EFFECT OF EXTREMES IN WINTER NUTRITION ON GROWTH AND REPRODUCTIVE PERFORMANCE OF BEEF FEMALES

by

Don O. Pinney

Bachelor of Science
University of Illinois
Urbana, Illinois
1959

Master of Science
Oklahoma State University
Stillwater, Oklahoma
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Thesis Approved:

Thesis Adviser

Dennis D. Goetsch

Robert R. Noble

Roger E. Koeppe

Dean of the Graduate School

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INTRODUCTION

The literature contains numerous reports with both laboratory and farm animals concerning the effects of different nutritional planes on growth and reproductive performance. However, little long-term research of this type has been conducted with beef females. In the Southwest, where supplemental winter feed for beef females represents a large portion of the expense in a cow-calf operation, the problem of optimal nutritional plane is of great economic significance.

It is known that extremely low winter feed levels for beef females will result in smaller and less thrifty calves at birth, lighter calves at weaning and lower percentage of calf crop weaned, but the plane of nutrition where this begins to occur is not well defined. Also, relatively little information is available on the effects of extremely high planes of winter nutrition on the beef female. While overfeeding is probably less prevalent than underfeeding under farm and ranch conditions, it may be practiced in varying degrees in purebred herds where it is desirable to keep beef females in a fat condition for show and sale. It is important to ascertain whether or not such a practice is detrimental to their productivity.

Studies on different winter feed levels for beef cows have been in progress at the Oklahoma Station since 1948. In general, it has been found that levels of winter supplement lower than ordinarily recommended did not adversely affect reproductive performance and did increase productive lifespan of the cow and percentage of calf crop weaned. In subsequent studies, more severe restrictions in winter supplement resulted in reduced calf crops, reduced birth and weaning weights of the calves, and slower maturity of the cows.

The trials reported in this thesis were initiated to determine the effects of widely differing levels of winter supplement. Two trials, each involving 60 heifers are reported. Data have been obtained for females through 5.5 years of age (Trial I) and 4.5 years of age (Trial II).

REVIEW OF LITERATURE

The literature pertaining to the effects of plane of nutrition on growth and productivity have been extensively reviewed by Thomas (1952), Shroder (1954), Zimmerman (1958), Zimmerman (1960) and Pinney (1962). Therefore, this review will deal primarily with the more pertinent and recent literature in this field.

Experiments at the Oklahoma Station

Research on the effects of different levels of supplemental winter feed for beef cows was initiated at the Fort Reno Experiment Station in 1949. The initial trial, involving 120 Hereford heifers, was summarized by Pinney (1962), at which time these cows had been on experiment for 13.5 years. All of the cows grazed native grass year-long at a stocking rate of approximately 10 acres per head and were divided into three groups and received from November to mid-April each year, the following amounts of supplement per head daily: Low level, 1.0 lb. cottonseed meal; Medium level, 2.5 lb. cottonseed meal; and High level, 2.5 lb. cottonseed meal plus 3.0 lb. of whole oats. Each of these nutritional groups were subdivided into two lots, one of which calved first at 2 years of age, while the other calved first at 3 years of age. All cows were bred to purebred Hereford bulls and calved in February, March and April of each year. The calves were weaned at approximately 210 days of age in early October. None of the calves were creep-fed. The pertinent results of this study are given in the following table.

LIFETIME EFFECTS OF DIFFERENT WINTER FEED LEVELS ON PERFORMANCE OF RANGE BEEF COWS

	Level of Winter Supplement		
	Low	Medium	High
Winter gain of cows (lb.):			
1st winter as calves	23	60	88
2nd winter as bred yearlings	-90	-52	-26
Av. winter gain; 3rd, 4th and 5th winter	-197	-164	-124
Mature body weight of cows (lb.)	1142	1147	1194
Average calving date of cows	3/15	3/10	3/9
Average birth weight of calves (lb.)	77.6	77.6	78.8
Percent calf crop weaned	90.3	83.9	83.8
Average weaning wt. of calves (lb.) (sex corrected only)	479	482	483
Number of years on test per cow	12.7	11.6	10.7

Winter gains were directly related to winter feed levels, whereas summer gains were inversely related to feed level. The difference between the Low and High groups in mature body weight at 8 years of age was about 50 lb. This difference was not significant, however. Both mature live measurements and carcass measurements on cows killed after maturity indicated no important differences in skeletal development due to winter feed levels. At earlier ages, however, significant differences in these "body size" measurements did occur (Shroder, 1954). Evidently the Low level cows had overcome nearly all of the early growth disadvantage by 8 years of age.

Of interest is the fact that average calving date was delayed by the Low level regime by 5 to 6 days as compared to the Medium and High groups. It was assumed that Low level females had a longer post-partum interval to estrus. Average birth weights were not significantly affected by nutritional treatment.

Percent calf crop was drastically reduced by the two higher feeding levels as a result of a lower conception rate and/or a higher embryonic mortality. Also, more calves died from birth to weaning in these groups. Average weight of the calves at weaning did not differ to any great extent; if they are corrected for age differences, the Low level offspring were actually slightly the heavier since they were calved later.

This study yielded some of the first data indicating that high nutritional planes may adversely affect lifespan or longevity. To the author's knowledge this is the first trial of its kind continued long enough to observe effects on longevity. In this study, only failure to wean a calf 2 successive years and serious diseases or injury were considered ample reasons for removal of a cow from test. The productive lifespan thus measured gave an advantage of over 2 years for the Low, and nearly a year for the Medium regime, vs. the High level winter treatment in average number of years spent on test per cow to 13.5 years. Several studies indicate that excessive energy intake has a depressing effect on the lifespan of laboratory animals, but little work of this nature with cattle has been reported. It has been reported by Hansson et al. (1953) that significant increases in longevity of dairy cows could be induced by low nutritional planes. If this is true in the case of beef cattle, a re-evaluation of feeding standards may be appropriate since some yearly productivity could be sacrificed for a longer productive lifespan, particularly with valuable breeding females.

In 1954, a new series of experiments was initiated using daughters of the original cows. Further repetitions were begun each year from 1954 to 1958. All of these experiments involved three lots of 14 or 15 heifers each, designated as Low, Medium or High winter feed level groups.

In contrast to the original study, where a specified amount of winter supplemental feed was consumed by the cows, the winter feed level in these subsequent trials was adjusted at frequent intervals in an attempt to obtain predetermined rates of gain or loss from November to mid-April, as follows:

First winter as calves

Low level - no gain during the winter period.

Medium level - 0.5 lb. gain per day.

High level - 1.0 lb. gain per day.

Second and subsequent winters

Low level - 200 lb. or more loss.

Medium level - 100 lb. loss.

High level - no loss in weight.

These trials were conducted in the same manner as the original study, with the exception of amount of winter feed and the fact that all heifers in the more recent trials calved first at 2 years of age.

All of the trials since 1954 were summarized by Zimmerman (1960); the results through 1959 are shown in the table which follows.

EFFECT OF DIFFERENT WINTER FEED LEVELS ON
PERFORMANCE OF RANGE BEEF COWS (5 Trials)

	Level of Winter Supplement		
	Low	Medium	High
Winter gains of cows (lb.):			
1st winter as calves	8	90	155
2nd winter as bred yrlgs.	-149	-95	-32
Av. winter gain, 3rd and 4th winters	-196	-108	-55
Average calving date of cows	3/17	3/8	2/28
Average birth weight of calves (lb.)	68.6	76.2	77.0
Percent calf crop weaned	77.2	84.2	83.2
Average weaning weight of calves (lb.)			
Corrected for age and sex	380	420	433
Corrected for sex only	364	416	442

Average data through three calf crops are presented.

Some of the differences in results between these trials and the original trial are striking. A similar trend in regard to delayed calving date from Low feed levels was noted; however, there was more spread between the three feeding levels in the repetitions. Also birth and weaning weights were significantly decreased by the Low level regime. This is in contrast to the original study where level of winter feed had no effect on either birth or weaning weights. Moreover, in the later trials, percent calf crop weaned was drastically decreased by the Low level treatment, whereas in the original study percent calf crop was increased by the Low feed level.

In the later series of trials, all measures of body size were directly related to winter feed level up to 3.5 years of age. Measures more closely associated with skeletal size, such as wither height, were much less affected by feed level, however, than measures such as heart girth circumference which is greatly affected by fatness of the animal.

Several reasons are apparent as to why the results from the later repetitions did not agree with those obtained in the original study. First, there was a difference in the feed levels offered in the later trials as compared to the initial study. The average feed consumption of the Lows was less than half that consumed by the Lows in the original trial, and also the Highs were given slightly more winter feed than the original High level group. When one compares winter gains, it is seen that there was much less variation between the three nutritional levels in the original study than in the later studies. This possibly may be partly accounted for by a lighter stocking rate and milder winter conditions in the early years of the initial study, resulting in much smaller differences in actual total nutrient intake and, consequently, little difference in performance of these cows in terms of the birth and weaning weights of their calves.

However, one must still assume that there was a large enough difference in nutrient intake to affect longevity of the cows if this is taken to be a "real" effect of winter feed level. There is no way of determining the long-term effects of winter feed level on lifespan in the later trials since the first three of these trials were discontinued at 3.5 years of age.

One other factor should be mentioned in regard to a comparison of the original trial with the later repetitions. In the original study one-half of the cows calved first at 3 years of age which would give them a distinct advantage in overcoming the effects of a low winter feed level, since less body growth occurred during first gestation. In addition, the exact age of the original females was unknown. They were apparently winter calves, however, and were probably older when started on test than heifers used in the later studies. This would mean that the original heifers calving first at 2 years of age would have had a distinct advantage over those used in later trials, i.e. they were probably 27 to 28 months of age at first parturition.

In addition to the trials summarized in this thesis (started in 1957 and 1958), two further trials were initiated in 1959 and 1960 and were summarized by Pinney (1963) through one calf crop for each trial. The purpose of these trials was to study the effect of alternating winter feed levels from one year to the next. A total of 150 heifers were involved and were fed either Low, Medium or High winter feed levels the first winter as weaner calves corresponding to daily gains of -0.16, 0.58 and

0.92 lb. per head, respectively. The following winter as bred yearlings half of the Low level heifers were advanced to a High level treatment which resulted in a winter weight gain of 26 lb. and, conversely, one-half of the High level heifers were reverted to a Low level which resulted in an average loss of 230 lb. in body weight. Those continued on the Low, Medium and High treatments for both winters lost an average of 156, 115 and 36 lb., respectively, during the second winter. Differences in body weight, wither height, body length and various width measurements were not great at 2.5 years of age, but heifers fed continuously on the Low regime were significantly smaller than heifers on the High level for 2 successive years.

The results clearly indicate that the plane of nutrition during the first winter as weanling calves affected the calving date the following year regardless of nutritional plane during the second winter. Conversely, birth weights and gains of calves from birth to weaning were determined to a great extent by the nutritional plane imposed during the second winter during gestation regardless of the nutritional plane practiced during the first winter. Neither alternate system of winter feed (Low-High or High-Low) proved to be of any great advantage over the Medium regime imposed both winters. The sequence of Low level the first winter followed by the High level the second winter seemed to offer some promise if the first winter's effect of delayed calving date could be overcome. On the other hand, the sequence of High level the first winter followed by Low level the second winter was detrimental in terms of the birth weights and gains of the calves during the suckling period.

A more recent trial has been reported by Turman (1962). In this study weanling Hereford heifers were wintered at Low, Moderate, or High levels corresponding to the same gains previously practiced. In addition, half of the heifers from each nutritional level were restricted in summer gain by confining to drylot on alternate days the following summer. An additional group of Low level heifers were "flushed" with a high level of silage and grain from March 15 to May 1. A vasectomized bull was used to determine the occurrence of estrus prior to the breeding season.

An increase in age at first estrus was observed with each decreasing feed level, an average of over 30 days difference occurring between the Low and High level groups. Percent conception over a 105-day breeding period was decreased by the Low level regime, and drastically reduced in the Low level group restricted in summer grazing. The conception rate for the Low level-flushed lot, however, was normal. This would indicate that the plane of nutrition prior to the breeding season can adversely affect age at first estrus, and that "flushing" shortly before the breeding season may overcome these adverse effects on percent of heifers conceiving during a limited breeding season.

Other Related Experiments

Wiltbank <u>et al</u>. (1957) conducted a factorial experiment to determine the effects of three different levels of protein and three levels of energy on the occurrence and length of estrus in 54 weanling beef heifers. The energy levels were full-feed, two-thirds full-feed and maintenance of body weight. Digestible protein intakes per day per cwt. body weight were 0.23, 0.15 and 0.06 lb. for the three protein levels. The low energy level depressed the percent of heifers showing estrus over the 250-day trial at all protein levels. The low protein level also decreased the percent of heifers exhibiting estrus but was more pronounced when combined with the low energy intake. Both low energy and low protein levels increased the age at first estrus. Energy level seemed to have a much more pronounced effect than protein level on this trait. In this study 0.15 lb. of digestible protein per cwt. of body weight daily appeared to be adequate in promoting early estrus. A correlation of -0.39 was obtained between average daily gain of the heifers and number of days required to reach first estrus.

Bond et al. (1957) demonstrated that underfeeding of either protein or energy resulted in cessation of estrus and ovarian activity in heifers already cycling.

The effect of two energy levels on 88 mature Hereford cows in regard to reproductive phenomena was investigated by Wiltbank et al. (1962). Four treatments were involved and were started shortly after weaning in October. The cows were divided into groups designated as high-high, high-low, low-high and low-low with the change in level of energy occurring at calving. The high groups received TDN intakes approximating the NRC requirements for mature cows (9.0 lb. of TDN per head daily prior to calving and 16.0 lb. after calving). The low groups received 4.5 lb. of TDN before and 8.0 lb. per head daily following calving.

Body weights and condition scores were significantly influenced by the different treatments, and birth weights were reduced 11 lb. by the low energy level prior to calving. Both pre-and post-calving energy levels influenced the time required for occurrence of first estrus following calving, but the energy level prior to calving seemed to be more important. The percentage of cows showing heat within 60 days after calving were: high-high, 80; high-low, 81; low-high, 45; and low-low, 17. Most of the cows fed continuously on the low energy level failed to show estrus in 90 days, but 85 percent of those fed the low-high regime exhibited estrus before 90 days. The low-high group, however, required significantly longer than any of the other treatment groups to reach estrus.

