lots was approximately three percent. The heifers consumed considerably less corn per head than the steers, part of which is due to the shorter length of feeding period for the heifers and part to a lighter final and average on-feed weight. On the basis of feed per 100 pounds gain, the "Limited-lots" used slightly more concentrate and slightly less

roughage. The heifers ate less concentrate and more corn silage per 100 pounds of gain.

The heifers ate considerably less total digestible nutrients (T.D.N.) per head than steers due to the shorter feeding period and lighter weights. When the estimated T.D.N. per 100 pounds average body weight during the feeding experiment was calculated, there was very little difference due to treatment. The heifers did consume slightly less T.D.N. per 100 pounds of gain in weight than did the steers.

The "Delayed-lots", when they were on full feed toward the end of the experiment, were consuming approximately the same daily corn ration as the "Limited-lots", thus one and a quarter pounds of corn plus a quarter of a pound of soybean meal per 100 pounds body weight was nearly a full feed for the "Limited-lots". Snapp and Neumann (1960) define a full feed of concentrates as 1.5 to 2.0 pounds per hundred pounds body weight, including any grain that may be contained in corn silage.

Although monetary values placed on a feeding experiment are valuable only for the conditions under which the experiment was conducted, they will give an indication of the economic results. The "Limited-lot" of steers returned slightly more per head above calf and feed cost ($2.70) than the "Delayed-lot" (Table 17) whereas the reverse was true for the heifers ($1.68). Heifers returned considerably less per head than steers due mainly to the lower total gain of

TABLE 17. SUMMARY OF EXPERIMENTAL FEEDING PERIOD

	Steer Calves		Heifer Calves	
	Lot 1 Limited-fed corn	Lot 2 Delayed Full-fed Corn	Lot 3 Limited-fed corn	Lot 4 Delayed Full-fed Corn
No. per lot	11	11	11	10
Av. days on experiment	275	282	231	260
Av. initial wt., (pounds)	405	396	382	381
Av. final wt., (pounds)	1013	980	864	887
Av. total gain per head	608	584	482	506
Av. daily gain per head	2.21	2.07	2.09	1.95
Av. total feed per head				
Gr. shelled corn	2392	2172	1745	1800
Corn silage	4145	4248	3732	3975
Feed per 100 pounds gain (lbs.)				
Gr. shelled corn	393	372	362	355
Corn silage	681	728	775	785
Estimated T.D.N. per 100 pounds gain	550	547	537	543
Av. return above cost of feed and calf[1,2,3]	$ 60.49	$ 57.79	$ 46.81	$ 48.49
Feed cost per 100 pounds gain	$ 13.69	$ 13.97	$ 13.75	$ 13.85
Slaughter grade[1]	19.6	19.2	19.3	19.3

1. Low choice = 19 Av. choice = 20

2. Feed costs
   - Shelled corn $ 2.00/cwt.
   - Soybean meal $ 3.60/cwt.
   - Hay $20.00/ton
   - Corn silage $10.00/ton

3. Prices per 100 pounds

	Feeder Cattle	Fat Cattle
Steers	$30.00	$27.00
Heifers	$28.00	$26.00

the heifers and lesser amounts of feed per head consumed by the heifers. On the basis of feed cost per 100 pounds gain, the "Limited-lots" were slightly more efficient than the "Delayed-lots" but there was no difference between steers and heifers.

Skinner and King (1922) concluded that with two-year-old cattle fed corn silage it was a better practice to full feed corn during the latter part of the feeding period than to feed a half corn ration during the entire period. Johnson _et al_. (1958), with yearling steers, observed similar results to Skinner and King in that the feeding of a given amount of concentrate during the last part of the feeding period was more economical than feeding a similar total amount throughout the feeding period. The results of the above authors were not borne out in this experiment or the 1940-42 experiments at Michigan State University, in which all cattle received more than a half feed of corn.

SLAUGHTER AND CARCASS DATA

The reason for the statistically significant interaction between treatment and sex on dressing percentage is unknown. One factor which may be involved is that heifers tend to fatten at lighter weights and more readily on less concentrate as shown in this experiment and also by other authors (Hankins 1932, Foster and Miller 1933, Gramlich and Thalman 1930, Trowbridge and Moffat 1932, Branaman _et al_. 1936, Branaman _et al_. 1940, Dyer and Weaver 1955).

In this experiment there was a higher percent ether extract in the rib-eye of the "Delayed-lots" as compared to the "Limited-lots", although the difference was not significant. This is the reverse of the 1940-42 experiments at Michigan State University. Hendrickson _et_ _al_. (1959a) observed no difference in ether extract of the rib-eye from steers fed to gain at a high then a moderate rate or the reverse, but the moderate-high lot had a lower marbling score. In a similar experiment conducted by the same researchers (Pope _et_ _al_. 1958), the moderate-high lots had less marbling and ether extract in the rib-eye than high moderate lot.

SPECIFIC GRAVITY

The high correlations between ether extract (-.84) or physical separation (-.79) and specific gravity of the 9-10-11 rib cut indicate the usefulness in using specific gravity as an estimation of fat in this cut. In Figure 3, the average percentage of ether extract (fat) in the boneless 9-10-11 rib cut is plotted against corresponding intervals of specific gravity of the 9-10-11 rib cut (bone in), along with the number of samples in each interval, it will be seen that there is a steady decline in fat percentage with increasing specific gravity except for one instance. It is possible to expect that with a greater number of samples this irregularity might be altered.

In Figure 4 the percent ether extract of the boneless 9-10-11 rib cut has been plotted against specific gravity of

FIGURE 3. DISTRIBUTION OF SPECIFIC GRAVITY OF THE 9-10-11 RIB CUT (BONE IN) AND CORRESPONDING FAT PERCENTAGES OF THE BONELESS 9-10-11 RIB CUT

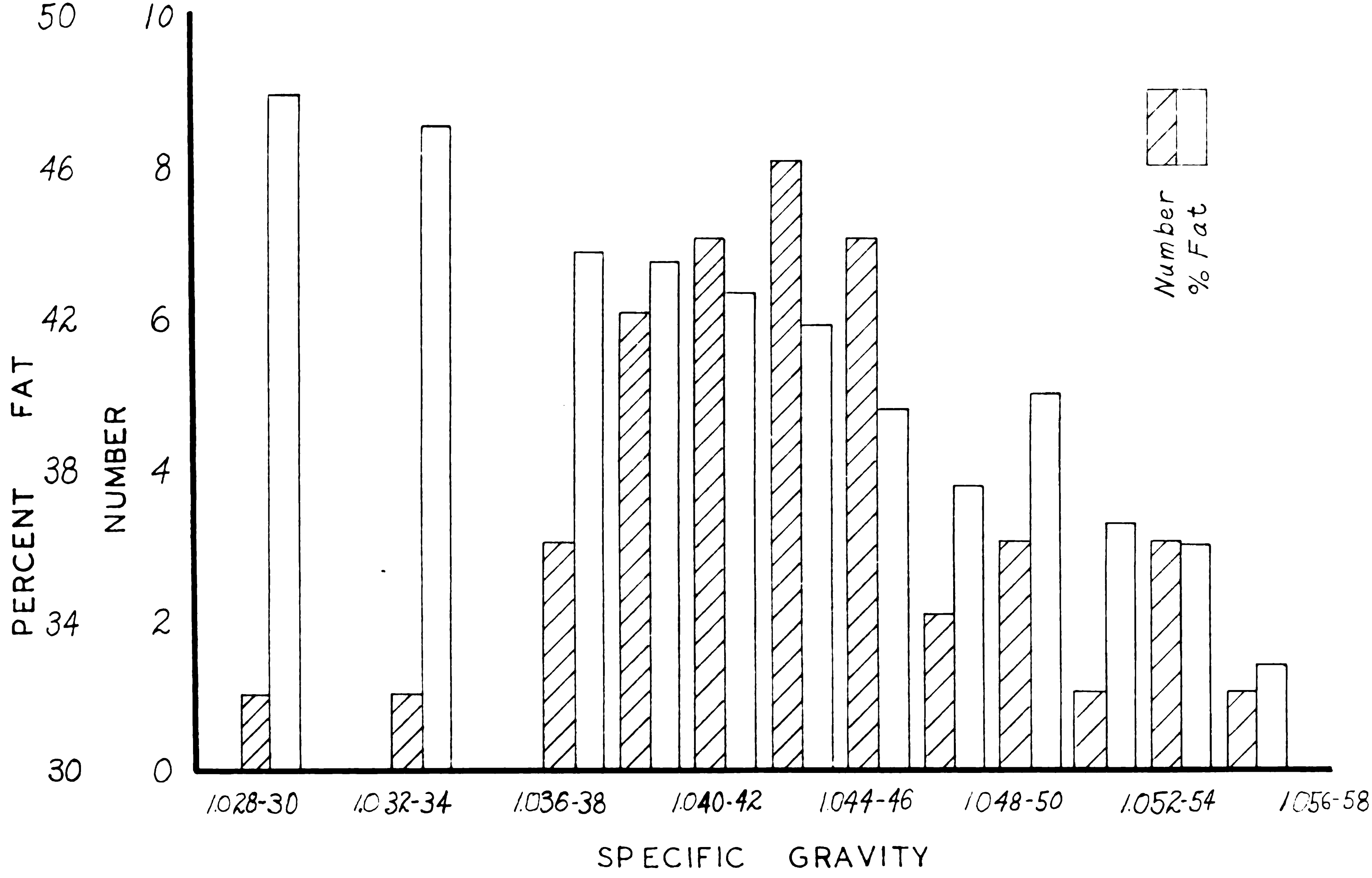
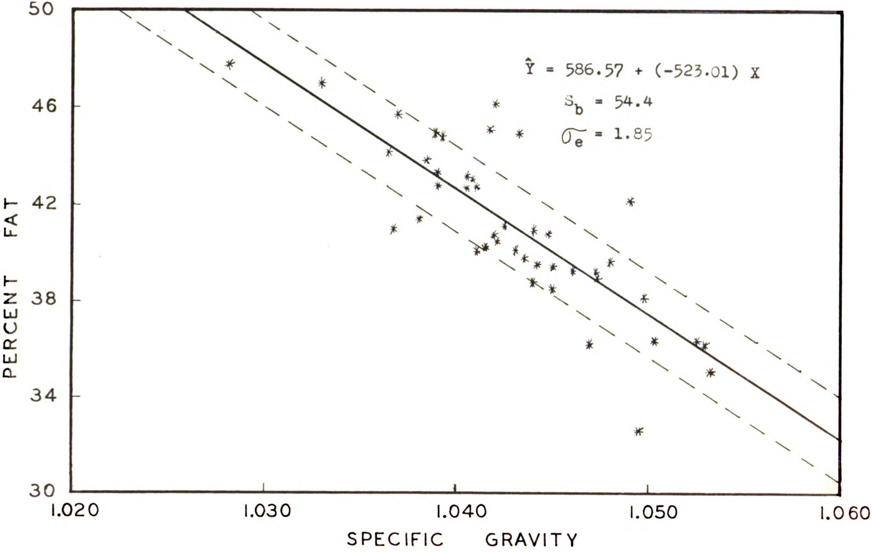