The conception rate was somewhat lower in cows fed at the low energy level after calving. No difference in conception rate was found between the two groups fed high energy levels after calving. Significantly fewer cows fed the low energy level subsequent to calving were diagnosed pregnant than those fed the high level, largely due to failure to show estrus in the low energy groups. The percentage of cows diagnosed pregnant during the experiment was 95, 77, 95 and 20 for the cows on the high-high, high-low, low-high and low-low regimes, respectively.

Number of services per conception was highest for the low-low energy group and least for the high-high and low-high energy groups. The workers cited support for the theory that failure to exhibit estrus following low energy intake was due either to a failure of release or production of gonadotrophic hormone from the anterior pituitary, rather than decreased sensitivity of the ovary. They proposed that possibly body condition rather than energy intake per se was the more important factor influencing occurrence of estrus since the level of energy fed prior to calving had the most important effect on this trait.

Joubert (1954a) studied supplemental feeding vs. no supplement during the winter in the Union of South Africa with both dairy and beef cattle. The winter feeding periods ranged from 147 to 173 days in length, with 1,700 to 3,100 lb. of hay, 447 to 865 lb. of silage and none to over 800 lb. of concentrates being fed during these periods to each High plane female. Poor nutritional conditions each winter significantly retarded the development of the Low plane, unsupplemented, heifers with noticeable differences still occurring at 4 years of age. Shorthorns were very severely stunted, but Jerseys were only slightly affected by the Low regime. Skeletal development was retarded each winter, whereas measures of muscular development showed significant decreases for the Low regime. The Low plane individuals made greater increases in weight and growth during the summer, however.

The Low nutritional plane delayed puberty 221 days with a tendency for the subsequent reproductive cycle to be retarded. Birth weight of the calves was reduced 7.5 lb. by the Low regime. While no differences in milk production due to feed level were observed in the dairy breeds, the Low plane females started at a lower level of production but were more persistent in lactation. Weaning weights of calves in the beef breeds were significantly reduced by the Low nutritional plane.

When reproductive data were analyzed (Joubert, 1954b), it was seen that whereas most of the High plane heifers reached puberty during the winter, 86 percent of the Low plane females did so in the summer. Also the Low plane animals invariably experienced anestrus during subsequent winters, whereas the High plane heifers continued cycling. In addition, usually a year was required by the Low plane heifers after weaning their calves before sexual activity was resumed, while the High group resumed cycling shortly after weaning their calves. Although the effects of the Low plane were not as drastic in the dairy females, post-partum estrus was delayed 21 days by the Low regime. No differences were seen in number of services required per conception between the two groups.

The effect of supplemental winter feed as compared to no supplement for winter-calving beef cows in the San Joaquin Range Station in California was reported by Wagnon et al. (1959). The supplemented group of cows received 1.0 lb. of cottonseed meal starting in late summer with an additional lb. at calving, and an additional lb. of barley when winter rains started. Such supplementation resulted in an increased pregnancy rate of 15 percent, fewer calf losses before weaning and an advantage of 58 lb. in weaning weights. The unsupplemented cows eventually reached the same size in terms of body length and height, but required longer to do so than supplemented cows.

A long-term study of the effects of plane of nutrition during early life upon the performance of Holstein dairy females was reported by Reid (1960). The feeding levels used from birth to first calving as a percent of the upper level of Morrison's standards for TDN were: Low, 65; Medium, 100; and High, 140. During the first lactation the quantities of TDN provided were: Low, 118; Medium, 109; and High, 100 (expressed as a percent of Morrison's TDN standard for mature cows). After second calving, all females were fed in accordance with Morrison's standards. All heifers were bred at 18 months of age. Thirty-four trios of heifers had been allotted to the study at the time of this report.

Body size, as determined by weight and linear measurements at first estrus, was nearly the same for all groups, while age at first estrus was inversely related to nutritional level. Over 300 days difference in age at first estrus existed between females on the Low and High level regimes. Birth weights of the first calves were directly related to energy intake; however, when expressed as percent of body weight of the dam, they were inversely related to energy level. After the second calf, no relation between birth weight and nutritional rearing level of the dam was seen. Although the percent of females conceiving at first service was lower with each increase in energy level, the total services required per conception was similar for all groups since a few of the Low level females required a great number of services for first conception. None of the Low level animals became sterile, whereas three Medium level and five High level cows were removed for this reason.

Low level heifers had more calving difficulty at first calving, but no difference between treatment groups was seen thereafter. No significant differences in milk production occurred through five lactations (Reid et al., 1957).

A corollary experiment to that of Reid's (1960) was reported by Sorenson et al. (1959). Feed levels based on TDN intake similar to that of Reid's were used, and calves from each of the three TDN levels were slaughtered at 0, 16, 32, 48, 64 and 80 weeks of age to determine the effects on body growth and the development of reproductive and endocrine organs. Again, the delaying of first estrus was noticed for the lower feeding levels. The average ages at first estrus were 37.4, 49.1 and 72.0 weeks for the High, Medium and Low level groups, respectively. Only three of the twenty Low level heifers ever showed signs of estrus, and two were slaughtered at 80 weeks of age after having shown no signs of estrus. However, once estrous cycles were initiated they occurred with equal regularity in all groups.

At 16 weeks of age, the mammary glands of the High level heifers were infiltrated with fat cells in contrast to the relatively large amounts of fibrous connective tissue seen in the glands of the Low level heifers. Histological studies of the reproductive tracts revealed no differences between treatments except those related to differences in maturity. An increase in feed level appeared to result in increased thyroid activity and metabolic rate, as shown by increases in the thyroid-stimulating hormone content of the pituitary glands and the increased height of the thyroid acinar cells. The increased metabolic rate which should result from this might be expected to result in a shortened lifespan.

Some evidence has been reported to indicate that extremely high levels of feeding prior to first lactation results in decreased milk yields. Swanson (1960) determined the effects of fattening prior to first calving using identical-twin Jersey heifers. One of each of seven twin-mates was full-fed concentrates prior to first calving (24 to 29 months of age), while the other twin-mate was fed limited grain to 10 or 12 months of age, and unlimited roughage thereafter. The fattened group consumed 157 percent of the TDN given the control group to first calving. The TDN consumption of the control group was calculated to be less than standard recommendations, and they "appeared to be lean" prior to calving. After calving, both groups received the same amount of concentrates with unlimited roughage.

At both 24 months of age and first calving, the fattened heifers weighed 132 percent as much as the controls; however, differences in body weight were greatly reduced by 9 months after parturition. Two weeks after parturition the fattened cows had lost 143 lb. as compared to only 50 lb. for the control twins. During the first lactation only one fattened twin produced more milk than her mate. When expressed on a fat-corrected basis, the fattened heifers gave only 85 percent the milk yield of the control heifers. This was not a temporary effect since similar results were observed during the second lactation. Examination of the udder tissue of the fattened twins after the second lactation revealed a lack of development of alveolar-secreting cells. The workers noted a great variability in milk production of the fattened heifers, which might indicate that some heifers are more severely damaged by high energy levels than others. They postulated that the cause of greater milk production in the controls was an effect of hormonal stimuli, since they were growing rapidly during the first lactation while the fattened heifers were losing weight. However, differences during the second lactation cannot be explained by this theory.

A similar study with 11 identical twins of beef breeding has been reported by Arnett (1963). One of each of the twin-mates was full-fed a high energy ration to induce fattening starting before 8 months of age, while the other twin-mate was fed a moderately-high energy ration calculated to maintain them in a thrifty condition. The fattened heifers weighed an average of 320 and 507 lb. more than their moderately fed twin-mates at first mating and first calving, respectively. The fattening of the heifers resulted in an earlier calving date, increased birth weights, lower milk yields and decreased survival rates of both heifers and calves. The effects of fattening were highly variable between twin-pairs, however, and reduction of milk yield was much more pronounced in Angus than Hereford females. Rectal body temperatures taken during four periods of ten days each showed that the fattened cows had a significantly higher body temperature, thus indicating a higher rate of metabolism.

In a corollary study (Holland, 1961), 8-year-old cows wintered on prairie hay and ground milo for two successive winters gave birth to, and weaned, heavier calves than cows receiving only prairie hay and cottonseed meal. The free-choice milo feeding prior to calving caused these cows to weigh 248 and 323 lb. more than the controls at parturition the first and second year, respectively. Thus it was indicated that the mature cow is less easily injured by excessive fatness than the young, developing heifer.

EXPERIMENTAL

Two trials were initiated at the Fort Reno Experiment Station, one each in 1957 and 1958, to study the effects of widely differing planes of winter nutrition on the growth and reproductive performance of beef heifers. In each trial, four lots of 15 weanling Hereford heifer calves each were started on test at approximately 8 months of age. All heifers were produced in the commercial herd at the Fort Reno Station and were sired by purebred Hereford bulls. It was possible to allot the heifers to treatment on the basis of age, sire, body weight, conformation grade and dam's average productivity.

The amount of supplemental feed (cottonseed meal and ground milo) was adjusted at frequent intervals during the winter to control body weight changes from early November to mid-April according to the following pattern:

First winter as calves (8-13 months of age):

Low level - no gain during the winter period.

Moderate level - 0.5 lb. per head daily gain.

High level - 1.0 lb. per head daily gain.

Very High level - self-fed a 65 percent concentrate ration.

Second and subsequent winters as pregnant females (including calving loss):

Low level - 200 lb. loss for each heifer.

Moderate level - 100 lb. loss.

High level - no loss in weight.

Very High level - self-fed either a 65 or 50 percent concentrate ration for maximum gain.

A mixture of two parts salt and one part steamed bone meal was available to all cattle throughout the study.

The Very High females received a 65 percent concentrate ration during the first two winters in the case of Trial I and only during the first winter for Trial II. In all subsequent winters, a 50 percent concentrate diet was fed to this treatment group to reduce the incidence of bloat.

The Moderate, High, and Very High groups grazed native grass yearlong (primarily bluestems, grama and annual grasses). Since in previous trials, the desired weight loss for the Low level was difficult to obtain, these heifers were fed wheat straw in dry-lot from early November to early or mid-December each year. They were allowed to graze approximately 1 day each week during this confinement. During the remainder of the year the Low groups grazed native pasture comparable to that available to the other groups. The stocking rate during the entire study was approximately 8 to 10 acres per breeding female. The amount of forage available and the quality of it would be considered excellent; and, no shortage of grass occurred in either summer or winter.

In Trial I, the Very High level heifers were reverted back to the Moderate level during the fourth and subsequent winters to determine the effects of a drastic reduction in winter feed following maximum winter gains between 8 and 42 months of age. They were maintained and fed in the same pastures as those cows continuously wintered at the Moderate level.

All heifers were pasture-mated to purebred Hereford bulls between May 1 and August 15 and calved first at 2 years of age. Each year, the heifers were allotted to bulls used in the station's breeding program on the basis of their previous productivity and calving date; equal numbers of heifers from each treatment were exposed to the same bull. In this manner, differences due to sires were minimized. All calves were dehorned and vaccinated for blackleg, and bull calves were castrated at 6 to 8 weeks of age. None of the calves were creep fed, and all were weaned in early October.

During the experiment, the following data were collected:

1. Supplemental feed consumption by lots.
2. Body weights at approximately 4 week intervals.
3. Calving dates.
4. Birth and weaning weights of all calves. Birth weights were adjusted to a bull equivalent and weaning weights to a 210-day steer equivalent by the method of Botkin (1952) who derived the correction factors using data from similar cattle.
5. Estimated daily milk production of cows in Trial I at approximately 1 month intervals while nursing their third calves, and in Trial II while nursing their second and third calves. This was accomplished by separating the calves from their dams and weighing the calves immediately before and after nursing for two successive 12-hour periods. When the calves were under a month of age, three 8-hour periods were used since the calves had difficulty in nursing the dam completely dry when allowed to nurse only at 12-hour periods.

6. Conformation grade of calves at weaning.

7. Seven body measurements on each female in early November and mid-April of each year. Height at withers, length of body and depth of chest were measured from photographs of the heifers taken while they were standing behind a grid. Heart girth, width of loin (immediately posterior to last rib), width of hips (across widest part of the tuber coxac) and width of pin bones (across widest part of the tuber ischii) were measured while the heifer was maintained in a squeeze chute.

The data were analyzed by the methods of Snedecor (1956). Where analyses of variance were determined, the following orthoganol contrasts were made within each trial and age classification: Low vs. Moderate, High and Very High; Moderate vs. High and Very High; and High vs. Very High regimes. The probability values associated with these contrasts are presented in the Appendix (Table XIV).

RESULTS AND DISCUSSION

Data collected through the fall of 1962, when the Trial I and II cows were 5.5 and 4.5 years of age, respectively, have been included in this thesis. The average supplemental feed consumed per head each winter by treatment is shown in Table I. This represents the amount consumed from early November to mid-April, or during an approximate 165-day wintering period. All females were weighed at approximately 2-week intervals during the winter, and subsequent feed intake was adjusted to achieve the desired winter gain or loss. It is apparent that considerable variation exists between trials as to amount of feed consumed. This is because the trials were started in different years and the variation in severity of winters and other factors influenced the amount of feed required to obtain the desired gain or loss.

On the average, daily feed intake per heifer was: Low, 0.25 lb. of cottonseed meal and 0.10 lb. of milo; Moderate, 1.58 lb. of cottonseed meal and 0.68 lb. of milo; High, 2.26 lb. of cottonseed meal and 4.28 lb. of milo; and Very High, 29.47 lb. of a 50 or 65 percent concentrate mixture. During the fourth winter the Very High cows in Trial II consumed over 40 lb. per head daily of the 50 percent concentrate ration. The small amount of supplement fed the Low level females was usually given during late winter, just prior to and following calving.

Body Weight Changes and Growth Patterns

The winter body weight gains or losses which resulted from the four

AVERAGE AMOUNT OF FEED CONSUMED (LB.) EACH WINTER BY HEIFERS
ON DIFFERENT LEVELS OF SUPPLEMENT

	LEVEL OF WINTER SUPPLEMENT								
	LOW		MODERATE		HIGH		VERY-HIGH[1]		
WINTER	CSM[2]	MILO[3]	CSM	MILO	CSM	MILO	50 or 65% CONC.[4]	CSM	MILO
1st Winter as calves									
Trial I	26		312	198	368	663	3433		
Trial II	80	80	238	320	408	797	3422		
2nd Winter as Bred Yrlgs.									
Trial I	45		348	160	382	735	5169		
Trial II	74	74	272	112	332	552	4810		
3rd Winter									
Trial I	74		272	75	332	798	5575		
Trial II	32		202	88	464	704	4681		
4th Winter									
Trial I	32		202	56	464	512		202	56
Trial II	46		249		302	795	6951		
5th Winter									
Trial I	46		249		302	795		249	

[1] The Very-High group in Trial I was reverted to the Moderate level for the fourth and subsequent winters.

[2] Cottonseed meal, 43% solvent process.

[3] Ground milo.

[4] A 65% concentrate ration was fed the first two winters in Trial I and for the first winter only in Trial II. Thereafter, a 50% concentrate ration was fed in both trials. The 65% ration consisted of: 49.7% gr. milo, 7.7% CSM, 7.0% molasses, 17.5% chopped alfalfa, 17.5% cottonseed hulls and 0.6% ground limestone. The 50% ration consisted of: 33.2% gr. milo, 9.5% CSM, 7.0% molasses, 25.0% chopped alfalfa, 25.0% cottonseed hulls and 0.3% ground limestone.

treatments are shown in Table II. It should be pointed out that this winter weight loss included loss at parturition and only those cows that calved before the spring weighing are included in the data presented.

Weight changes for Trial I were similar to thos obtained in Trial II after the first winter period; however, much difference occurred between trials with respect to weight changes occurring during the winter phase as calves. For this reason, the data are reported separately for each trial, rather than pooled. During the first winter in Trial I the difference in weight change from Low to High was only 112 lb.; whereas, in Trial II over 200 lb. difference existed between Low and High groups. Even though the Lows in Trial II were fed over six times the quantity of feed given the same treatment lot in Trial I, they lost 48 lb. as compared to a gain of 23 lb. for heifers in Trial I. The same trend held true for the Moderate level; Trial II heivers gained only one-half as much as Trial I heifers.

When the trials are averaged, they closely approximate the weight changes attempted; the Lows lost 0.08 lb., the Moderates gained 0.60 lb. and the Highs gained 0.89 lb. per head daily. In subsequent winters, the overall average loss in lb. per heifer was: Lows, 216; Moderates, 125; and Highs, 77. The great loss in weight occurring in the Low level groups is even more striking when expressed on a percent of body weight basis. The High level females continued to lose weight each winter even though they received nearly 5.0 lb. of milo and 2.5 lb. of cottonseed meal per head daily during several winters.

The Very High females gained nearly twice as much as the Highs on the average during the first winter, and were the only treatment groups

TABLE II

AVERAGE WINTER WEIGHT GAINS[1] AND STANDARD ERRORS OF HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

	Level of Winter Supplement							
	Low		Moderate		High		Very High[2]	
	Pounds	Percent[3]	Pounds	Percent	Pounds	Percent	Pounds	Percent
First Winter as Calves:								
Trial I	23 ± 6 (15)[4]	5	124 ± 11 (15)	27	135 ± 7 (14)	29	263 ± 8 (14)	57
Trial II	-48 ± 5 (14)	-10	69 ± 5 (15)	14	154 ± 5 (15)	31	280 ± 10 (15)	57
2nd Winter as Bred Yrlgs:								
Trial I	-241 ± 9 (9)	-30	-113 ± 9 (13)	-13	-79 ± 9 (14)	-9	182 ± 14 (8)	20
Trial II	-236 ± 7 (11)	-31	-144 ± 13 (7)	-18	-84 ± 16 (10)	-7	142 ± 37 (10)	16
3rd Winter:								
Trial I	-204 ±10 (9)	-24	-100 ± 7 (11)	-11	-58 ± 11 (10)	-6	111 ± 15 (12)	11
Trial II	-202 ±21 (6)	-23	-83 ± 11 (13)	-9	-66 ± 14 (13)	-7	100 ± 21 (12)	9
4th Winter:								
Trial I	-176 ±12 (11)	-18	-108 ± 9 (12)	-10	-85 ± 13 (14)	-8	-246 ± 17 (14)	-21
Trial II	-221 ±24 (9)	-23	-143 ± 10 (12)	-12	-71 ± 11 (10)	-7	241 ± 15 (13)	20
5th Winter:								
Trial I	-231 ±18 (15)	-21	-182 ± 14 (15)	-16	-95 ± 8 (13)	-8	-174 ± 11 (12)	-16

[1] Includes only those heifers calving before mid-April and raising a calf.
[2] The Very High group in Trial I was switched to the Moderate level for the fourth and fifth winter.
[3] Winter weight change expressed as a percentage of the prior fall weight.
[4] Indicates the number of observations involved in the standard error.

which had a net gain in weight each subsequent winter.

It is interesting to note the tremendous loss in body weight which occurred in the Trial I when the Very High group was reverted to the Moderate level of supplemental feed during the fourth winter. Even though they were allowed to consume supplemental feed with the Moderate level females during this winter, they lost over twice as much weight as the cows wintered at the Moderate level throughout the study. This is probably the result of an increased maintenance requirement and/or decreased foraging ability. There is no doubt that the Very High-fed females did little if any winter grazing while on the full-fed regime and probably were still rather reluctant to graze when put on the Moderate level the fourth winter. With rats, Quimby (1948) found that the quantity of feed required to maintain body weight became progressively less as underfeeding continued. Also Grande et al. (1958) and Beattie and Herbert (1947) found decreased heat production in men during either a starvation or semi-starvation state. Most probably a combination of factors contributed to the greater loss of weight shown by the Very High females when reverted to the Moderate regime. The following winter, little difference was apparent in weight losses between Moderate and Very High females reverted to the Moderate level the previous winter.

The effect of winter feed level on weight gains during the summer is shown in Table III. In every case, the lots losing more weight in the winter gained more weight on pasture the following summer. This is good evidence of the remarkable recuperative power of the beef female. The smallest difference between groups with regard to summer weight gains was between Moderate and High winter treatments; the largest difference was between the High and Very High lots, as was true with winter gains. The

TABLE III

AVERAGE SUMMER WEIGHT GAINS[1] (LB.) AND STANDARD ERRORS OF HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

	Level of Winter Supplement			
	Low	Moderate	High	Very High[2]
1st Summer as Bred Yrlgs:				
Trial I	356 ± 5 (14)[3]	265 ± 9 (15)	256 ± 7 (14)	170 ± 9 (14)
Trial II	323 ± 9 (13)	255 ± 6 (15)	223 ± 10 (13)	122 ± 8 (14)
2nd Summer:				
Trial I	257 ± 15 (9)	147 ± 12 (12)	140 ± 8 (13)	-72 ± 17 (8)
Trial II	309 ± 18 (9)	212 ± 20 (7)	160 ± 14 (10)	51 ± 19 (8)
3rd Summer:				
Trial I	297 ± 8 (8)	211 ± 8 (11)	181 ± 15 (10)	-3 ± 12 (12)
Trial II	287 ± 17 (5)	190 ± 19 (12)	139 ± 12 (11)	-4 ± 17 (11)
4th Summer:				
Trial I	262 ± 10 (11)	175 ± 9 (12)	149 ± 13 (13)	155 ± 12 (13)
Trial II	292 ± 21 (9)	218 ± 17 (12)	183 ± 12 (10)	-110 ± 12 (13)
5th Summer:				
Trial I	246 ± 11 (15)	208 ± 10 (15)	160 ± 10 (13)	208 ± 11 (12)

[1]Includes only those heifers calving before mid-April and raising a calf.
[2]The Very High group in Trial I was reverted to the Moderate feed level for the fourth and fifth winter.
[3]Indicates the number of observations involved in the standard error.

inverse relationship between winter and summer gains is an example of "compensatory growth" which has been observed by many researchers.

Figures 1 and 2 show more vividly the winter and summer weight change patterns and the resultant body weights. These body weights were taken immediately before and after each winter feeding period. A marked difference between levels was apparent each spring with much of this difference disappearing by the fall weighing after summer grazing. With regard to the Low, Moderate and High groups, a wider and more consistent difference in body weight was maintained in Trial II than Trial I. This is a result

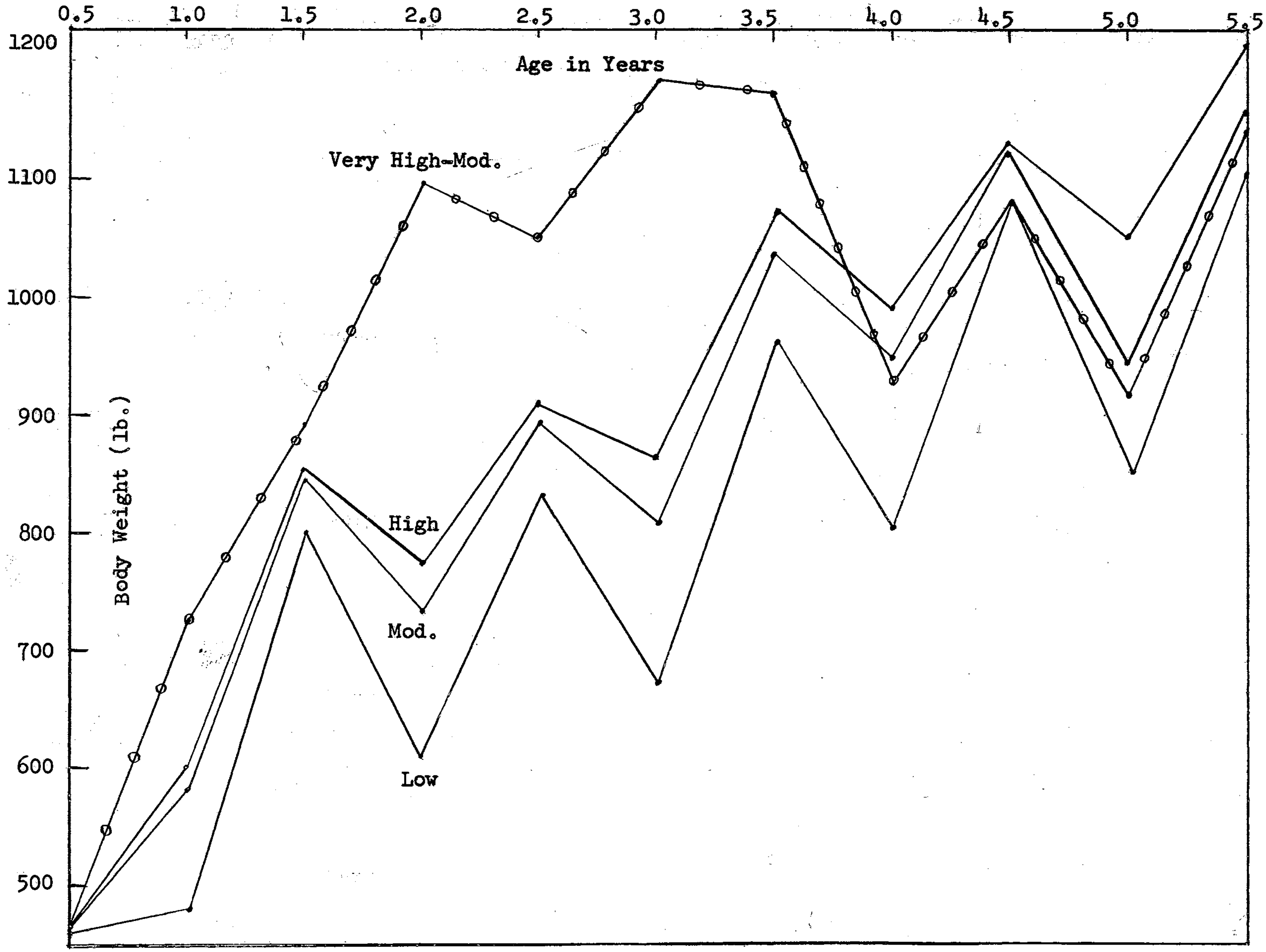

Figure 1. Average Body Weights of Heifers Receiving Different Levels of Supplement (Trial I)