FIGURE 4. REGRESSION PERCENT FAT (ETHER EXTRACT) ON SPECIFIC GRAVITY OF 9-10-11 RIB CUT



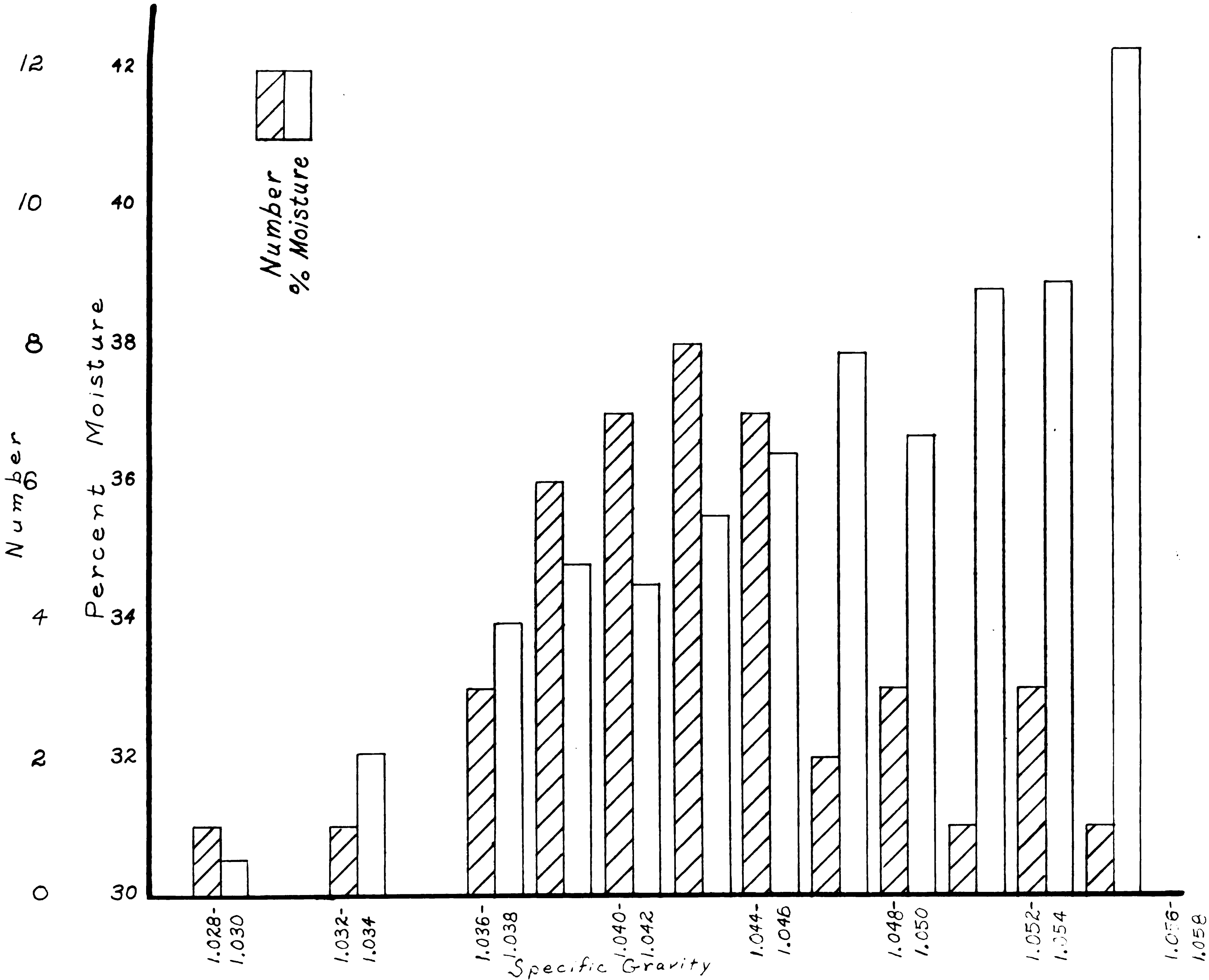
the 9-10-11 rib cut in the form of a scatter diagram and the normal regression line has been drawn in. The equation for this regression line is Y = 586.57 - 523.01X with a standard error of estimate of 1.85. Each .0001 unit increase in specific gravity resulted in a .05 decrease in fat percentage. The correlation between percent ether extract and specific gravity of the boneless 9-10-11 rib cut was -.84 which corresponds favorably to a value of -.73 obtained by Kropf (1959).

A bar chart similar to that in Figure 3 is shown in Figure 5 illustrating the relationship between specific gravity and percent water in the boneless 9-10-11 rib cut. In general it can be seen that with increasing increments of specific gravity there is an increase in percentage moisture. There are two instances in Figure 5 where, with increasing specific gravity the percent moisture declined, this illustrates that with only a few observations errors may occur in comparing samples.

In Figure 6 is plotted the scatter diagram of percent water of 9-10-11 rib cut on the specific gravity of the same cut. The equation for the regression line in this diagram is Y = 354.124X - 333.68 with a standard error of estimate of 1.58. Also for each .0001 unit increase in specific gravity a corresponding increase of .04 percent moisture occurred. The correlation between the above two measures is .78.

The regression line of percent physically separable lean of the 9-10-11 rib cut on the specific gravity of the 9-10-11 rib cut is shown in Figure 7. The equation to this