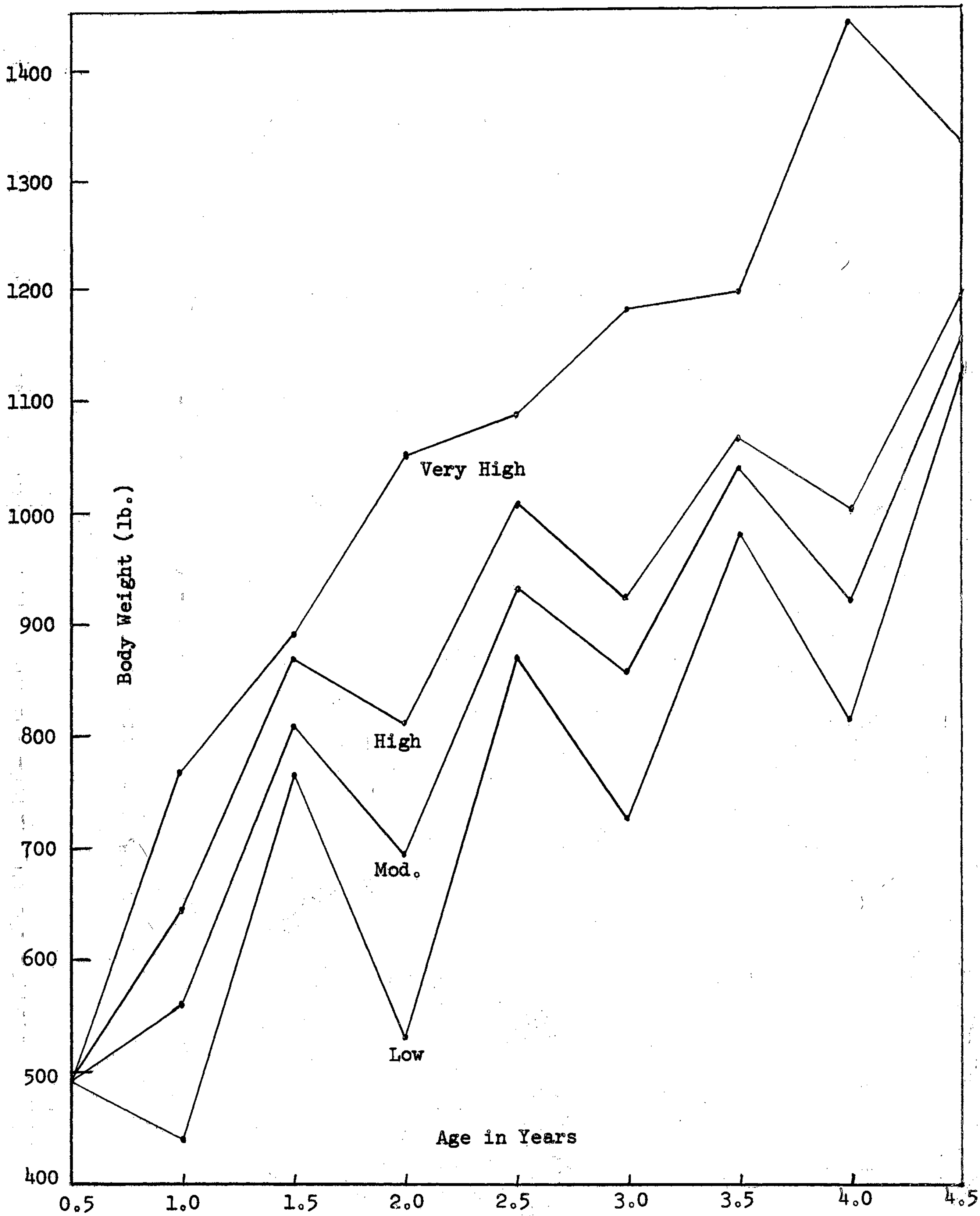

Figure 2. Average Body Weights of Heifers Receiving Different Levels of Supplement (Trial II)

of the larger difference in weight gains between treatment groups in Trial II during the first winter since subsequent weight changes were similar for both trials. At 2 years of age the Very High group weighed nearly twice as much as the Lows in both trials.

After the Very High females (Trial I) were reverted to the Moderate treatment, they maintained a body weight intermediate to the Low and Moderate level females. This would indicate that the initial advantage in body weight of the Very High group was largely the result of amount of fat, rather than true skeletal or muscle development. The body weight attained by the Very High females is amazing considering the fact that the cows continued on the Very High treatment through four winters (Trial II) weighed nearly 1450 lb. after calving as 4-year-olds. Prior to parturition one cow in Trial II attained a weight of over 1800 lb.

At 4.5 years of age, highly significant differences occurred for all comparisons of body weight in Trial II, but no significant differences were found in Trial I. (Appendix Table XIV). At 5.5 years of age, the Low group in Trial I was significantly lighter than the other three treatment groups. The advantage in weight of the High group over the Very High-Moderate group approached significance at 5.5 years of age. The recuperative power of the Low level cows is shown by the fact that in both trials at 4.5 years of age the difference between Low and High level body weights was reduced to about 50 lb., whereas in some previous springs this difference was well over 100 lb. in both trials.

Figures 3 through 9 represent the growth curves of various body-size measurements taken each spring and fall. Numerical values for these measurements with their standard errors are given in Tables XV through XXI in the Appendix. No measurements were taken in the spring of 1962 when cows of Trial I were 5 years of age and Trial II cows were 4 years of age.

All body measurements reflected the pattern of body weights, in that much greater differences occurred between treatment groups at the end of the winter feeding period than after summer grazing. That these differences are not entirely due to skeletal growth is suggested by the fact that in many cases the average measurement decreased during the winter feeding period. Obviously the length of the bones was not decreasing; thus, it must be assumed that this decrease was associated with losses in fat and/or muscle. These decreases were most marked in the measures which are normally felt to be influenced by degree of fatness. Wither height decreased in several cases during the winter period even though it is generally assumed not to be largely influenced by fatness of the animal. During the period from the spring of 1961 to the spring of 1962, or from 4.5 to 5.5 years of age for Trial I and from 3.5 to 4.5 years of age for Trial II, the average height of wither decreased in both trials.

Although the objective in taking the body measurements was to determine skeletal size, very good evidence was obtained in Trial I that the differences in the measurements between treatment groups were largely the effect of differences in fatness of the cows. After being reverted to the Moderate level for two winters, the Very High females in Trial I were not larger than the Moderate-continuous group in any of the seven measurements taken. The Very High-Moderate group was actually smaller in size than the Moderate-continuous group in three of the seven measurements at 5.5 years of age, suggesting that the Moderate treatment promoted maximal skeletal growth.

By far the least difference between treatment groups occurred in regard to wither height (Figure 3). This is not surprising since the measurement is largely a measure of the long bones of the forelegs and should not be greatly affected by differences in body fat, and it is a well accepted fact that low nutritional planes have less effect on bone growth than lean or fat development. The largest difference between treatment groups was slightly over 2 inches at 2 years of age in both trials. Thereafter differences tended to become smaller with time.

Length of body measurements (Figure 4) were probably the least repeatable of the measurements taken due to difficulty in locating the reference points on the photograph (pin bones and point of shoulder). Also, small changes in position of the animal can result in large differences in the location of these reference points. The fact that this measurement decreased during many of the winter periods indicates that it was influenced to some extent by the fatness of the cows. As was the case with all other measurements, differences between treatment groups were much greater following winter feeding than after the summer grazing period.

Figure 5 shows the average heart girth circumference by treatment groups. This measurement was most sensitive to the different winter feed levels. In most cases the difference between the Low and Very High groups was 10 to 15 inches following the winter feeding period. These differences were much smaller after the summer period when all heifers were treated alike. This measurement tended to reflect changes in body weight to a greater degree than the other measurements. In fact, through 4.5 years of age these curves are almost identical to the body weight curves (Figures 1 and 2). Although remarkable amounts of recovery took

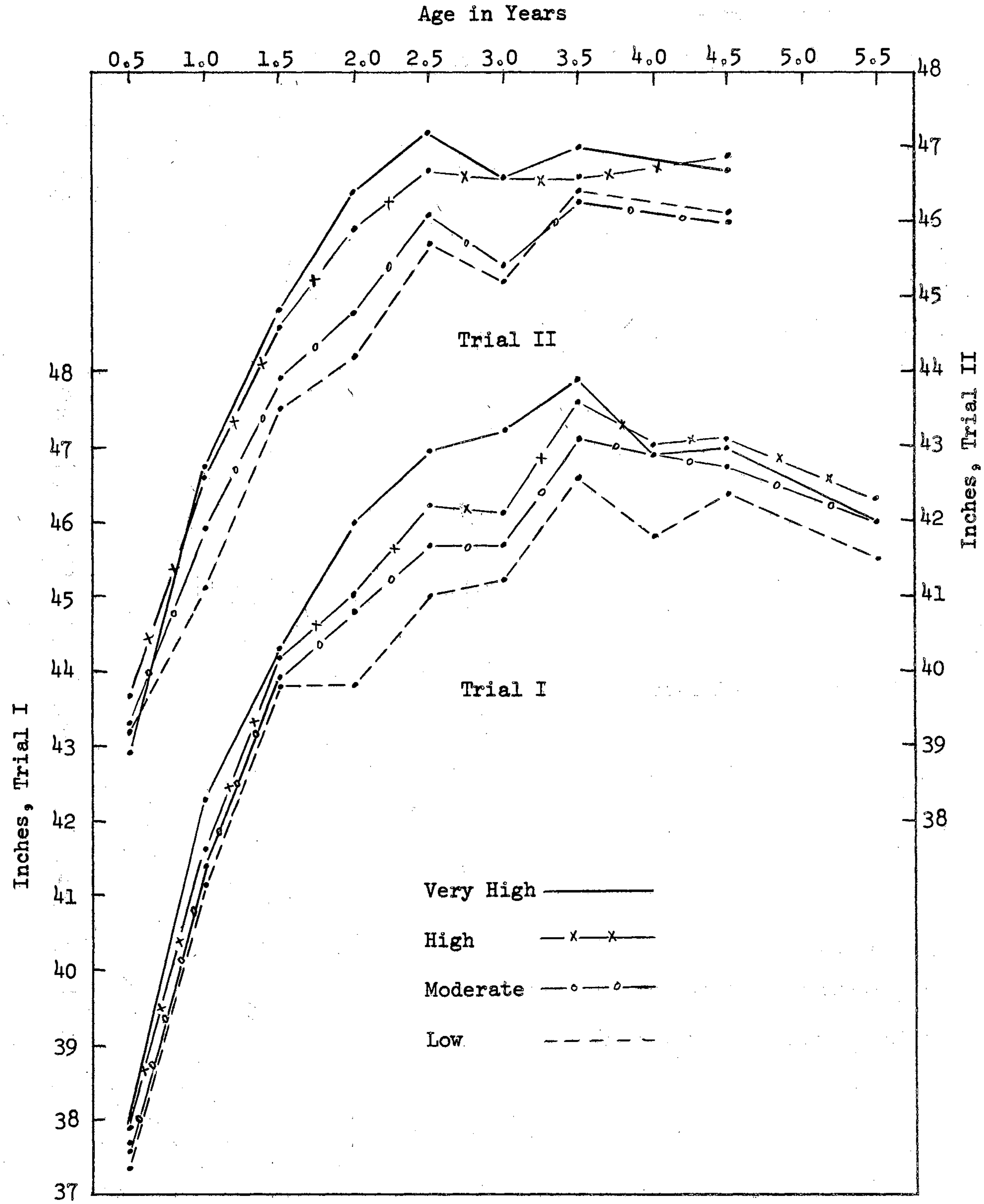

Figure 3. Average Height of Withers of Heifers Receiving Different Levels of Supplement

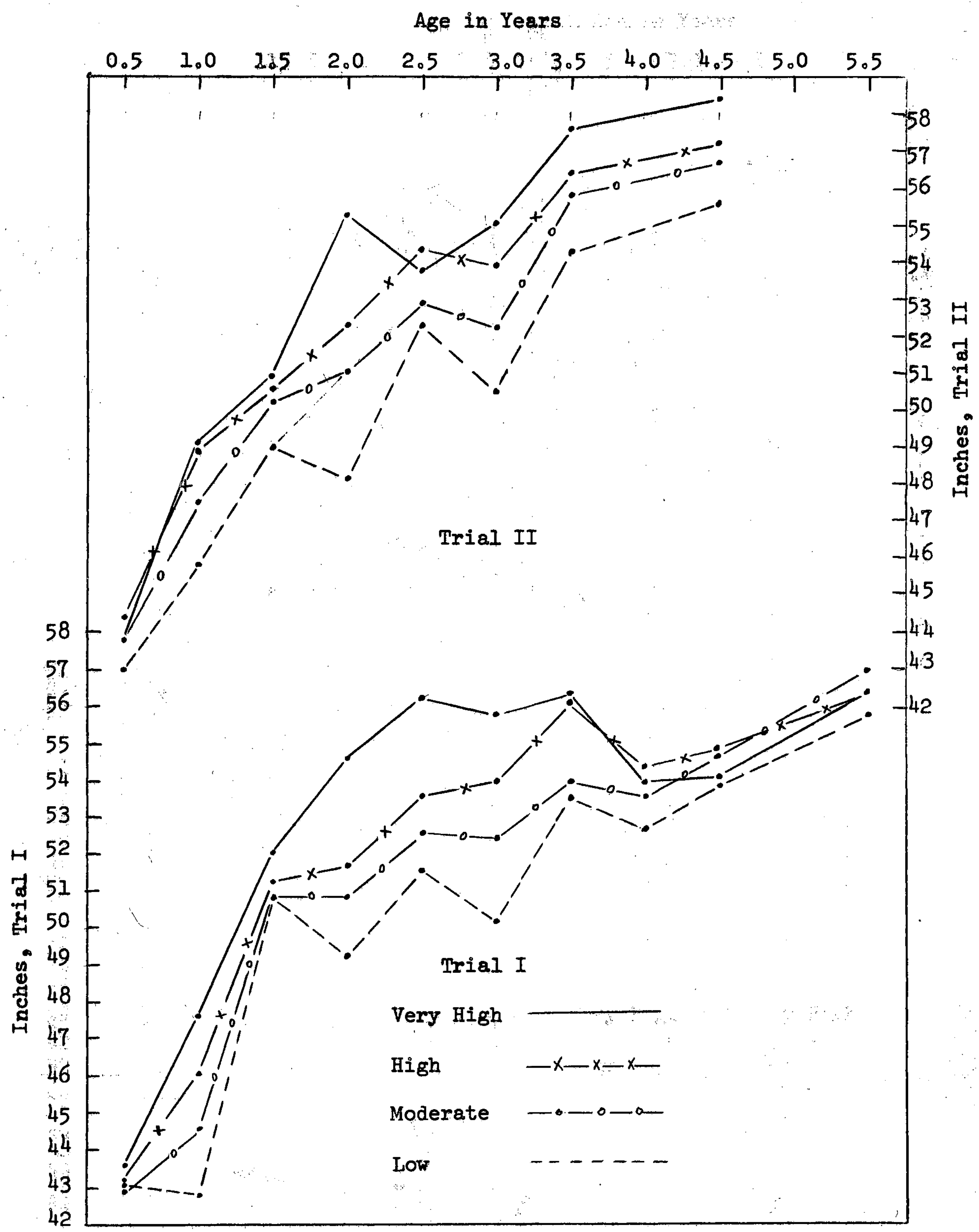

Figure 4. Average Length of Body of Heifers Receiving Different Levels of Supplement