FIGURE 5. DISTRIBUTION OF SPECIFIC GRAVITY AND CORRESPONDING MOISTURE PERCENTAGES OF THE 9-10-11 RIB CUT



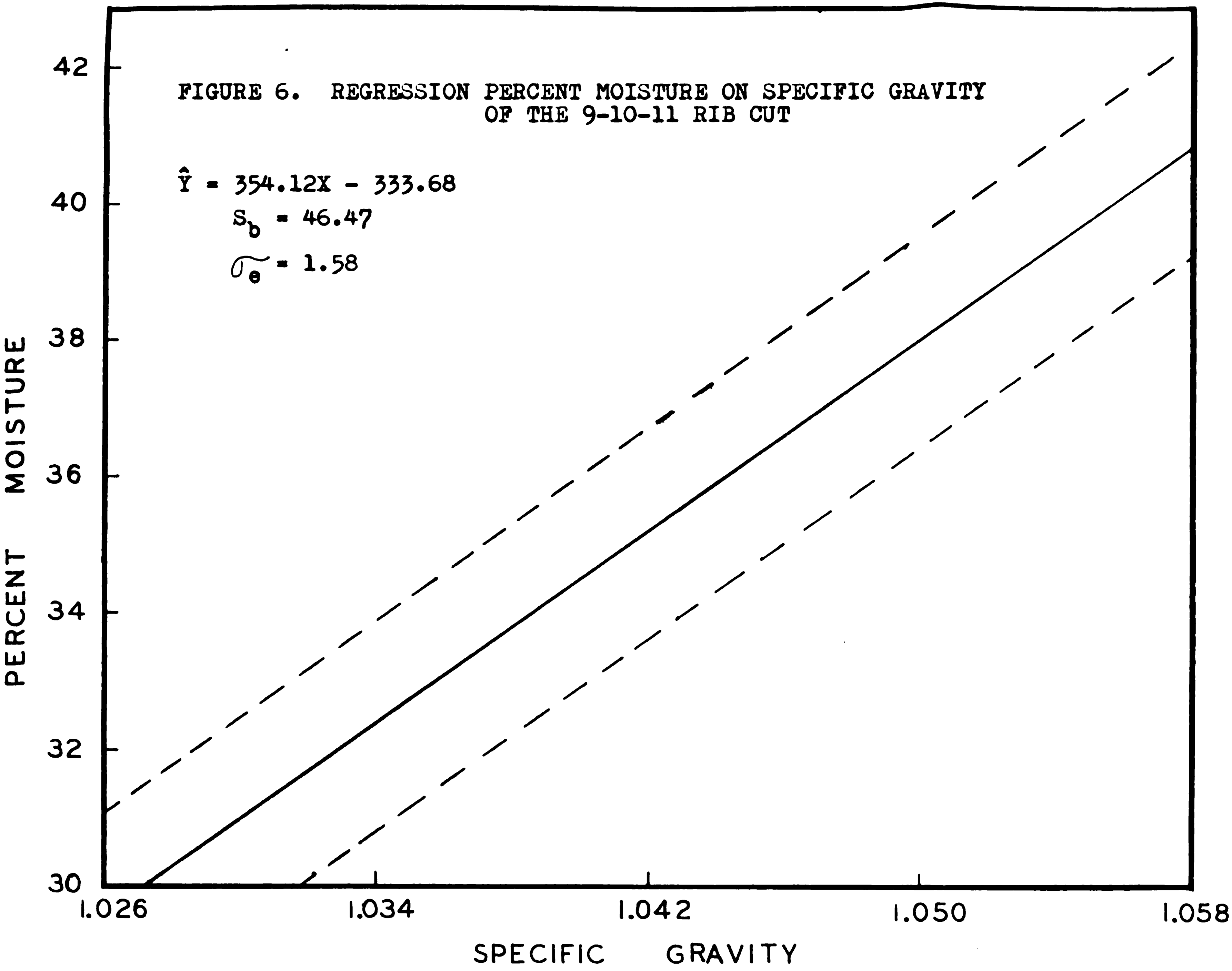


FIGURE 6. REGRESSION PERCENT MOISTURE ON SPECIFIC GRAVITY OF THE 9-10-11 RIB CUT

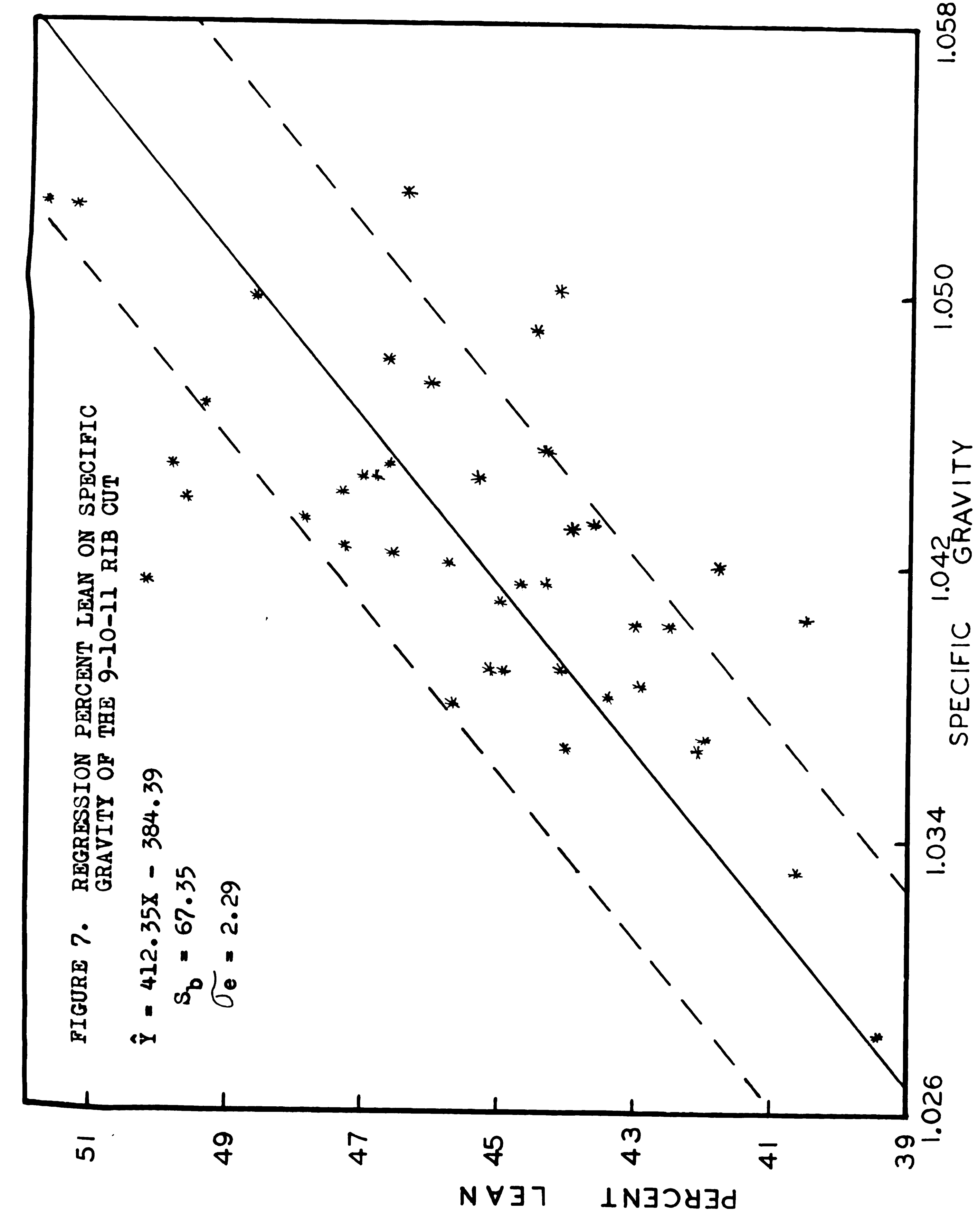


FIGURE 7. REGRESSION PERCENT LEAN ON SPECIFIC GRAVITY OF THE 9-10-11 RIB CUT

line is Y = 412.35X - 384.39 with a standard error of estimate of 2.29. Each increase of .0001 units in specific gravity is represented by a .04 increase in percentage lean of the cut.

In Figure 8 is plotted the specific gravity of the 7-rib wholesale cut against the specific gravity of 9-10-11 rib cut. The regression equation for these data is Y = .875X + .1357 with a standard error of estimate of .0019.. For each increase of .0001 units in specific gravity of the 9-10-11 rib there is an increase of .0001 units in specific gravity of the 7-rib wholesale cut. This close relationship is further exemplified by the high correlation between the specific gravities' of the two cuts (.93). Thus it would appear that the major factors contributing to the specific gravity of the one rib cut also contributes to the specific gravity of the other rib cut. If this were true, then estimates of such factors as percent moisture, fat and lean of the 9-10-11 rib cut could be obtained from the 7-rib wholesale cut without destroying some of its economic value and eliminating possible cutting errors. Theorizing further, it may be possible to use specific gravity of the 7-rib wholesale cut as an indicator of the amount of muscling and fat in the carcass since Breidenstein et al. (1955) has observed the following indices of carcass fatness to be in excellent agreement; specific gravity of the wholesale rib, physical separation of the wholesale rib, determination of the ether extract of separable lean and fat of the wholesale rib. Also,

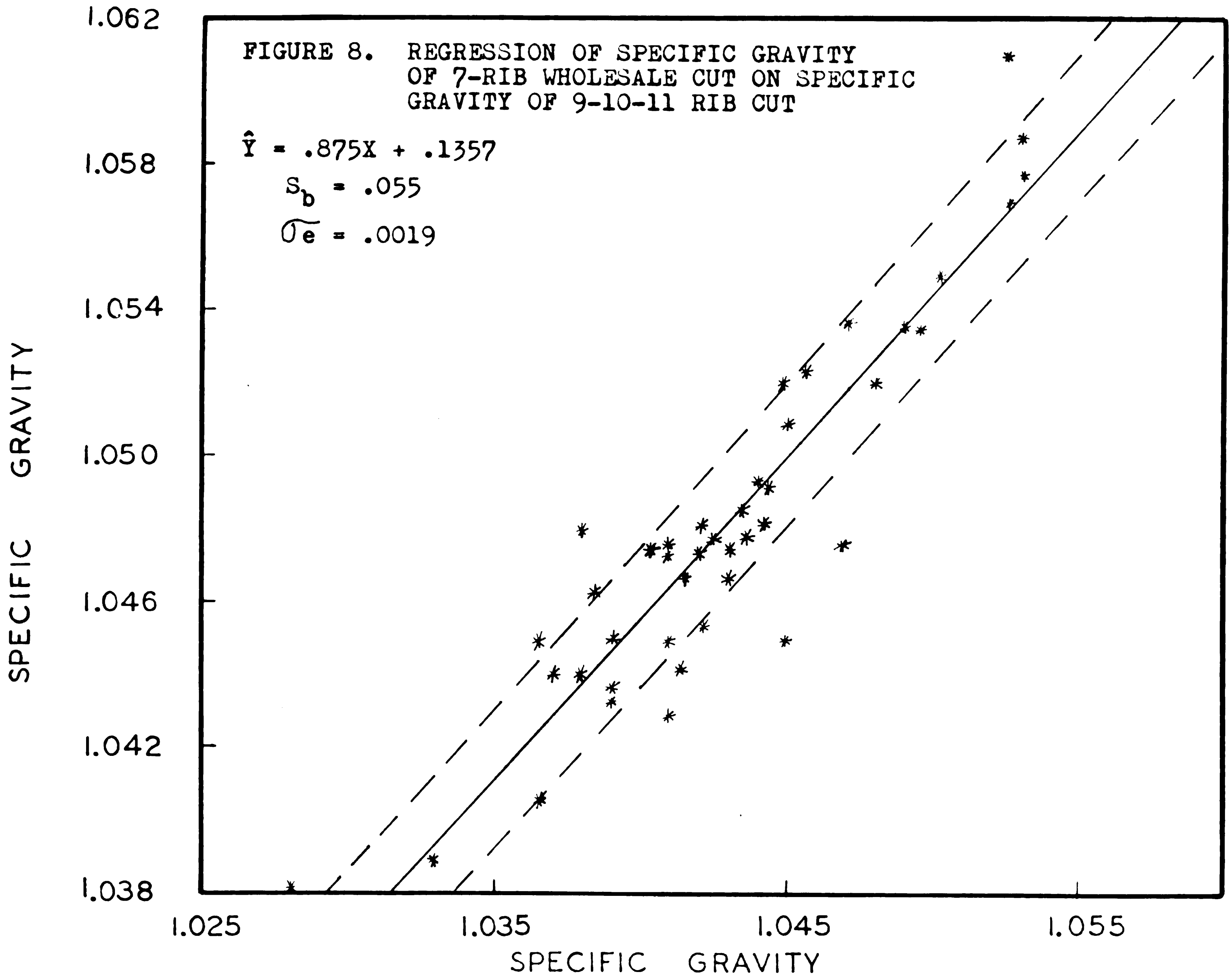


FIGURE 8. REGRESSION OF SPECIFIC GRAVITY OF 7-RIB WHOLESALE CUT ON SPECIFIC GRAVITY OF 9-10-11 RIB CUT

$\hat{Y} = .875X + .1357$

$S_b = .055$

$\sigma_e = .0019$

several researchers have observed high correlations between physical and chemical analysis of the 9-10-11 rib cut and analysis of the whole carcass (Hankins and Ellis 1939, Hankins and Howe 1946, Hopper 1944). Kraybill _et_ _al_. 1951-52, has observed a high correlation between specific gravity of the 9-10-11 rib cut and specific gravity of the carcass.

There was considerable variation in the percentage of ether extract of the rib-eye muscle with intervals of specific gravity as shown in the bar graph in Figure 9. The range of specific gravity of the rib-eye muscle was 1.0565 to 1.0684 while the percent ether extract of the rib-eye ranged from 10.76 to 2.09, a difference of 8.67 percent. The equation for the regression line, shown in Figure 10 is $Y = 386.78 - 357.96X$ with a standard error of estimate of 1.34. Each .0001 unit increase in specific gravity of the rib-eye was accompanied by a decrease of .03 percent ether extract in the rib-eye. The correlation between these two variables was -.65. Orme (1958) observed a range of specific gravity of the _longissimus_ _dorsi_ muscle of from 1.051 to 1.071 (.02) and a range in fat percentage from 1.90 to 11.21 (9.31) percent. The correlation observed by Orme between these two variables was -.81. (Orme 1958, Orme _et_ _al_. 1957).

Since the range in both specific gravity and fat percentage was greater in Orme's (1958) data it is possible to expect a higher correlation than was observed in the present experiment.