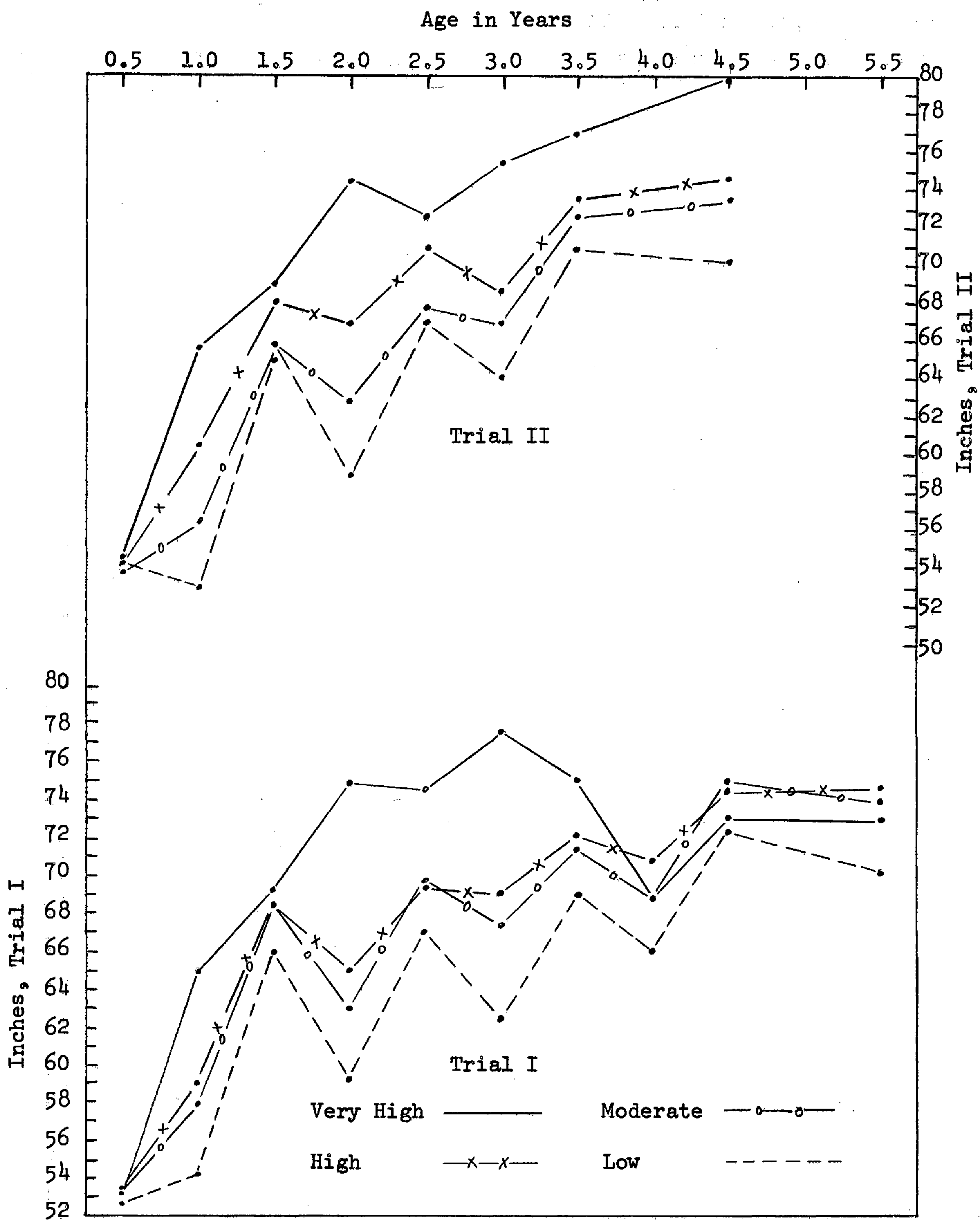

Figure 5. Average Circumference of Heart Girth of Heifers Receiving Different Levels of Supplement

place in the Low level groups each summer, they were never greater than 96.1 percent the size of the High level females.

Depth of chest measurements are shown in Figure 6. This measurement decreased nearly every winter for the Very High group. This would indicate that, like heart girth this measurement was also influenced by fatness of the animal. All width measurements (Figures 7, 8 and 9) appear also to be influenced greatly by fatness.

The tremendous difference which occurred at 3.0 years of age for the width measurements is interesting. At this time, the Low group (Trial I) was only 70.8, 79.1 and 75.5 percent as large as the Very High group for width of loin, hips and pin bones, respectively. However, after two successive winters wherein the Very High females were reverted to the Moderate feed level, this was reduced to 95.4, 96.3 and 96.0 percent, again illustrating the effect of fatness on these measurements.

It is obvious that there was real effect of winter feed level on each of the seven measures of body size taken. There was a direct relationship between magnitude of the measurement and the winter feed level in nearly every case, each year. Statistical analyses of these measurements at 4.5 and 5.5 years of age are shown in Appendix Table XIV. Three orthogonal contrasts were made in each case, namely: Low vs. Moderate, High and Very High; Moderate vs. High and Very High; and High vs. Very High. In general, the only significant differences ($P<.05$) between the Low and all other treatment groups were in heart girth and width measurements. Only two significant differences ($P<.05$) occurred with respect to the Moderate vs. High and Very High comparisons (heart girth and loin width, Trial II). The same differences occurred in regard to the High and Very High treatment comparison in Trial II. In Trial I, there were no significant

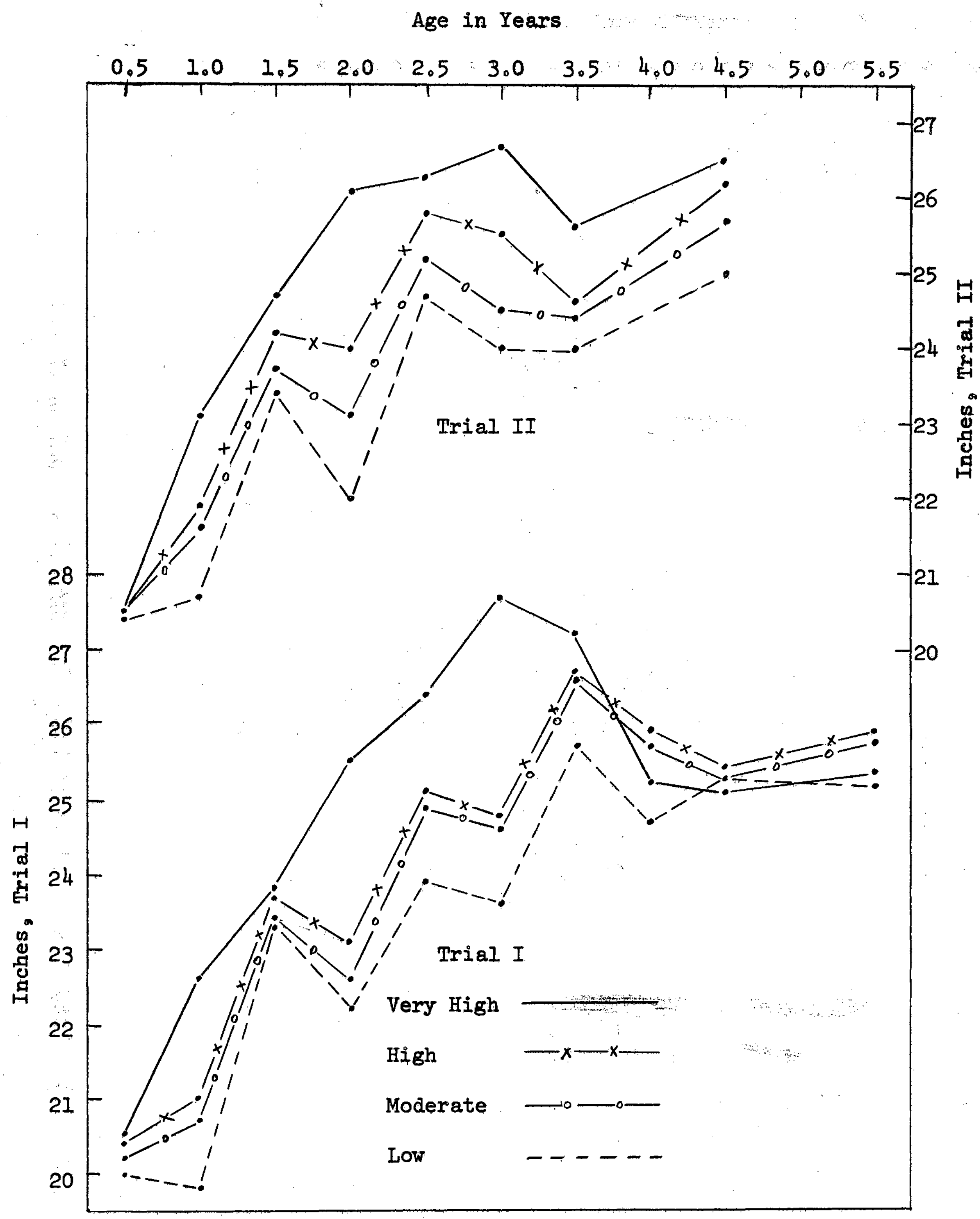

Figure 6. Average Depth of Chest of Heifers Receiving Different Levels of Supplement

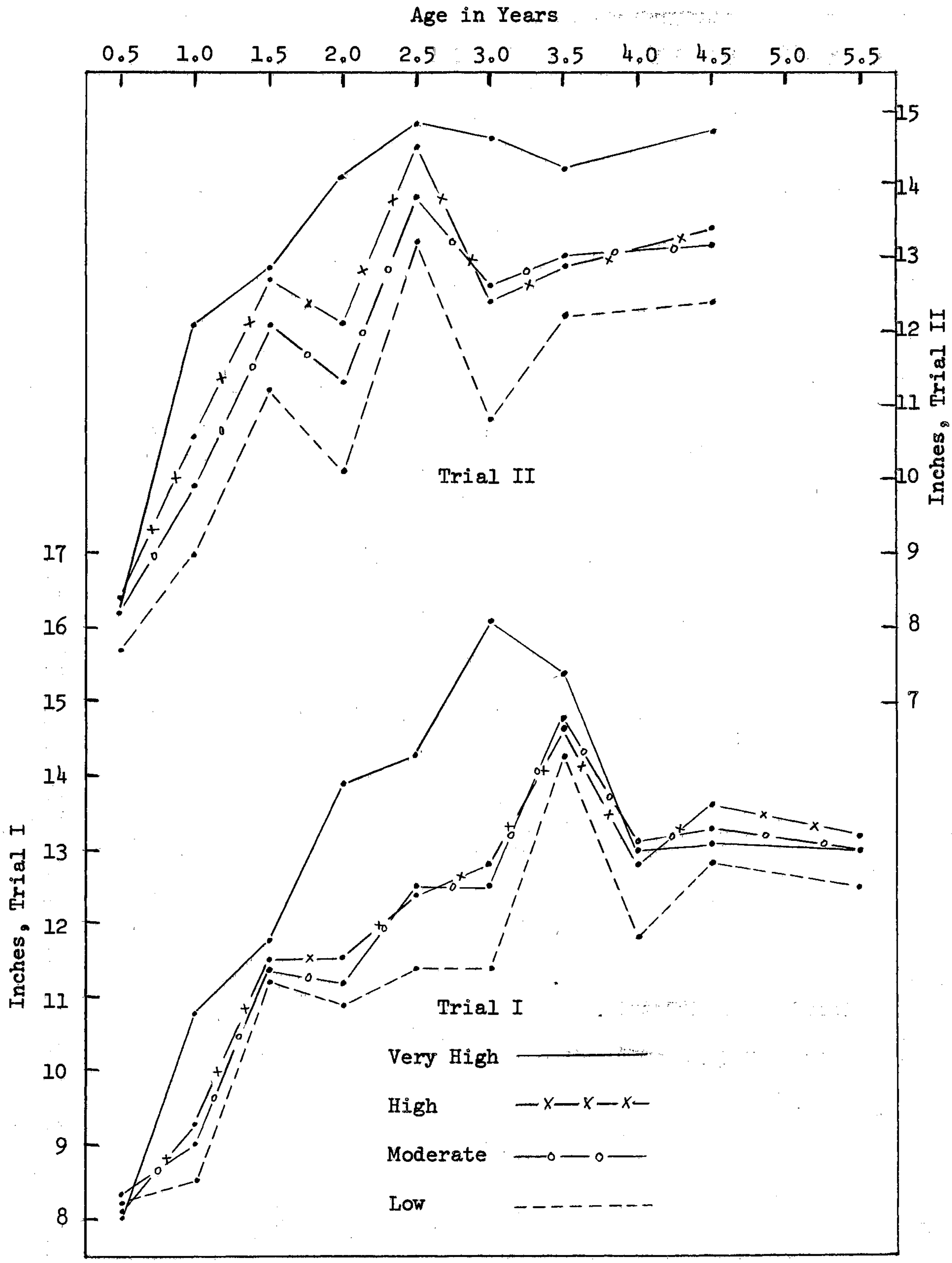

Figure 7. Average Width of Loin of Heifers Receiving Different Levels of Supplement

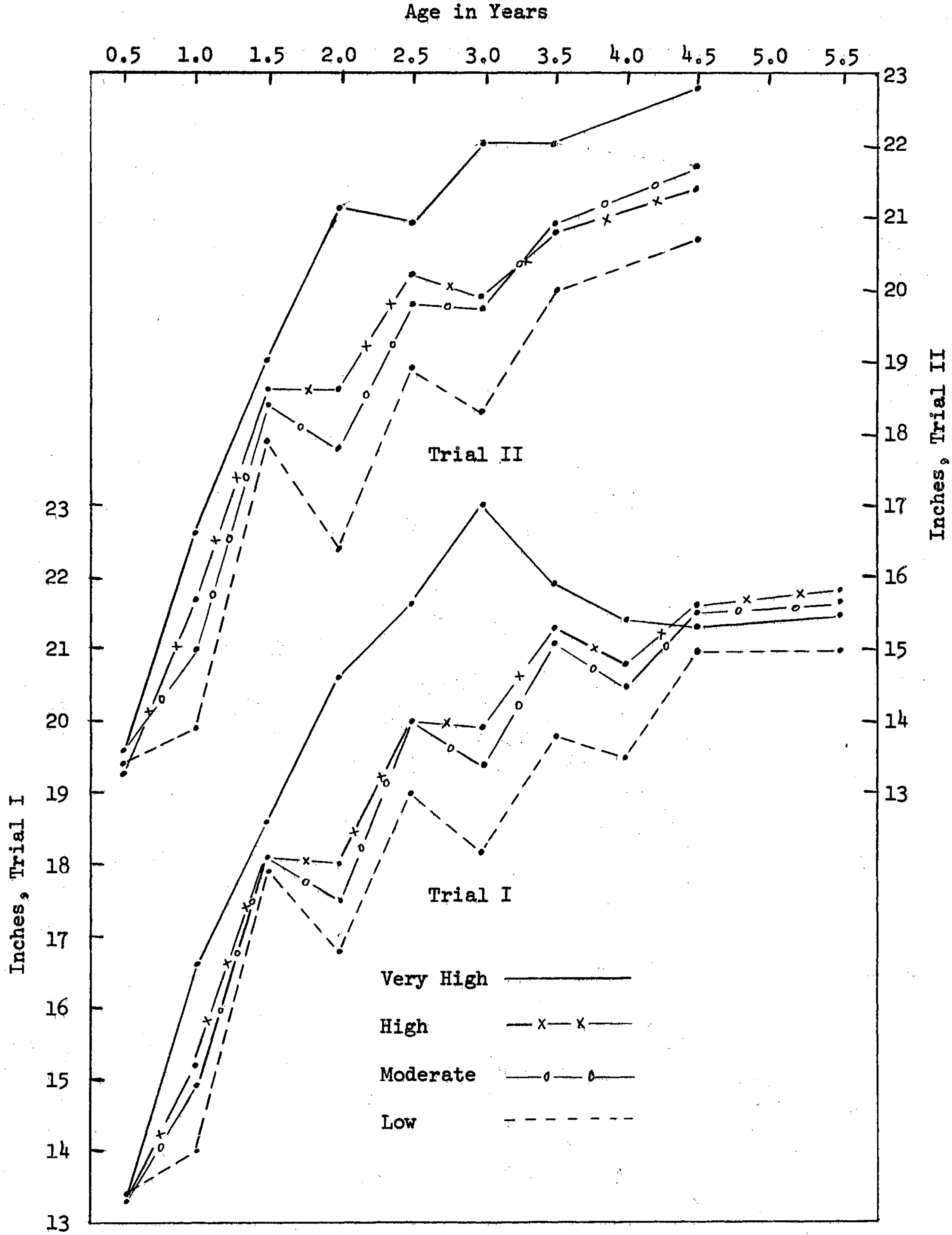

Figure 8. Average Width of Hips of Heifers Receiving Different Levels of Supplement

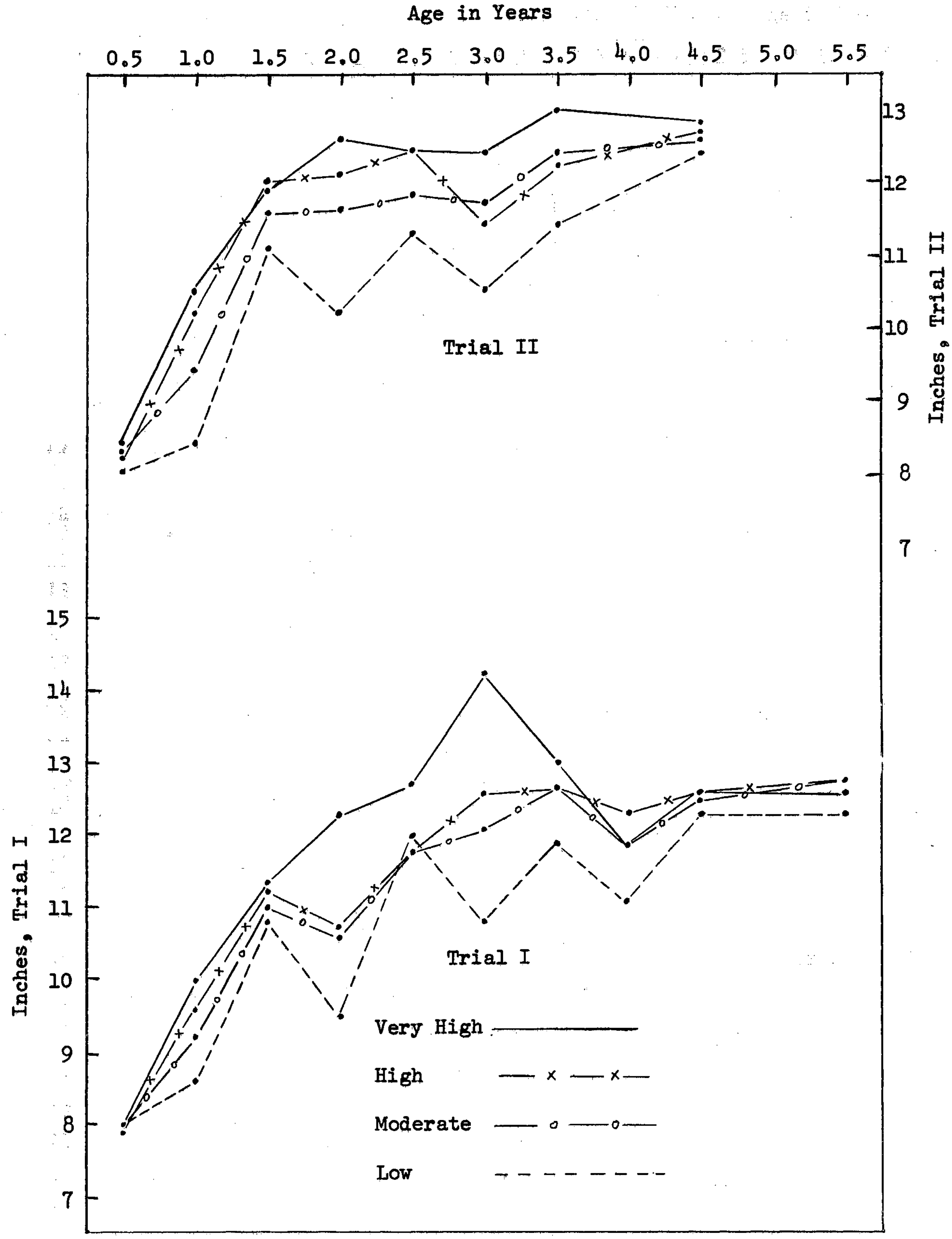

Figure 9. Average Width of Pin Bones of Heifers Receiving Different Levels of Supplement

differences with respect to Moderate vs. High and Very High, or High vs. Very High group comparisons. This would be expected since the Very High group had been reverted to the Moderate level and very small differences in the means occurred following this reversal of treatment.

Figure 10 graphically represents the absolute mean difference between the Low and High level females for each measurement taken in the fall. Only the fall measurements were used since differences in fatness were believed to be less at this time. The Very High groups were not used since there was good evidence that measurements on these females were greatly influenced by fat. Through 4.5 years of age, it is apparent that maximum differences had been attained and were decreasing with the exception of heart girth. From 4.5 to 5.5 years, little change was evident for any measurement except heart girth, based on data obtained only in Trial I. The only measurement in which full recovery of the Low level females had been attained was length of body. It should be mentioned that for most of the measurements, the High level group held an advantage at the start of the experiment (0.5 years of age) even though the groups were allotted to treatment at random.

Figure 11 shows relative recovery of body parts in terms of the mean of the Low group expressed as a percent of the High treatment. The recovery of the Low level cows is even more apparent in this graph. A percentage of full recovery was achieved for both body length and depth, with some recovery occurring for all width measurements. Wither height was largely unaffected by treatment, although some recovery is evident. Again heart girth shows little evidence of any recovery by the Low level group except for the period from 2.5 to 3.5 years of age.

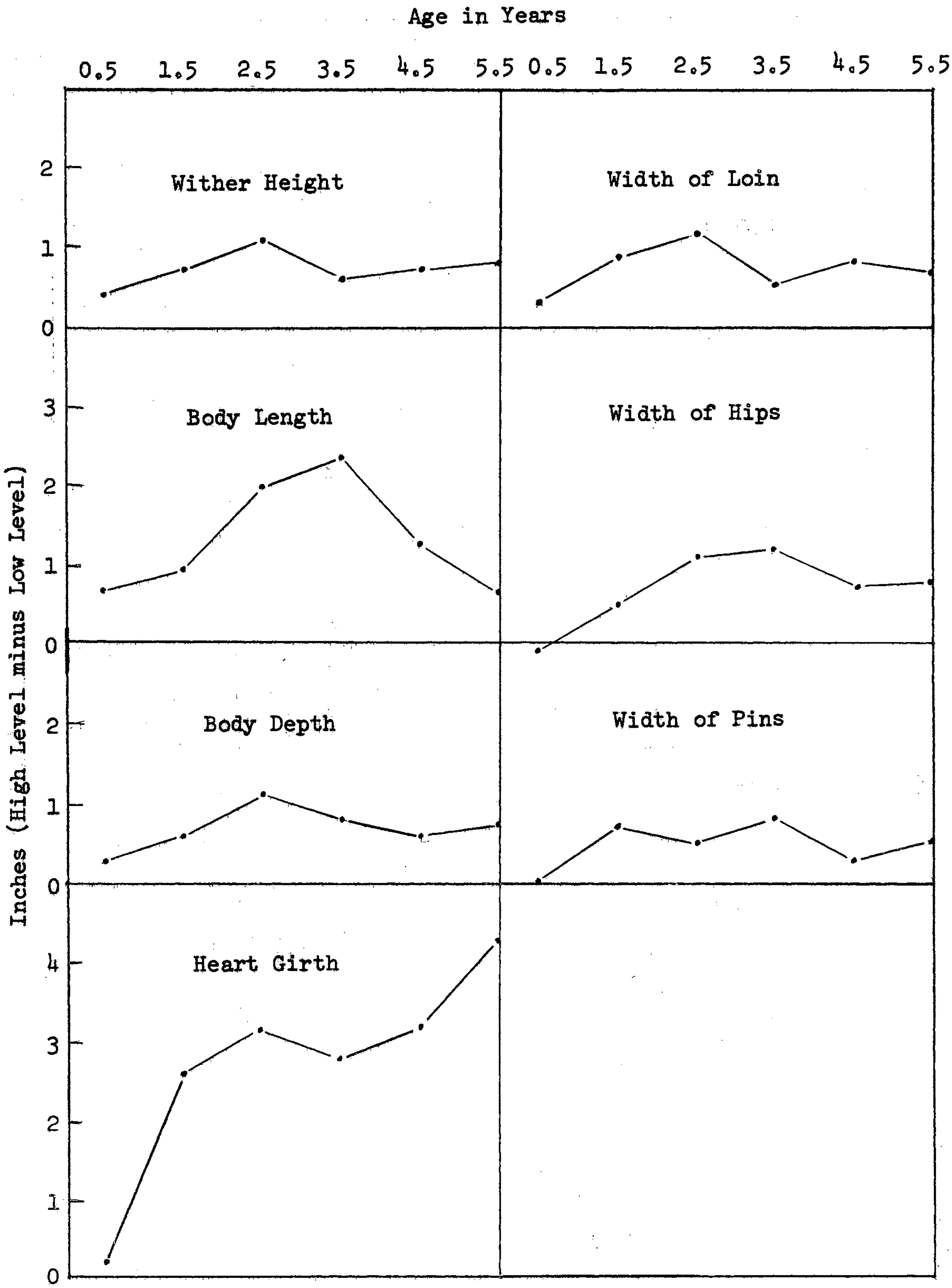

Figure 10. Absolute Treatment Differences in Various Body Dimensions (Trials I and II)

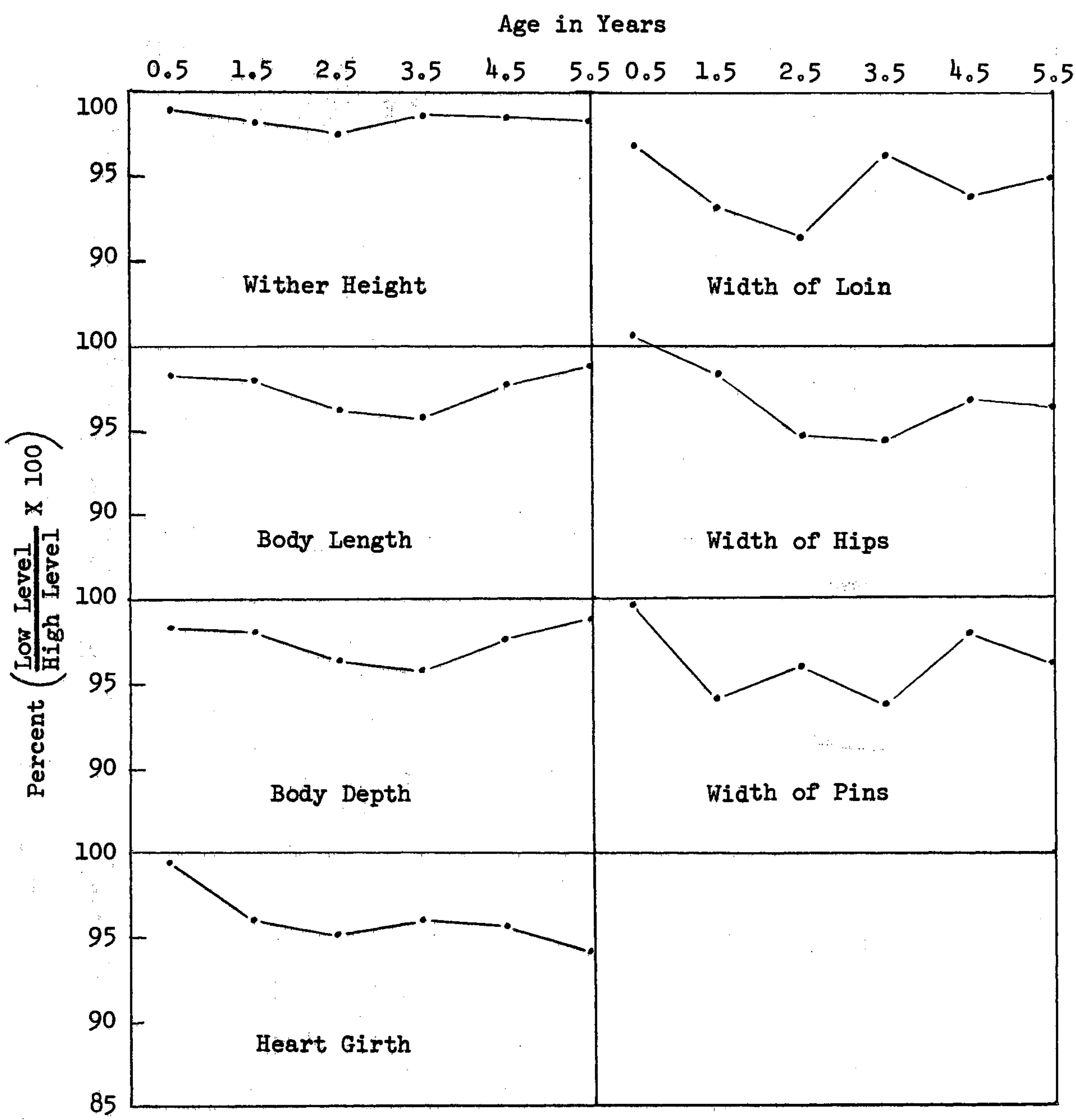

Figure 11. Relative Treatment Differences in Various Body Dimensions (Trials I and II)