The relationship between specific gravity and percent

FIGURE 9. DISTRIBUTION OF SPECIFIC GRAVITY AND CORRESPONDING FAT (ETHER EXTRACT) PERCENTAGES OF THE <u>LONGISSIMUS</u> <u>DORSI</u> MUSCLE

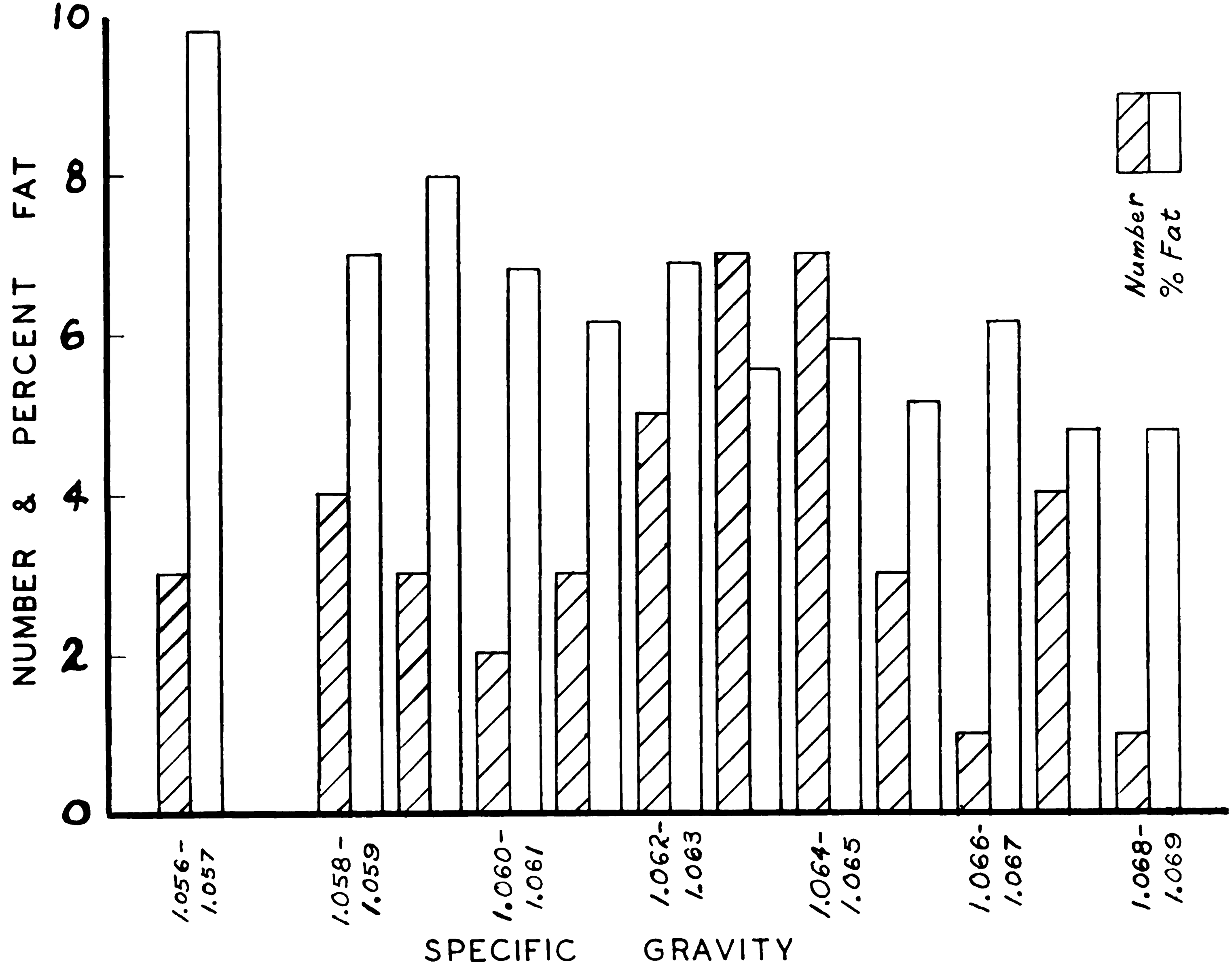
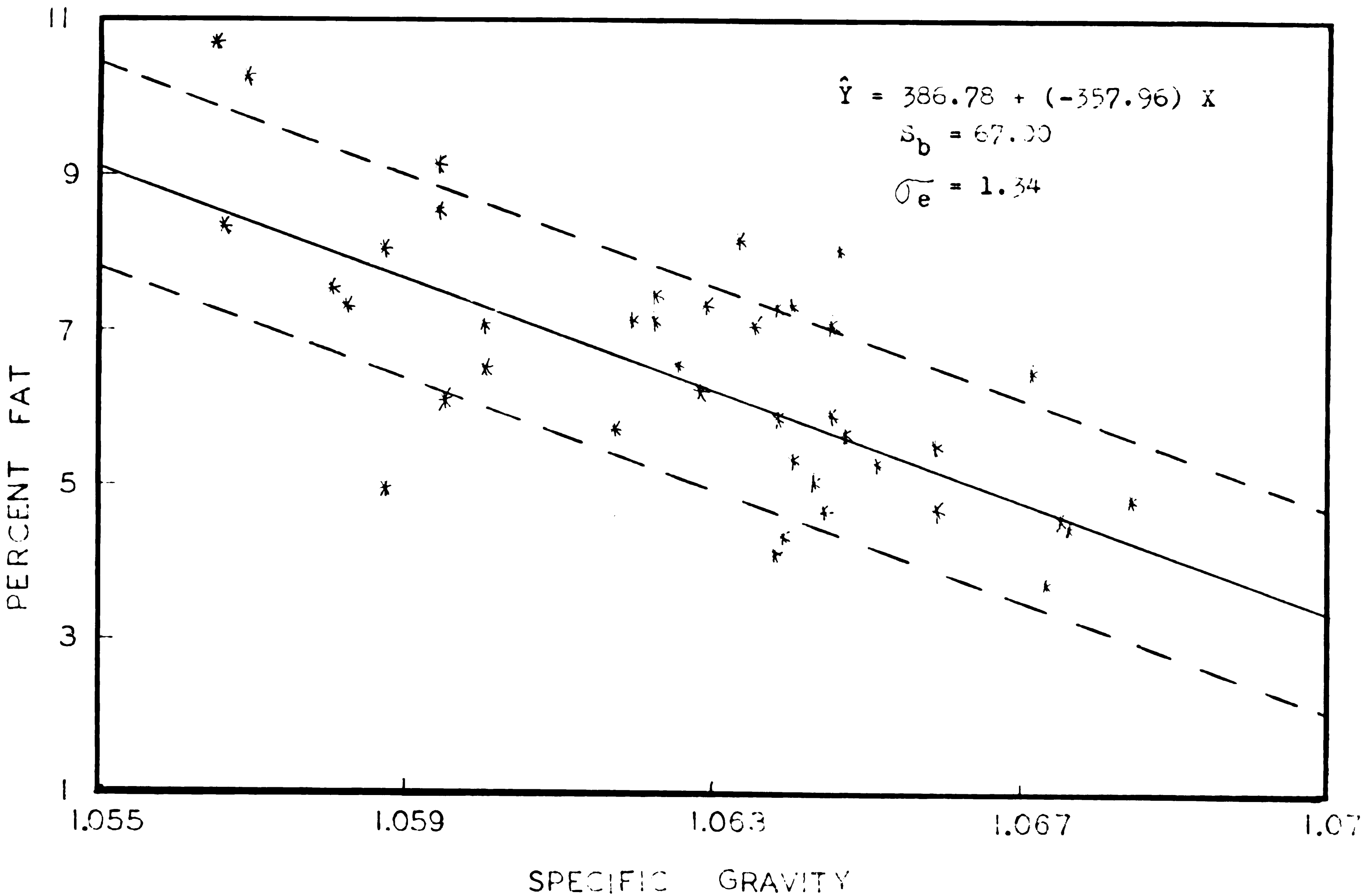


FIGURE 10. REGRESSION OF PERCENT FAT (ETHER EXTRACT) ON SPECIFIC GRAVITY OF <u>LONGISSIMUS</u> <u>DORSI</u> MUSCLE



water in the *longissimus dorsi* (rib-eye) muscle is illustrated in Figure 11. The regression equation is $Y = 223.37X - 165.90$ with a standard error of estimate of 1.15. Thus each change of .0001 unit in specific gravity was accompanied by a change of .02 in percentage moisture of the rib-eye.

RELATIONSHIP OF CERTAIN LIVE ANIMAL AND CARCASS ATTRIBUTES

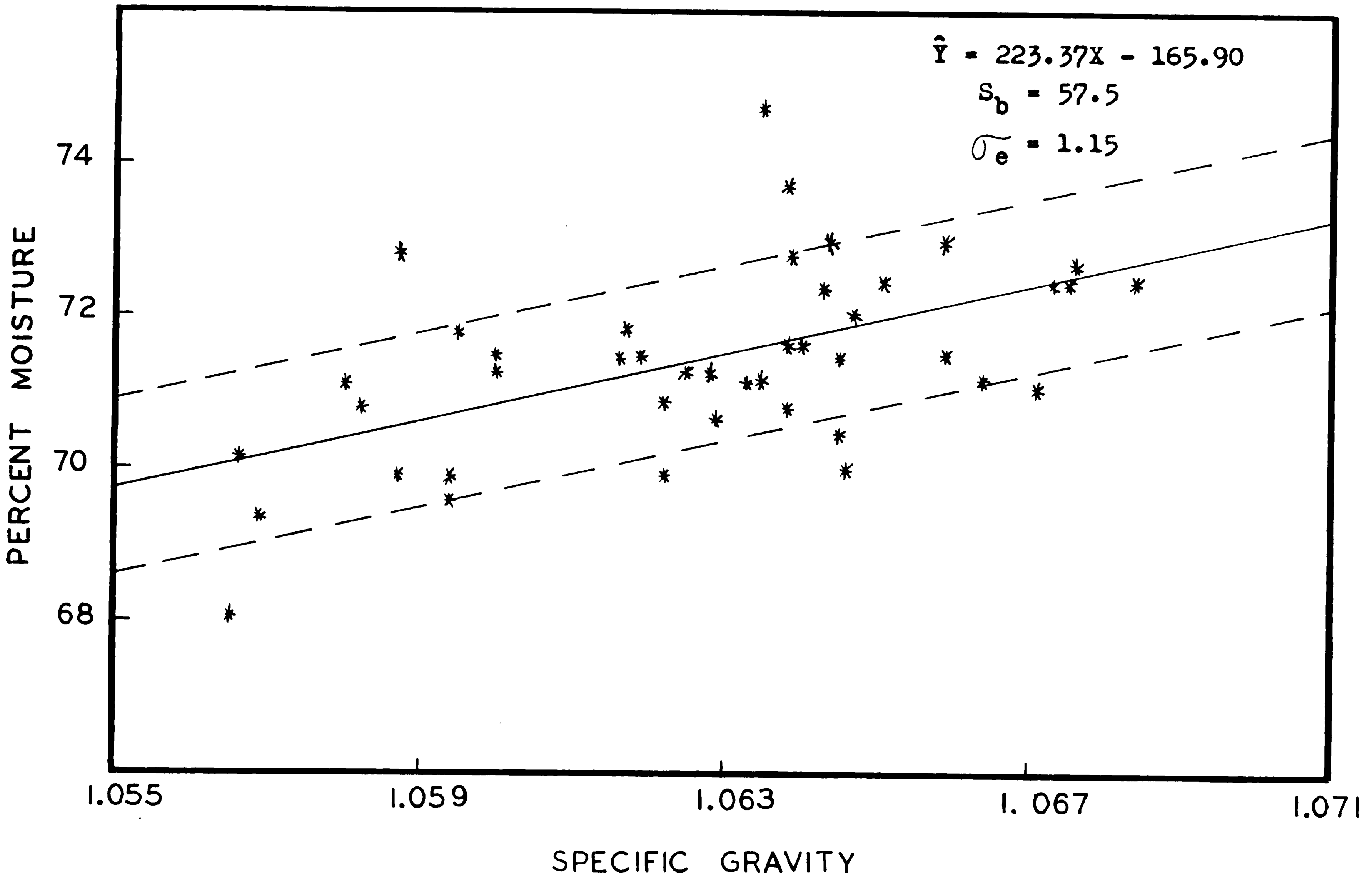
Live Animal Measurements and Live Weight