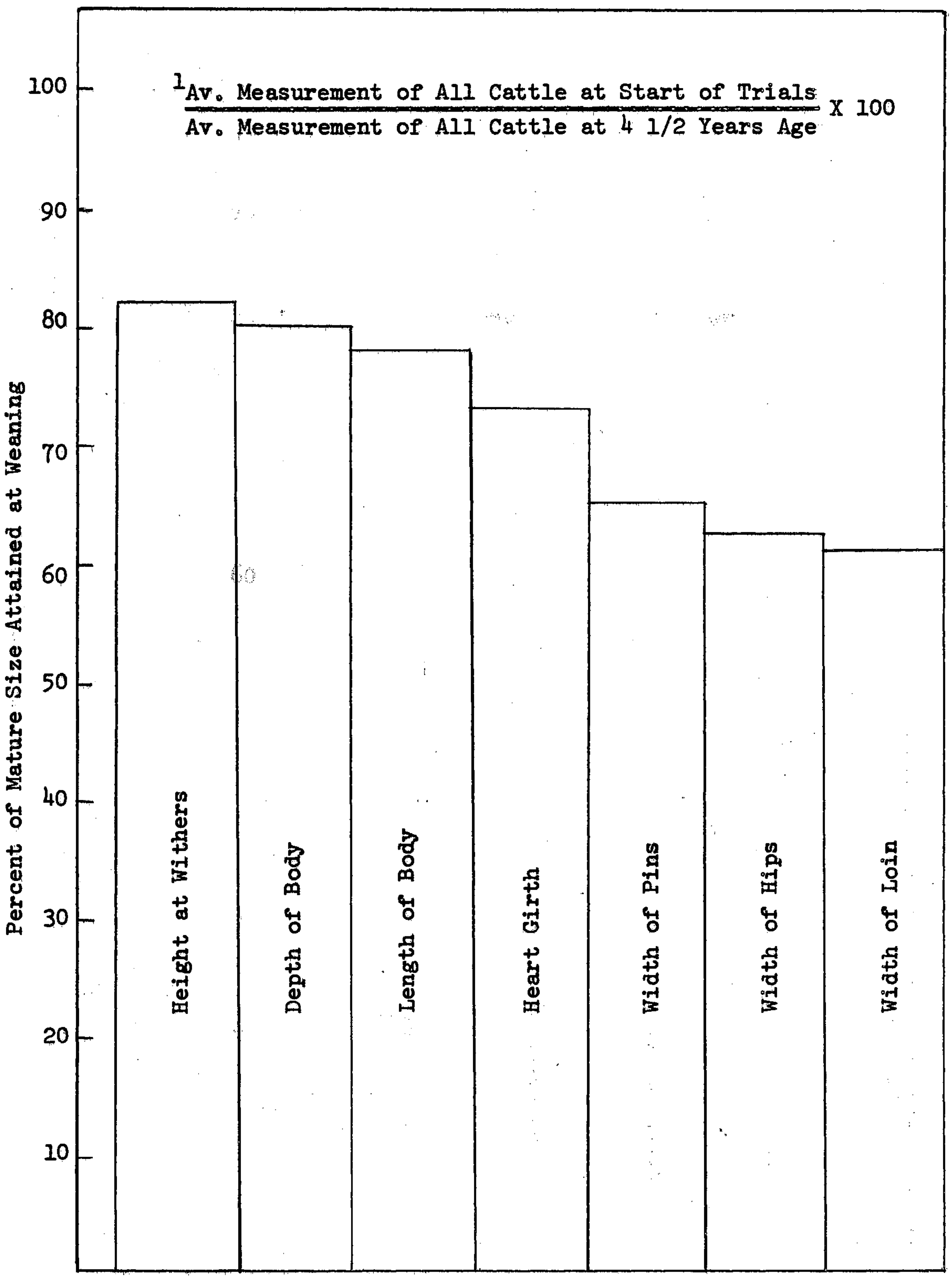

Figure 12. Relative Rate of Growth of Various Body Dimensions[1]

The relative degree of maturity of the various body parts achieved at weaning age is shown in Figure 12. The mature age used was 4.5 years, since measurements on both trials were available at that time. Height of withers more closely approached its mature size at weaning from a relative standpoint, with the width measurements being later maturing dimensions. This is in almost perfect agreement with data reported on previous Oklahoma trials (Zimmerman, 1960). It is also in agreement with the anterior to posterior gradient in body growth proposed by McMeekan (1940). In general, the dimensions which most nearly approached maturity at weaning were least affected by the different treatments. In contrast those dimensions still in a rapid state of growth were most affected by the various treatments imposed each winter.

Reproductive Performance

The average calving dates for the various treatment groups are shown in Table IV. Each year, the Low level treatment consistently delayed the average calving date. Females on the Low level calved significantly later than all other groups in each case, except for the first calf crop in Trial II and the fourth calf crop in Trial I (Appendix Table XIV). Over all years and trials, the Low level cows calved 16 days later than the Highs and 10 days later than the Moderate fed cows. The effect of the Very High treatment was variable but, on the average was approximately equal to the High groups. The greatest delay in calving date from the Low level treatment was during the second calf crop in both trials. This coincides with the breeding season following the largest weight loss for both trials. Thereafter, the differences in calving date seemed to diminish; only 6 days difference was noted between Low and High groups for the fourth calf

TABLE IV

AVERAGE CALVING DATES AND STANDARD ERRORS OF HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

	Level of Winter Supplement			
	Low	Moderate	High	Very High[1]
1st Calf Crop				
Trial I	3/23 ± 8 (14)[2]	3/15 ± 4 (15)	3/4 ± 3 (14)	2/24 ± 5 (14)
Trial II	3/15 ± 4 (13)	3/12 ± 7 (15)	2/29 ± 4 (13)	3/8 ± 8 (14)
2nd Calf Crop				
Trial I	3/26 ± 9 (13)	3/11 ± 5 (14)	3/1 ± 4 (12)	3/5 ± 6 (15)
Trial II	4/6 ± 8 (11)	3/16 ± 5 (13)	3/1 ± 4 (13)	3/9 ± 7 (13)
3rd Calf Crop				
Trial I	3/19 ± 5 (13)	3/9 ± 6 (13)	3/4 ± 5 (14)	3/3 ± 4 (14)
Trial II	3/16 ± 7 (9)	3/5 ± 2 (12)	3/4 ± 4 (11)	2/26 ± 4 (13)
4th Calf Crop				
Trial I	3/6 ± 4 (15)	3/4 ± 3 (15)	2/28 ± 2 (13)	2/27 ± 3 (13)

[1]The Very High group in Trial I was reverted to the Moderate feed level for the fourth and fifth winters.
[2]Indicates the number of observations involved in the standard error.

crop. However, it should be pointed out that during the winter prior to breeding for the fourth calf crop, by far the least difference in weight loss between Low and High groups occurred. Thus, it would appear that weight loss during the winter prior to breeding is related to the delay in calving the following year. In addition to delayed calving, the Low level also resulted in a more variable calving date as shown by the larger standard error of the mean.

There are two possible causes for delayed calving when females are subjected to a Low level, i.e. either a delay in occurrence of estrus following the winter feeding phase and/or an increase in the number of cycles required per conception. Turman (1962) studied the breeding pattern of weanling heifers wintered at Low, Moderate and High levels corresponding to the treatments used in the present study. It was observed that decreasing levels of winter feed resulted in increasing delays in occurrence of first estrus. Similar results with heifers have been reported by Joubert (1954), Crichton *et al.* (1959) and Reid (1960). Wiltbank *et al.* (1957) showed that either protein or energy deficiencies increased the number of days to first estrus in beef heifers, but energy level had a much more pronounced effect than protein level. Also Bond *et al.* (1957) observed that underfeeding of either protein or energy resulted in cessation of estrus in heifers already cycling. Studies with mature cows (Wiltbank *et al.*, 1962) indicate that Low levels of energy fed prior to calving markedly increased interval to subsequent estrus, and Low levels of energy following calving decreased conception rate and increased services required per conception. These workers theorized that failure of a release or production of gonadotrophic hormone from the pituitary is a primary cause of failure to exhibit estrus. It would seem in the present study that the delay in calving date from the Low feed level was primarily a result of an increase in interval from calving to first estrus, rather than decreased fertility since the cows were all on lush spring grass prior to, and during the breeding period. However, the conception rate was also reduced by the Low level regime as will be discussed later.

The average birth weights resulting from the various treatments are shown in Table V. The Low level cows gave birth to significantly smaller calves during each year and trial, with the exception of the fourth calf crop, Trial I (Appendix Table XIV). There was a small but consistent advantage in weight at birth for calves from dams on the High level as

TABLE V

AVERAGE BIRTH WEIGHT[1] (LB.) AND STANDARD ERRORS OF CALVES FROM HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

	Level of Winter Supplement			
	Low	Moderate	High	Very High[2]
1st Calf Crop				
Trial I	61.7 ± 1.4[3]	70.8 ± 2.0	74.6 ± 2.0	70.5 ± 2.1
Trial II	56.2 ± 1.4	75.7 ± 1.7	70.0 ± 1.7	69.3 ± 2.4
2nd Calf Crop				
Trial I	70.9 ± 2.3	77.2 ± 1.9	81.3 ± 4.1	74.5 ± 1.6
Trial II	69.5 ± 2.0	73.8 ± 2.5	75.3 ± 1.9	77.4 ± 2.0
3rd Calf Crop				
Trial I	75.7 ± 1.1	79.1 ± 2.4	81.7 ± 2.2	79.7 ± 1.7
Trial II	79.6 ± 3.3	81.7 ± 2.4	81.0 ± 1.8	73.2 ± 1.4
4th Calf Crop				
Trial I	80.9 ± 2.3	79.8 ± 2.1	82.8 ± 2.0	77.8 ± 2.6

[1]Heifer birth weights corrected to bull equivalent by the methods of Botkin (1952).
[2]The Very High group in Trial I was reverted to the Moderate feed level for the fourth and fifth winters.
[3]Number of observations correspond to those given in Table IV.

compared to the Moderate group, but this was nonsignificant. Over the entire seven calf crops reported herein, the Lows gave birth to calves averaging 7.5 lb. smaller at birth than calves resulting from the High regime, and about 5.0 lb. smaller than the Moderate regime calves. This is the same order of magnitude reported by Zimmerman (1960) under similar conditions through three calf crops, except that he noted less difference between Moderate and High groups. Probably of more interest in the present study is the fact that the differences became progressively smaller with each succeeding calf crop. For the fourth calf crop, no significant effect of winter feed level on birth weight was noted. The average difference between Low and High groups decreased in the order of 13.4, 8.1, 3.7 and 1.9 lb. for the first through fourth calf crops, respectively. Differences between Moderate and High groups followed the same trend. This can be explained by the fact that less of the nutrient intake would be required each year for body growth as the cow approached maturity, and thus there is less competition with the fetus for nutrients with advancing age. The direct relationship between winter feed level and birth weight of calves was not noted in an earlier trial (Pinney, 1962), although differences in winter feed levels were not as marked.

It is interesting that the Very High nutritional regime depressed birth weight as compared to the High level regime in four of the five comparisons possible. This effect was significant in only one case, however. In three of the five comparisons the Very High level cows actually had smaller calves at birth than did the Moderate level cows. No report of such an effect has been noted in the literature. Holland (1961) reported that heifers fed for maximum gain through two calf crops gave birth to calves averaging 5 lb. larger at birth than heifers fed "normal" rations. The "normal" ration provided for gains slightly better than the Moderate level used in the present study.

The Very High-Moderate regime in Trial I gave birth to calves of nearly the same weight as those from the Moderate fed group during the third and fourth calf crops.

The percent of possible cow-bull exposures resulting in a calf weaned is presented in Table VI. The results within year and Trial are rather inconsistent; however, the Low level cows weaned a lower percent calf crop in four of the seven calf crops. When all trials and years are averaged, calf crop percents were 81.2, 85.4 and 84.8 for the Low,

TABLE VI

PERCENT CALF CROP WEANED FROM HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

	Level of Winter Supplement			
	Low	Moderate	High	Very High[1]
1st Calf Crop				
Trial I	86.7	93.3	100.0	60.0
Trial II	78.6	66.7	66.7	66.7
2nd Calf Crop				
Trial I	80.0	80.0	71.4	86.7
Trial II	71.4	85.7	86.7	84.6
3rd Calf Crop				
Trial I	80.0	86.7	100.0	93.3
Trial II	69.2	85.7	76.9	100.0
4th Calf Crop	100.0	100.0	92.9	85.7

[1]The Very High group in Trial I was reverted to the Moderate feed level for the fourth and fifth winters.

Moderate and High treatment groups, respectively. Although these differences are small, they are in agreement with Zimmerman (1960) who observed a reduction in calf crop percentage for the Low regime, with little difference occurring between Moderate and High groups.