Four live animal measurements had approximately the same high correlation with live weight, these were height at withers (.84), heart girth (.84), circumference of hind flank (.85) and width of hooks (.84). Lush (1928), Kidwell (1955) and Orme (1958) observed that heart girth was the best single estimate of body weight. Other live animal measurements which had high relationships to live weight as reported by Orme (1958) and supported by this study, were shoulder width, circumference of rear flank, height at withers, and circumference of middle.

Live Animal Measurements and Rib-eye Area

Correlations between live animal measurement and rib-eye area were generally low but heart girth and live weight were highly significantly correlated with rib-eye area. Other measures which were significantly correlated with rib-eye area were: circumference of hind flank, circumference of cannon bone and width of loin. Orme (1958) observed that heart girth, circumference of middle and circumference of hind flank were

FIGURE 11. REGRESSION PERCENT MOISTURE ON SPECIFIC GRAVITY OF *LONGISSIMUS DORSI* MUSCLE



highly significantly correlated (P.01) with rib-eye area, and live weight was significantly correlated (P.05) with rib-eye area, thus supporting the above observations.

Relationship of Factors to Rib-eye Area

Although the coefficient of correlation between the area of the rib-eye obtained from the first tracing of the rib-eye before "squaring" of the 7-rib wholesale cut and the second tracing of the rib-eye made after "squaring" the cut was high (.88), there was considerable variation in the measurements from the two tracings. In all cases the area obtained from the second tracing was smaller than that obtained from the first tracing, the difference varying from .01 to 2.04 square inches.

No significant correlation was observed between the average fat thickness over the rib-eye at the twelfth rib and rib-eye area. This observation was supported by Woodward *et al*. (1954). Weseli *et al*. (1958) observed a highly significant correlation of -.21 between loin-eye area and fat thickness of beef carcasses varying in live weight between 800 and 1,300 pounds. Negative correlations between the above two variables were observed by Matthews (1959) in lamb carcasses and by Whatley and Enfield (1957) in swine carcasses.

A correlation of .42 was obtained between area of rib-eye and the percent separable lean of the 9-10-11 rib cut, this compares to a correlation of .547 obtained by Cole *et al*. (1959).

Live Animal Measurements and Grades

Width of crops was the only live animal measurement significantly correlated (.33) with final carcass grade. Orme (1958) observed a similar correlation but it was not statistically significant in his study. A negative non significant correlation of -.16 between height at the withers and final carcass grade was observed in this experiment. Cook (1951) and Yao *et al.* (1953) observed larger negative correlations (-.42 and -.31 respectively) between height of withers and final grade, than was observed in this experiment, but Orme (1958) observed an equally large positive correlation of .416 for the same measures.

Grade Relationships

The relationships between live animal measurements and grade have already been discussed.

Several authors (Cook 1951, Yao *et al.* 1953, and Orme 1958) have obtained reasonably high correlations of from .68 to .70 between slaughter grade and carcass grade. In this study the correlation between these two grades to the nearest third of a grade was .18 and non significant. There was small variation in grade of the animals studied.

Carcass conformation grade had a low non significant correlation of .25 with final carcass grade indicating it had little effect in determining the final carcass grade with this group of cattle. Wheat *et al.* (1959) obtained exactly the same correlation between carcass conformation grade and after

ribbing carcass grade. The extremely high correlation of .98 between ribbed quality grade and final carcass grade in this study indicates that quality as exhibited in the ribbed carcass is the major factor in determining carcass grade, accounting for 96 percent of the variation between ribbed quality grade and final carcass grade. The correlation of .58 between before ribbing quality grade and ribbed quality grade was similar to that obtained by Wheat _et al_. (1959) and suggests that the indices of quality exhibited in the unribbed carcass are not sufficiently accurate to indicate ribbed quality to the nearest third of a grade.

Zero correlation was observed between fat thickness over the rib-eye and the ribbed quality grade of the carcass, this is in contrast to a correlation of +.72 obtained by Clifton and Shepherd (1953) in a study of 355 carcasses.

The correlation obtained in this study between area of rib-eye and final carcass grade was almost zero (.03). Other researchers obtained correlations varying from .10 to .28, between these two variables (Clifton 1952, Clifton and Shepherd 1953, Woodward 1954, Blumer _et al_. 1959.)

The specific gravity of the rib-eye or of the 7-rib wholesale cut was highly significantly correlated with ribbed quality grade. The use of specific gravity of the 7-rib wholesale cut was as useful as the specific gravity of the rib-eye in predicting the ribbed quality grade.

In Table 18 is presented the mean and range of various

TABLE 18. MEAN AND RANGE FOR VARIOUS INDICES OF GRADES

	Percent Fat		Percent Water	
	9-10-11 rib cut	*Longissimus dorsi* muscle	9-10-11 rib cut	*Longissimus dorsi* muscle
Choice	41.77(36.14-47.77)	6.90(4.05-10.76)	35.28(30.50-40.11)	71.12(68.14-73.75)
High	42.53(40.44-44.53)	8.88(8.03-10.25)	35.72(34.61-37.11)	69.84(69.39-70.22)
Av.	41.76(39.51-45.15)	7.46(4.05-10.76)	34.98(31.89-37.64)	70.70(68.14-73.75)
Low	41.66(36.14-47.77)	6.28(4.57- 8.13)	35.37(30.50-40.11)	71.55(70.07-73.02)
Good	39.01(32.53-46.26)	4.82(2.09- 6.48)	37.14(31.70-42.32)	72.55(71.33-74.80)
High	39.28(32.53-46.26)	5.09(3.74- 6.48)	36.98(31.70-42.32)	72.33(71.33-73.41)
Av.	36.31 ----	2.09 ----	38.78 ----	74.80 ----

	Specific Gravity	
	9-10-11 rib cut	*Longissimus dorsi* muscle
Choice	1.0418(1.0283-1.0525)	1.0620(1.0565-1.0675)
High	1.0400(1.0389-1.0422)	1.0574(1.0566-1.0587)
Av.	1.0416(1.0366-1.0450)	1.0611(1.0565-1.0664)
Low	1.0421(1.0283-1.0525)	1.0632(1.0580-1.0675)
Good	1.0469(1.0380-1.0545)	1.0649(1.0600-1.0684)
High	1.0466(1.0380-1.0545)	1.0650(1.0600-1.0684)
Av.	1.0501 -----	1.0635 ----

indices which may be related to final carcass grade. It will be seen that there is considerable over-lapping of various measures between grades especially when grade was estimated to the nearest third. This is to be expected since the division between grades is only an arbitrary point and can be affected by numerous variables such as: marbling, texture, firmness and color of the rib-eye. There is a very close agreement of these data and Orme's (1958) for the mean and range of specific gravity of the rib-eye for the choice and good grades.

Relationships of Various Measures of Fatness

The relationships between specific gravity and certain measures of fatness have already been discussed.

Fat thickness over the rib-eye in these cattle was not an accurate indicator of either fatness in the rib-eye ($r = -.10$) or in the 9-10-11 rib cut ($r = .20$). Weseli *et al.* (1958) observed a partial correlation (weight removed) of .14 between fat cover and marbling score, whereas Hankins and Burke (1938), using a larger number of cattle, reported a correlation of .88 between thickness of external fat and marbling of lean.

The highly significant correlation of .88 was obtained between ether extract and physical separation of the 9-10-11 rib cut and was supported by a report from Missouri (Anonymous 1952-53) which revealed a rather close agreement between the separable fat and ether extract of the 9-10-11 rib cut.

The correlation of .37 between the percent ether extract in the boneless 9-10-11 rib cut and the percent ether extract in the rib-eye indicates fatness of the 9-10-11 rib cut is associated with approximately 14 percent of the variation in percent fat of the rib-eye.

It must be taken into consideration in applying the results of this experiment to the general population of livestock that the variation in the sample used in this experiment was small as compared to the general livestock population. Thus certain correlations obtained in this small population would be considerably biased when applied to a large more heterogenous population.

SUMMARY

The two lots of steers were fed approximately the same length of time (average difference of seven days), whereas the "Delayed Full-fed" lot of heifers were fed an average of 29 days longer than the "Limited-fed" lot. Heifers were fed for a shorter period of time than steers.

The "Limited-fed" steer calves consumed an average of 220 pounds more ground shelled corn per head than the "Delayed Full-fed" steer calves. In the case of heifers the trend was reversed and the "Delayed-lot" consumed an average of 55 pounds more ground shelled corn than the "Limited-lot". The "Delayed-lots" required slightly less ground shelled corn per 100 pounds gain than did the "Limited-lots". Heifers consumed more corn silage and slightly less ground shelled corn per 100 pounds gain than did the steers. There was little difference in estimated total digestible nutrient consumption per 100 pounds gain due to treatment or sex.

Slaughter weights were similar between treatments, but heifers averaged considerably lighter than steers. There was no significant difference due to treatment or sex in slaughter or carcass grades except steers graded higher than heifers in carcass conformation grade. Treatment or sex had no significant effect on: percent caul fat, area of _longissimus dorsi_ muscle, average thickness of fat over the _longissimus dorsi_ muscle, percent ether extract of _longissimus_

dorsi muscle, physical or chemical analysis of the 9-10-11 rib cut, specific gravity of the 7-rib wholesale cut, 9-10-11 rib cut or longissimus dorsi muscle .

Specific gravity of the 7-rib wholesale cut was very highly correlated with the specific gravity of the 9-10-11 rib cut. The specific gravity of the longissimus dorsi muscle was not significantly correlated with the specific gravity of the 7-rib wholesale cut or the 9-10-11 rib cut, but was highly significantly correlated with percent ether extract and percent moisture of the longissimus dorsi muscle. Specific gravity of the 9-10-11 rib cut was highly significantly correlated with percent fat, percent moisture, percent lean and percent bone of the 9-10-11 rib cut.

Final live grade and carcass conformation grade were not significantly related to other carcass grades or to each other. Unribbed quality grade, ribbed quality grade and final carcass grade were significantly correlated with each other. Ribbed quality grade was significantly correlated with percent ether extract of the longissimus dorsi muscle. There was no significant correlation between ribbed quality grade and fat thickness over the longissimus dorsi muscle. Specific gravity of the longissimus dorsi muscle, the 7-rib wholesale cut, and the 9-10-11 rib cut were significantly correlated with ribbed quality grade. The ribbed quality grade and final carcass grade were almost perfectly correlated.

The average fat thickness over the longissimus dorsi muscle was not significantly correlated with ether extract of the longissimus dorsi muscle or the ether extract of the 9-10-11 rib cut. The percent fat of the 9-10-11 rib cut determined by ether extraction was significantly correlated with the percent fat of the same cut determined by physical separation.

A low significant correlation between ether extract of the boneless 9-10-11 rib cut and the ether extract of the longissimus dorsi muscle was observed.

CONCLUSIONS

Two comparative methods of feeding steer calves a similar amount of total concentrates with corn silage full-fed over approximately the same total feeding period produced similar cattle in three experiments. Cattle were slaughtered as they reached choice live grade. The final weights, slaughter dates, carcass grades and carcass analyses were approximately the same.

Heifers were fed in only one of the three experiments and comparative results were similar to those of the steers except "Limited-fed" heifers were finished a month earlier than "Delayed Full-fed" heifers. Heifers finished an average of 33 days sooner than steers, at lighter weights and on less total feed. Steers and heifers consumed approximately the same amounts of estimated total digestible nutrients for each 100 pounds gain.

In the 1957-58 experiment unribbed quality, ribbed quality and final carcass grades were highly significantly correlated with each other. Final live grade and carcass conformation grade were not correlated significantly with unribbed quality, ribbed quality or final carcass grades or with each other in this experiment involving rather uniform cattle.

Specific gravity of the 7-rib wholesale cut could be predicted from the specific gravity of the 9-10-11 rib cut with a high degree of accuracy.

The following estimates of fatness were in good agreement: specific gravity of the 9-10-11 rib cut, ether extract of the boneless 9-10-11 rib cut and percent separable fat of the 9-10-11 rib cut. Prediction of ether extract of the _longissimus dorsi_ muscle by the use of specific gravity of that tissue was not as accurate, relatively, as predicting fatness of the 9-10-11 rib cut by its specific gravity. Fat thickness over the rib-eye, in this study, was not related to the percent ether extract of the boneless 9-10-11 rib cut or of the rib-eye muscle.

Areas of tracings obtained before and after squaring the loin end of the 7-rib wholesale cut were highly significantly correlated (.88). The area of the tracing obtained after squaring was .01 to 2.04 square inches smaller than the area of the tracing obtained before squaring, indicating variations in cutting procedures.

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APPENDIX TABLE I (a)
WEIGHTS GAINS AND FEED PER HUNDRED POUNDS GAIN
1940-42

Calf No.	Initial Weight	Final Weight	Total Gain	Days on Feed	Average Daily Gain	Feed Per 100 Pounds Gain: Ground Corn	Protein Supplement	Corn Silage	Hay
					1940-41				
Limited-fed									
1	402	1002	600	364	1.65	292.6	98.8	725.8	176.7
2	335	918	583	306	1.91	218.0	78.6	703.8	190.0
3	359	931	572	306	1.87	231.4	81.3	820.6	172.2
4	402	939	603	344	1.56	295.5	104.2	742.1	202.6
5	321	924	537	344	1.75	246.1	88.2	759.5	154.1
Average	363.80	942.80	579.00	333	1.74	256.7	90.2	750.4	179.1
Delayed Full-fed									
6	362	849	487	309	1.58	361.1	67.0	554.7	213.0
7	394	948	554	306	1.81	318.8	60.9	573.4	220.1
8	376	871	495	354	1.40	409.2	83.7	589.9	227.0
9									
10	355	928	573	344	1.67	415.5	76.8	642.1	193.4
Average	371.75	899.00	527.25	328	1.61	376.2	72.1	590.0	213.4
					1941-42				
Limited-fed									
11	458	1009	551	352	1.57	445.0	109.9	662.5	167.5
12	406	926	520	352	1.48	437.7	108.0	632.3	172.0
13	364	923	559	352	1.59	397.2	98.4	595.0	162.4
14	310	882	572	352	1.63	371.5	90.9	603.9	151.7
15	456	966	510	352	1.45	485.9	135.4	637.0	182.0
Average	398.85	941.20	542.40	352	1.54	425.9	103.8	625.6	166.7
Delayed Full-fed									
16	419	1033	614	352	1.74	441.1	95.9	570.0	155.7
17	421	998	577	352	1.64	458.8	100.8	591.7	164.1
18	375	944	569	352	1.62	421.9	97.3	561.2	154.8
19	317	869	552	352	1.57	394.5	93.1	475.4	153.4
20	309	859	550	352	1.56	409.2	91.8	459.3	162.7
Average	368.20	940.60	572.40	352	1.63	425.8	95.8	533.1	158.1

APPENDIX TABLE 1 (b)

APPENDIX TABLE I (b)
SLAUGHTER DATA AND CARCASS GRADES
1941-42

Calf No.	Slaughter Weight	Hot Dressed Weight	Cold Dressed Weight	Cold Dressed Percent	Average Grade Slaughter	Average Grade Carcass
			1940-41			
Limited-fed						
1	970	603.5	596.0	59.48	Ch-	Ch
2	899	543.5	533.5	58.12	Ch	Ch
3	891	582.5	574.0	61.65	Ch+	Ch+
4	910	569.0	563.0	59.96	Ch	Ch
5	888	549.0	537.5	58.17	P-	Ch+
Average	911.60	569.50	560.80	59.48	9.2	9.2
Delayed Full-fed						
6	833	535.5	527.0	62.07	Ch+	Ch+
7	922	577.0	565.5	59.65	Ch-	Ch-
8	860	520.5	511.0	58.67	Ch+	Ch-
9						
10	907	568.0	558.0	60.13	P	Ch+
Average	880.50	550.25	540.38	60.11	8.0	10.0
			1941-42			
Limited-fed						
11	997	610.5	597.5	59.22	Ch+	Ch+
12	910	566.0	553.5	59.77	Ch	Ch-
13	948	568.0	558.0	60.46	Ch+	Ch+
14	870	533.0	521.5	59.13	Ch-	Ch-
15	955	599.0	588.0	60.87	Ch-	Ch
Average	936.0	575.30	563.70	59.85	10.0	10.0
Delayed Full-fed						
16	1020	606.0	595.0	57.60	Ch+	Ch+
17	978	593.0	578.0	57.92	Ch+	Ch+
18	907	561.0	551.0	58.37	G+	Ch+
19	863	538.0	527.0	60.64	G+	Ch
20	860	523.0	512.5	59.66	Ch-	Ch
Average	925.60	564.20	552.70	58.76	11.2	8.8

APPENDIX TABLE I (c)
ANALYSES OF 9-10-11 RIB CUT
1940-42

	Percent of Total Sample				Percent Composition			
					Rib-eye		Total Edible Portion	
	Eye	Remaining Edible Portion	Fat	Bone	Water	Fat	Water	Fat
				1940-41				
Limited-fed								
1	17.71	34.99	30.03	17.27	71.59	6.08	48.82	36.08
2	22.50	34.37	26.15	16.98	73.77	3.73	53.70	29.61
3	23.71	33.66	28.09	14.54	73.26	4.37	51.86	32.17
4	15.77	30.28	36.13	17.82	72.58	4.82	43.13	43.84
5	17.88	32.98	30.69	18.45	73.10	4.49	48.53	36.11
Average	19.42	33.28	30.27	17.03	72.86	4.70	49.21	35.56
Delayed Full-fed								
6	16.46	31.81	36.82	14.91	73.84	3.58	45.36	41.18
7	24.31	36.12	21.79	17.78	75.58	1.93	57.18	25.52
8	17.56	32.83	31.73	17.88	74.14	4.39	46.61	39.04
9								
10	17.04	32.68	34.35	15.93	71.87	6.33	44.60	41.63
Average	18.71	33.31	31.39	16.59	73.86	4.06	48.44	36.84
				1941-42				
Limited-fed								
11	18.04	30.88	31.06	20.02	70.38	3.51	47.25	37.94
12	18.46	33.14	27.70	20.70	73.22	3.63	50.12	33.58
13	18.02	27.19	37.08	17.71	73.77	2.92	43.80	42.15
14	15.06	29.34	31.95	23.65	73.42	3.64	45.26	40.33
15	18.05	32.14	30.24	19.57	72.36	4.20	48.77	35.37
Average	17.53	30.59	31.52	20.36	73.23	3.58	47.04	37.88
Delayed Full-fed								
16	16.73	28.65	34.81	19.81	73.92	1.73	45.68	39.81
17	16.97	29.44	35.28	18.31	73.85	2.85	44.28	41.54
18	16.02	29.48	34.61	19.88	73.32	2.79	44.82	40.12
19	17.35	29.44	35.28	17.93	72.78	4.06	43.70	42.64
20	20.06	33.23	30.66	16.05	73.98	2.59	48.65	35.05
Average	17.39	30.00	34.19	18.42	73.58	2.80	45.43	39.83

APPENDIX TABLE II (a)
WEIGHTS AND GAINS OF STEERS
1957-58

Calf No.	Initial Weight	Weight on 98th day	Final Weight	98 day Gain	Total Gain	Days on Feed	Average Daily Gain First 98 days	Average Daily Gain Total Period
Limited-fed								
1	348	576	1135	228	787	311	2.33	2.53
2	388	626	954	238	566	238	2.43	2.38
3	470	643	1009	173	539	269	1.77	2.00
4	375	550	846	175	471	269	1.79	1.75
5	412	624	1051	212	639	269	2.16	2.38
6	428	642	995	214	567	269	2.18	2.11
7	419	652	1140	233	721	311	2.38	2.32
8	464	676	1066	212	602	269	2.16	2.24
9	443	674	967	231	524	238	2.36	2.20
10	363	510	1031	147	668	311	1.50	2.15
11	342	560	951	218	609	269	2.22	2.26
Average	404.7	612.1	1013.2	207.4	608.5	274.8	2.12	2.21
Delayed Full-fed								
12	383	556	872	173	489	238	1.77	2.06
13	450	582	1154	132	704	311	1.35	2.27
14	503	686	1150	183	647	269	1.87	2.40
15	390	514	779	124	389	238	1.27	1.64
16	334	474	1007	140	673	311	1.43	2.16
17	308	392	837	84	529	269	.86	1.97
18	444	570	923	126	479	269	1.29	1.78
19	412	538	936	126	524	269	1.29	1.95
20	425	548	1019	123	594	311	1.26	1.91
21	353	498	966	145	613	311	1.48	1.97
22	358	516	1132	158	774	311	1.61	2.49
Average	396.4	534.0	979.6	137.6	583.2	282.5	1.41	2.05

APPENDIX TABLE II (b)
WEIGHTS AND GAINS OF HEIFERS
1957-58

Calf No.	Initial Weight	Weight on 98th day	Final Weight	98 day Gain	Total Gain	Days on Feed	Average Daily Gain First 98 days	Average Daily Gain Total Period
Limited-fed								
23	385	562	781	177	396	238	1.81	1.66
24	411	630	970	219	559	238	2.23	2.35
25	427	586	836	159	409	214	1.62	1.91
26	373	553	466	180	493	238	1.84	2.07
27	372	528	850	156	478	238	1.59	2.01
28	381	544	747	163	366	214	1.66	1.71
29	310	494	891	184	581	238	1.88	2.44
30	381	562	856	181	475	238	1.85	2.00
31	411	600	890	189	479	238	1.93	2.01
32	455	643	974	188	519	214	1.92	2.43
33	297	492	842	195	545	238	1.99	2.29
Average	382.1	563.1	863.9	181.0	481.8	231.5	1.85	2.08
Delayed Full-fed								
34	281	350	850	69	569	311	.70	1.83
35	356	472	875	116	519	269	1.18	1.93
36	410	524	813	114	403	214	1.16	1.88
37	371	542	876	171	505	238	1.74	2.12
38	333	435	767	102	434	269	1.04	1.61
39	431	577	973	146	542	238	1.49	2.30
40	411	584	863	173	452	214	1.77	2.11
41	411	560	966	149	555	269	1.52	2.06
42	411	556	971	145	560	269	1.48	2.08
43	390	498	917	108	527	311	1.10	1.69
Average	380.5	509.8	887.1	129.3	506.6	260.2	1.32	1.96

APPENDIX TABLE III (a)
SLAUGHTER DATA AND GRADES OF STEERS
1957-58

Calf No.	Slaughter Weight	Warm Weight	Chilled Weight	Dressing Percent	Live Grade	Carcass Grade Conformation	Carcass Grade Unribbed Quality	Carcass Grade Ribbed Quality	Final Grade
Limited-fed									
1	1112	725	713	64.07	19	23	18	19	19
2	913	557	545	59.64	20	20	19	19	19
3	976	621	611	62.60	20	20	19	18	18
4	827	534	526	63.60	18	20	18	18	18
5	1020	655	643	63.04	19	20	21	19	19
6	964	612	605	62.71	20	21	18	19	19
7	1124	737	730	64.95	21	23	21	20	20
8	1039	649	638	61.36	20	21	19	19	19
9	935	590	580	62.03	21	23	20	19	19
10	1000	628	617	61.65	19	21	19	19	19
11	922	569	560	60.74	20	21	20	20	20
Average	984.7	625.2	615.3	62.40	19.7	21.2	19.3	19.0	19.0
Delayed Full-fed									
12	841	522	512	60.88	20	20	20	18	18
13	1124	688	681	60.54	19	22	19	19	19
14	1096	679	668	60.90	20	21	19	19	19
15	756	473	466	61.57	20	23	20	20	20
16	973	602	590	60.59	19	23	20	19	19
17	808	501	492	60.83	20	20	20	19	19
18	892	556	549	61.49	19	21	19	19	19
19	892	550	544	60.99	19	20	19	18	18
20	990	621	610	61.57	20	21	19	19	19
21	932	576	565	60.62	16	20	18	18	18
22	1100	689	678	61.59	20	21	20	20	20
Average	945.8	587.0	577.7	61.05	19.3	21.1	19.4	18.91	18.9

APPENDIX TABLE III (b)
SLAUGHTER DATA AND GRADES OF HEIFERS
1957-58

Calf No.	Slaughter Weight	Warm Weight	Chilled Weight	Dressing Percent	Live Grade	Carcass Grade: Conformation	Carcass Grade: Unribbed Quality	Carcass Grade: Ribbed Quality	Final Grade
Limited-fed									
23	753	482	472	62.68	19	21	17	20	20
24	941	580	568	60.31	19	20	19	19	19
25	800	515	508	63.50	20	20	19	20	20
26	834	519	512	61.33	19	21	20	19	19
27	806	514	502	62.28	19	21	18	18	18
28	732	462	457	62.36	20	20	20	21	21
29	840	513	501	59.64	20	20	17	17	18
30	815	502	494	60.61	19	17	18	18	18
31	857	550	538	62.78	19	19	19	19	19
32	836	570	564	60.26	20	20	18	18	18
33	803	499	489	60.90	18	18	20	20	20
Average	828.8	518.7	509.5	61.51	19.3	19.7	18.6	19.00	19.1
Delayed Full-fed									
34	833	521	510	61.22	18	19	20	20	20
35	850	536	524	61.65	20	20	18	19	19
36	764	480	473	61.91	20	20	18	19	17
37	845	541	529	62.60	19	23	20	20	20
38	742	453	444	59.84	20	19	19	18	18
39	952	596	583	61.24	20	19	20	21	21
40	834	530	526	63.07	19	20	21	21	21
41	937	600	589	62.86	19	19	19	21	20
42	930	586	578	62.10	18	20	19	19	19
43	892	556	544	60.93	20	19	19	19	19
Average	857.9	539.9	530.0	61.73	19.4	19.8	19.3	19.5	19.4

APPENDIX TABLE IV (a)
CARCASS DATA AND SPECIFIC GRAVITY. STEERS
1957-58

Calf No.	Fat Thickness	Area of Rib-eye First Tracing	Area of Rib-eye Second Tracing	Specific Gravity 7-rib Wholesale Cut	Specific Gravity 9-10-11 Rib Cut	Specific Gravity Rib-eye Muscle
Limited-fed						
1	2.78	14.19	12.48	1.0571	1.0525	1.0625
2	1.72	9.06	8.31	1.0523	1.0456	1.0644
3	2.17	11.19	9.58	1.0480	1.0380	1.0659
4	2.05	10.59	8.55	1.0537	1.0474	1.0676
5	2.47	10.87	9.92	1.0382	1.0283	1.0628
6	2.95	10.45	8.83	1.0475	1.0404	1.0587
7	2.63	11.79	10.93	1.0476	1.0432	1.0638
8	2.18	9.64	9.29	1.0436	1.0390	1.0633
9	2.72	9.48	9.00	1.0388	1.0332	1.0595
10	2.64	11.61	11.60	1.0493	1.0441	1.0622
11	2.30	11.65	11.14	1.0429	1.0410	1.0619
Average	2.42	10.96	9.97	1.0472	1.0412	1.0630
Delayed Full-fed						
12	2.22	10.83	9.76	1.0455	1.0423	1.0600
13	1.78	12.64	11.79	1.0494	1.0444	1.0638
14	2.15	12.28	10.35	1.0520	1.0482	1.0640
15	2.15	9.22	9.00	1.0441	1.0381	1.0594
16	2.12	12.91	10.88	1.0477	1.0468	1.0671
17	1.67	11.38	9.75	1.0508	1.0450	1.0616
18	2.33	8.76	8.47	1.0477	1.0408	1.0638
19	2.12	10.77	8.83	1.0477	1.0407	1.0673
20	1.70	11.07	9.79	1.0450	1.0367	1.0645
21	1.52	8.38	8.24	1.0587	1.0533	1.0684
22	2.78	13.59	11.99	1.0450	1.0450	1.0622
Average	2.05	11.08	9.90	1.0485	1.0438	1.0638

APPENDIX TABLE IV (b)
CARCASS DATA AND SPECIFIC GRAVITY. HEIFERS
1957-58

Calf No.	Fat Thickness	Area of Rib-eye First Tracing	Area of Rib-eye Second Tracing	Specific Gravity 7-rib Wholesale Cut	Specific Gravity 9-10-11 Rib Cut	Specific Gravity Rib-eye Muscle
Limited-fed						
23	1.82	10.49	9.95	1.0467	1.0415	1.0582
24	2.22	9.69	9.21	1.0467	1.0433	1.0580
25	2.12	11.19	9.77	1.0406	1.0366	1.0664
26	1.63	11.10	10.65	1.0463	1.0385	1.0675
27	1.72	11.48	10.40	1.0579	1.0531	1.0645
28	1.17	10.60	9.81	1.0476	1.0422	1.0566
29	2.12	11.20	10.33	1.0613	1.0545	1.0639
30	2.32	8.03	7.69	1.0482	1.0421	1.0659
31	2.52	8.95	8.58	1.0440	1.0371	1.0629
32	2.35	11.38	9.64	1.0479	1.0446	1.0617
33	1.57	10.45	9.96	1.0481	1.0439	1.0594
Average	1.96	10.41	9.64	1.0487	1.0434	1.0623
Delayed Full-fed						
34	2.25	12.13	10.09	1.0486	1.0435	1.0600
35	2.22	10.93	9.58	1.0479	1.0425	1.0647
36	1.77	9.59	7.83	1.0549	1.0501	1.0635
37	1.68	9.93	9.81	1.0442	1.0414	1.0635
38	1.77	10.22	9.38	1.0535	1.0497	1.0651
39	1.72	9.65	9.34	1.0450	1.0389	1.0569
40	2.67	9.48	8.98	1.0452	1.0390	1.0587
41	1.50	11.30	10.91	1.0451	1.0417	1.0565
42	2.43	9.77	8.52	1.0538	1.0489	1.0643
43	1.47	10.79	9.57	1.0520	1.0448	1.0646
Average	1.95	10.38	9.40	1.0490	1.0441	1.0618

APPENDIX TABLE V (a)
ANALYSIS OF 9-10-11 RIB CUT. STEERS
1957-58

	Chemical Analysis				Physical Separation				
	Rib-eye		9-10-11 Rib Cut Boneless		9-10-11 Rib Cut Bone In			Boneless	
Calf No.	Percent Ether Extract	Percent Moisture	Percent Ether Extract	Percent Moisture	Percent Bone	Percent Lean	Percent Fat	Percent Fat	Weight of Rib-eye
Limited-fed									
1	6.57	71.29	36.14	40.11	11.41	51.32	37.26	42.06	1258.6
2	4.62	73.02	39.43	36.84	12.22	44.40	43.39	49.42	726.6
3	4.63	72.94	41.36	36.77	10.52	45.78	43.70	48.84	930.9
4	4.43	72.71	38.87	36.67	13.07	46.12	40.82	46.95	863.8
5	6.14	71.29	47.77	30.50	12.10	39.53	48.37	55.02	910.0
6	4.94	72.95	42.58	34.23	12.16	40.58	47.26	53.80	819.9
7	4.05	73.75	40.33	36.39	12.66	43.77	43.57	49.88	1006.9
8	8.13	70.17	43.42	34.84	10.85	44.99	44.16	49.54	841.6
9	6.08	71.85	46.72	32.06	10.94	40.70	48.36	54.30	764.7
10	7.47	70.91	38.63	37.17	12.98	47.36	39.66	45.58	996.4
11	7.16	71.54	42.74	35.54	11.11	45.05	43.84	49.32	851.6
Average	5.84	72.04	41.64	35.56	11.82	44.51	43.67	49.52	906.5
Delayed Full-fed									
12	6.48	71.33	40.54	36.22	11.47	46.63	41.90	47.33	794.0
13	7.32	70.84	39.55	35.39	14.07	45.37	40.56	47.20	1058.5
14	5.18	72.62	39.76	36.68	12.11	46.66	41.23	46.91	1004.1
15	8.58	69.93	44.94	33.50	11.20	43.43	45.38	51.10	631.1
16	6.48	71.03	36.25	39.06	12.42	49.40	38.18	43.59	872.4
17	5.42	72.51	38.39	38.53	11.44	49.89	38.67	43.67	851.3
18	5.87	71.62	43.00	34.73	11.27	43.03	45.69	51.50	715.6
19	3.74	73.41	43.13	34.37	11.36	42.60	46.03	51.93	794.0
20	7.09	70.48	41.10	34.97	12.79	44.08	43.13	49.46	1012.0
21	4.81	72.50	35.52	36.79	16.08	46.25	37.67	44.89	815.0
22	7.12	69.22	39.51	35.09	14.12	46.70	39.18	45.63	972.1
Average	6.19	71.41	40.15	35.94	12.58	45.82	41.60	47.56	865.5

APPENDIX TABLE V (b)
ANALYSIS OF 9-10-11 RIB CUT. HEIFERS
1957-58

	Chemical Analysis				Physical Separation				
	Rib-eye		9-10-11 Rib Cut Boneless		9-10-11 Rib Cut Bone In			Boneless	
Calf No.	Percent Ether Extract	Percent Moisture	Percent Ether Extract	Percent Moisture	Percent Bone	Percent Lean	Percent Fat	Percent Fat	Weight of Rib-eye
Limited-fed									
23	7.37	70.85	40.12	31.89	11.32	44.75	43.93	49.54	726.7
24	7.55	71.15	44.92	33.67	11.00	44.00	45.00	50.56	713.4
25	6.17	71.22	44.26	34.21	10.42	42.16	47.42	52.94	831.1
26	4.57	72.42	43.92	33.70	10.99	42.98	46.02	51.71	899.6
27	5.91	71.54	36.25	39.81	11.25	51.77	36.98	41.67	841.9
28	8.37	70.22	40.44	37.11	10.93	45.91	43.16	48.46	856.9
29	4.33	72.86	32.53	42.32	11.67	54.49	33.83	38.30	1082.2
30	5.51	71.58	46.26	31.70	11.72	41.88	46.40	52.56	715.9
31	7.18	70.71	45.87	32.75	11.24	42.13	46.63	52.53	760.6
32	5.73	71.88	40.36	36.18	11.44	46.97	41.59	46.96	812.8
33	9.18	69.60	40.88	36.28	11.75	49.69	38.56	43.69	880.1
Average	6.53	71.28	41.44	35.42	11.25	46.07	42.68	48.08	829.2
Delayed Full-fed									
34	7.12	71.52	39.66	36.01	13.33	47.96	38.70	44.66	970.0
35	5.68	72.02	41.29	36.99	10.37	47.35	42.28	47.17	867.6
36	2.09	74.80	36.31	38.78	12.68	44.16	43.16	49.43	702.1
37	7.09	71.22	39.99	37.64	10.77	50.24	38.98	43.69	858.9
38	5.32	72.53	38.02	38.96	10.87	48.68	40.45	45.39	854.5
39	10.25	69.39	44.53	34.61	10.74	44.14	45.12	50.55	952.1
40	8.03	69.91	42.63	35.45	10.43	45.19	44.38	49.55	842.9
41	10.76	68.14	45.15	33.25	11.33	44.39	44.28	49.93	1009.2
42	5.01	72.41	42.08	34.27	12.97	44.53	42.50	48.83	898.4
43	8.01	70.07	40.75	35.53	12.55	47.09	40.35	46.15	994.7
Average	6.94	71.20	41.04	36.16	11.60	46.38	42.02	47.54	895.0

APPENDIX TABLE VI (a)
LIVE ANIMAL MEASUREMENTS. STEERS
1957-58

Calf No.	Height of Withers	Heart Girth	Circumference			Width				
			Belly	Hind Flank	Cannon Bone	Shoulders	Crops	Loin	Hooks	Thighs
Limited-fed										
1	120	199	219	191	20.50	54	39	34	45	53
2	111	184	222	186	19.75	53	40	30	44	53
3	113	187	216	181	19.50	56	39	34	46	54
4	112	182	198	174	18.25	52	38	32	42	49
5	116	197	216	189	19.50	55	41	35	45	54
6	112	187	213	188	18.50	52	42	34	46	53
7	117	194	220	193	19.75	57	42	36	48	55
8	114	194	230	192	19.50	55	42	33	47	54
9	109	190	222	185	20.00	56	43	36	44	54
10	112	193	219	195	21.75	53	40	34	47	54
11	110	185	224	184	18.25	53	42	35	44	55
Average	113	190	218	187	19.50	54	41	34	45	53
Delayed Full-fed										
12	108	182	213	176	17.75	53	40	29	43	55
13	117	200	233	196	21.00	57	39	35	50	54
14	116	191	237	191	20.50	58	42	36	48	55
15	103	179	208	170	17.00	53	42	31	42	52
16	112	187	217	194	20.75	55	37	34	45	52
17	108	179	205	173	18.00	50	40	32	42	50
18	110	182	214	179	18.75	53	41	31	44	51
19	111	184	216	181	18.50	54	42	34	44	53
20	114	193	219	186	19.50	53	35	32	45	53
21	117	182	205	176	20.50	52	35	31	45	51
22	117	195	228	189	20.00	56	39	33	48	55
Average	112	187	218	183	19.25	54	39	33	45	53

APPENDIX TABLE VI (b)
LIVE ANIMAL MEASUREMENTS. HEIFERS
1957-58

Calf No.	Height of Withers	Circumference: Heart Girth	Belly	Hind Flank	Cannon Bone	Width: Shoulders	Crops	Loin	Hooks	Thighs
Limited-fed										
23	105	177	205	172	16.00	50	39	32	43	53
24	112	183	213	185	18.00	54	41	32	46	54
25	108	175	202	176	17.00	50	40	32	43	52
26	107	175	203	179	17.50	51	40	33	44	52
27	106	173	203	179	18.50	52	39	32	44	52
28	101	178	204	171	16.50	52	39	32	40	50
29	107	180	205	178	19.00	52	40	31	43	53
30	112	174	202	181	17.50	48	37	31	45	48
31	111	177	205	175	17.50	53	41	34	46	51
32	113	182	220	186	17.25	53	41	35	45	55
33	107	173	199	174	16.50	51	39	31	41	52
Average	108	177	206	178	17.50	51	40	32	44	52
Delayed Full-fed										
34	109	177	197	172	18.75	51	37	31	42	50
35	107	177	203	178	18.50	52	40	33	44	52
36	103	169	207	182	18.50	50	37	34	42	53
37	106	181	210	176	17.00	55	42	33	44	52
38	105	172	204	172	16.50	49	38	29	42	47
39	112	182	208	182	18.25	52	42	34	48	52
40	108	180	213	179	16.25	52	39	31	43	53
41	115	186	213	191	18.00	52	40	34	43	52
42	116	187	211	183	19.00	52	39	34	47	52
43	114	187	210	188	18.50	47	36	34	47	50
Average	110	180	208	180	18.00	51	39	33	44	51

APPENDIX TABLE VII
TOTAL FEED CONSUMPTION

	Ground Shelled Corn	Soybean Meal	Corn Silage	Hay
Limited-fed Steers				
98 days	6,102.0	1,241.0	18,761	2,112
Total Period	26,317.0	5,293.9	45,594	6,326
Delayed Full-fed Steers				
98 days	----	1,157.0	27,114	2,310
Total period	23,892.0	5,139.1	46,729	6,908
Limited-fed Heifers				
98 days	5,938.0	1,204.0	18,156	2,112
Total period	19,193.0	3,870.5	41,055	5,048
Delayed Full-fed Heifers				
98 days	----	1,045.1	23,150	2,066
Total period	18,001.8	3,968.8	39,754	5,449