It is of interest to examine some of the possible reasons for such an effect. The percent open cows of those exposed was 12.9, 3.9 and 7.1 percent for the Low, Moderate and High groups, respectively. Percent of calves dropped which were dead on arrival was 5.0, 9.7 and 7.0, respectively, for these groups. No difference was seen in number of calves which died from birth to weaning. Thus, the only apparent reason for the reduced calf crop percentage on the Low level was an increased rate in the number of open cows.

This effect has been noted by others working with Low nutritional planes (Wagnon et al., 1959; Wiltbank et al., 1962). This effect could result from either an extremely long period to first estrus following calving and/or a depressed conception rate. Wiltbank et al. (1962) noted that conception rate was decreased by a low energy level following calving, and also that interval to first estrus was increased by a low energy level prior to calving. In all probability, the effect observed in the present study was the result of both lowered conception and long anestrus periods.

The effect of the Very High regime on percent calf crop is worthy of consideration. If the third calf crop for the Very High-Moderate group is considered to be the result of the Very High regime, for the six calf crops these cows weaned approximately the same percent calf crop as the Low level cows. However, the percent open cows for the Very High group for all calf crops combined was only 2.3 percent, by far the smallest proportion of any of the treatment groups. In contrast, the percent calves lost at birth in the Very High groups was nearly 13 percent which was almost entirely a result of dystocia encountered at first parturition as 2-year-olds. Four calves were lost from the first calf crop in each trial in the Very High groups as a direct result of difficulty at calving; none were lost for this cause in subsequent years. Thus, it would seem that the only detrimental effect of over-feeding, in regard to percent calf crop, is the difficulty in calving encountered at first parturition. The conception rate was amazingly high, especially considering the belief of many breeders that fitted heifers are prone to be difficult breeders. The fact that these heifers were bred at a young age and on lush pasture may have some bearing on the results obtained, since many fitted heifers are not bred until a later age and while fed on high grain rations. The Very High females were actually in a declining condition each year during breeding season, since they were full-fed only during the winter phase.

Data reported by Chambers et al. (1960) with Angus heifer calves indicated that when self-fed a 60 percent concentrate mixture during a 5-month wintering period to gain 1.5 to 2.2 lb. per head daily, percent of heifers calving decreased from 85 to 76 percent as compared to heifers fed to gain only 0.5 lb. per head daily during the same period of time. Such results were not observed in the present study. The possibility exists of a breed difference between Angus and Herefords.

The average weaning weights, corrected for both age (210 days) and sex are given in Table VII. The correction method used was that of Botkin (1952), derived from data taken from Hereford cows at similar locations. In general, there was a direct relationship between winter feed level and weaning weight from the Low to High level treatments, with much less difference occurring between the Moderate and High groups than between Low and High groups. The Low level cows weaned significantly lighter calves in both trials for the first calf crop, as well as the second calf crop in Trial II (Appendix Table XIV). However, the lightest calves were weaned by the Low level females in all trials and years with the exception of the fourth calf crop, where the Very High-Moderate cows weaned the lightest calves.

The depressed weaning weights for the Low and Moderate treatments were much more pronounced in Trial II. This is not surprising in view of the fact that the difference between High and Low groups in first winter gain was much greater for Trial II. Considering all calf crops, the Low level depressed weaning weight 54 lb. and the Moderate level 14 lb.

TABLE VII

AVERAGE CORRECTED[1] WEANING WEIGHTS (LB.) AND STANDARD ERRORS OF CALVES WEANED FROM HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

	Level of Winter Supplement			
	Low	Moderate	High	Very High[2]
1st Calf Crop				
Trial I	347 ± 14 (13)[3]	391 ± 11 (14)	404 ± 12 (14)	396 ± 18 (9)
Trial II	331 ± 13 (11)	404 ± 10 (10)	426 ± 13 (10)	396 ± 18 (10)
2nd Calf Crop				
Trial I	421 ± 14 (12)	462 ± 12 (12)	458 ± 16 (10)	438 ± 17 (13)
Trial II	400 ± 14 (10)	460 ± 14 (12)	497 ± 10 (13)	455 ± 17 (11)
3rd Calf Crop				
Trial I	448 ± 10 (12)	471 ± 9 (13)	478 ± 14 (14)	453 ± 12 (14)
Trial II	440 ± 16 (9)	475 ± 12 (12)	486 ± 19 (10)	452 ± 16 (13)
4th Calf Crop				
Trial I	470 ± 11 (15)	472 ± 10 (15)	484 ± 16 (13)	460 ± 7 (12)

[1]Weaning weights were corrected to a 210-day steer equivalent using the methods of Botkin (1952).
[2]The Very High group in Trial I was reverted to the Moderate feed level for the fourth and fifth winters.
[3]Indicates the number of observations involved in the standard error.

as compared to the High level. The Very High level winter treatment for five calf crops depressed weaning weight by an average of 27 lb. as compared to the High level. Reversal of the Very High to the Moderate treatment appeared to have little effect on weaning weights.

Differences in weaning weights became smaller each succeeding year, similar to the effect of treatment on calving dates and birth weights. The average difference between Low and High groups was 76, 67, 38 and 14 lb. for the first through fourth calf crops. The difference between Moderate and High groups also decreased with age of the cow. Thus, as the cow approaches maturity and the nutritional demands for growth become smaller, more nutrients are available for fetal growth and milk production.

The actual economic merit of the various regimes may be determined more accurately by actual weaning weights, rather than age-corrected weights. The average weaning weights corrected only for sex are shown in Table VIII. The differences in these weaning weights are much larger than

TABLE VIII

AVERAGE WEANING WEIGHT[1] (LB.) AND STANDARD ERRORS OF CALVES WEANED FROM HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

	Level of Winter Supplement			
	Low	Moderate	High	Very High[2]
1st Calf Crop				
Trial I	341 ± 13[3]	393 ± 12	422 ± 14	421 ± 21
Trial II	322 ± 12	396 ± 20	446 ± 18	394 ± 22
2nd Calf Crop				
Trial I	390 ± 12	458 ± 13	470 ± 14	444 ± 22
Trial II	361 ± 19	455 ± 14	512 ± 14	456 ± 18
3rd Calf Crop				
Trial I	429 ± 9	470 ± 10	485 ± 14	463 ± 14
Trial II	429 ± 21	479 ± 13	493 ± 23	467 ± 18
4th Calf Crop				
Trial I	472 ± 11	479 ± 10	498 ± 18	478 ± 7

[1]Corrected only for sex, to a steer equivalent.
[2]The Very High group in Trial I was reverted to the Moderate feed level for the fourth and fifth winters.
[3]Number of observations correspond to those given in Table VII.

those corrected to a standard age, and show a rather large and consistent increase from Low through High treatment groups. Differences between the Low, Moderate and High level calves, however, decreased with each calf crop until no significant differences were observed between weaning weights in the fourth calf crop. The Lows weaned significantly smaller calves in each calf crop, with the exception of the fourth calf crop. The Very High regime in Trial II significantly reduced weaning weights for the first two calf crops as compared to the High level (Appendix Table XIV). This effect in reduction of weaning weights by extremely high nutritional planes before first calving has been reported by Turman (1962), and as a result of continuous fattening rations fed to heifers through several calf crops (Arnett, 1963). However, in a corollary study, no detrimental effect of fattening was found when range beef cows were put on test after 8 years of age. The adverse effect on weaning weight resulting from fattening of the young heifer appears to be associated with reduced milk flow, and will be discussed later.

Average daily gain of the calves from birth to weaning presents a more accurate picture of the mothering ability of the cows, since birth weight is excluded and errors in age correction factors are eliminated (Table IX). As with corrected weaning weights, the gains of the Low level calves were significantly depressed for both trials in the first calf crop, and for the second calf crop in Trial II (Appendix Table XIV). Through the Low to High treatments, gain from birth to weaning was directly related to winter feed level of the dam; however, differences between the Moderate and High levels were very small. Less drastic differences are seen between average daily gain of the calves to weaning than for corrected weaning weight. This is because the average daily gain does not take into account the smaller birth weights resulting with each decrease in feed level given the dams. The Very High regime resulted in a decrease in gain as compared to the High regime in every case, but these differences were not significant. In only one case did the Very High regime result in higher gains than the Moderate regime.

TABLE IX

AVERAGE DAILY GAIN FROM BIRTH TO WEANING AND STANDARD ERRORS OF CALVES WEANED FROM HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT[1]

	Level of Winter Supplement			
	Low	Moderate	High	Very High[2]
1st Calf Crop				
Trial I	1.37 ± .068[3]	1.52 ± .051	1.56 ± .052	1.55 ± .074
Trial II	1.32 ± .064	1.62 ± .045	1.68 ± .058	1.58 ± .088
2nd Calf Crop				
Trial I	1.70 ± .066	1.84 ± .060	1.77 ± .069	1.76 ± .091
Trial II	1.61 ± .060	1.84 ± .066	2.00 ± .042	1.84 ± .089
3rd Calf Crop				
Trial I	1.78 ± .051	1.87 ± .044	1.89 ± .062	1.77 ± .054
Trial II	1.73 ± .069	1.87 ± .056	1.92 ± .086	1.76 ± .081
4th Calf Crop				
Trial I	1.85 ± .051	1.86 ± .043	1.89 ± .088	1.80 ± .036

[1]Heifers were adjusted to a steer equivalent.
[2]The Very High group in Trial I was reverted to the Moderate feed level for the fourth and fifth winters.
[3]Number of observations correspond to those given in Table VII.

Differences in calf gain between treatment groups decreased each subsequent calf crop, and for the fourth calf crop very little difference occurred between any of the treatments.

Although of less importance, another factor in addition to weaning weight and percent calf crop determines the economic merit of these treatments. This is feeder grade or conformation grade of the calves at weaning (Table X). These grades were estimated each year at weaning by an unbiased, qualified grader. Theoretically, this grade was based on conformation and is independent of the condition or fatness of the calves. The Low level offspring were the poorest grading group each year and in

TABLE X

AVERAGE CONFORMATION SCORE[1] AT WEANING OF CALVES WEANED FROM HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

	Level of Winter Supplement			
	Low	Moderate	High	Very High[2]
1st Calf Crop				
Trial I	10.46[3]	10.71	11.07	11.00
Trial II	8.73	10.40	10.20	10.10
2nd Calf Crop				
Trial I	10.00	10.83	10.60	10.83
Trial II	9.30	10.42	10.85	10.64
3rd Calf Crop				
Trial I	10.42	11.15	10.93	10.79
Trial II	10.00	11.00	10.90	10.62
4th Calf Crop				
Trial I	10.67	10.87	11.15	10.67

[1]8 = average good, 9 = high good, 10 = low choice and 11 = average choice.
[2]The Very High group in Trial I was reverted to the Moderate feed level for the fourth and fifth winters.
[3]Number of observations correspond to those given in Table VII.

each trial, and graded significantly lower in four of the seven comparisons (Appendix Table XIV). No consistent difference was seen between calves from the Moderate or High level cows, while the Very High calves graded slightly lower than calves from High level dams in four out of the five comparisons. These differences were not significant, however.

In an attempt to determine why the gains of the calves differed between nutritional regimes, estimates of daily milk production for all cows nursing calves were made at five or six periods during the second lactation in Trial I and during the third lactation in both trials. These estimates were made by separating the cows and calves for several hours, after which the calves were allowed to nurse the cows dry. The cows and calves were again separated and, after 12 hours, were weighed individually to the nearest 0.25 lb. before and after nursing. The two successive 12-hour yields were combined to give an estimate of 24-hour milk production for each cow. While the calves were under 2 months of age, three 8-hour intervals were used to allow the young calves more opportunity to nurse the cows dry.

Table XI shows the average daily milk yield for five or six estimates

TABLE XI

AVERAGE MILK YIELDS OVER ENTIRE LACTATION OF HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT[1]

	Level of Winter Supplement			
	Low	Moderate	High	Very High[2]
2nd Calf Crop				
Trial II	8.34 ± .47[3]	9.68 ± .83	11.44 ± .70	8.88 ± 1.01
3rd Calf Crop				
Trial I	9.66 ± .75	10.75 ± .90	10.78 ± 1.02	9.71 ± .70
Trial II	8.95 ± .69	11.34 ± .74	11.99 ± 1.03	10.02 ± .91

[1]Average of five estimates for each cow, except the third calf crop, Trial II, where six estimates were averaged.
[2]The Very High group in Trial I was reverted to the Moderate feed level for the fourth and fifth winters.
[3]Standard error of the mean with number of observations corresponding to those given in Table VII.

each year. In general, the differences between treatments with regard to milk production were similar to differences in average daily gain of the calves. Also, differences were smaller between treatments in Trial I than Trial II, which was true for all criteria studied. The Low level significantly decreased milk production for Trial II during the third calf crop, and the Very High regime significantly reduced milk yield as compared to the High group in each trial (Appendix Table XIV). The Very High-Moderate group produced less milk than the Moderate group, as was the case with weaning weights and gain of calves from birth to weaning. Evidently, the Very High regime had already accomplished its detrimental effect after the first three winters. This is confirmed by Swanson (1960) with twin dairy heifers, when one member of each pair was fed heavily on concentrates prior to first calving. During the first two lactations, milk production was reduced to 85 percent of that observed in heifers fed normal rations and limited concentrates prior to first calving. Data presented by Chambers et al. (1960) indicate depressed weaning weights in calves from Angus heifers heavily fed prior to first breeding, presumably due to decreased milk flow. Arnett (1963) reported that feeding beef heifers for maximum gain during first gestation and lactation resulted in significantly reduced milk flow as compared to twin-mate heifers fed normally. The differences within pairs, however, were quite variable, and Angus females were affected to a much greater degree than were Hereford or crossbred Hereford heifers.

It should be mentioned that a comparison of milk production of the treatment groups in this study is complicated by the fact that each treatment group was at a different stage of lactation at any particular sampling. Thus treatment effects are confounded with stage of lactation. Undoubtedly, some advantage is given to groups in an earlier stage of lactation.

Figures 13, 14 and 15 illustrate milk production curves for the years and trials sampled. It can be seen that much larger differences between treatments occurred in Trial II than in Trial I. This was true also in the case of weaning weights and calf gains and can be explained in part

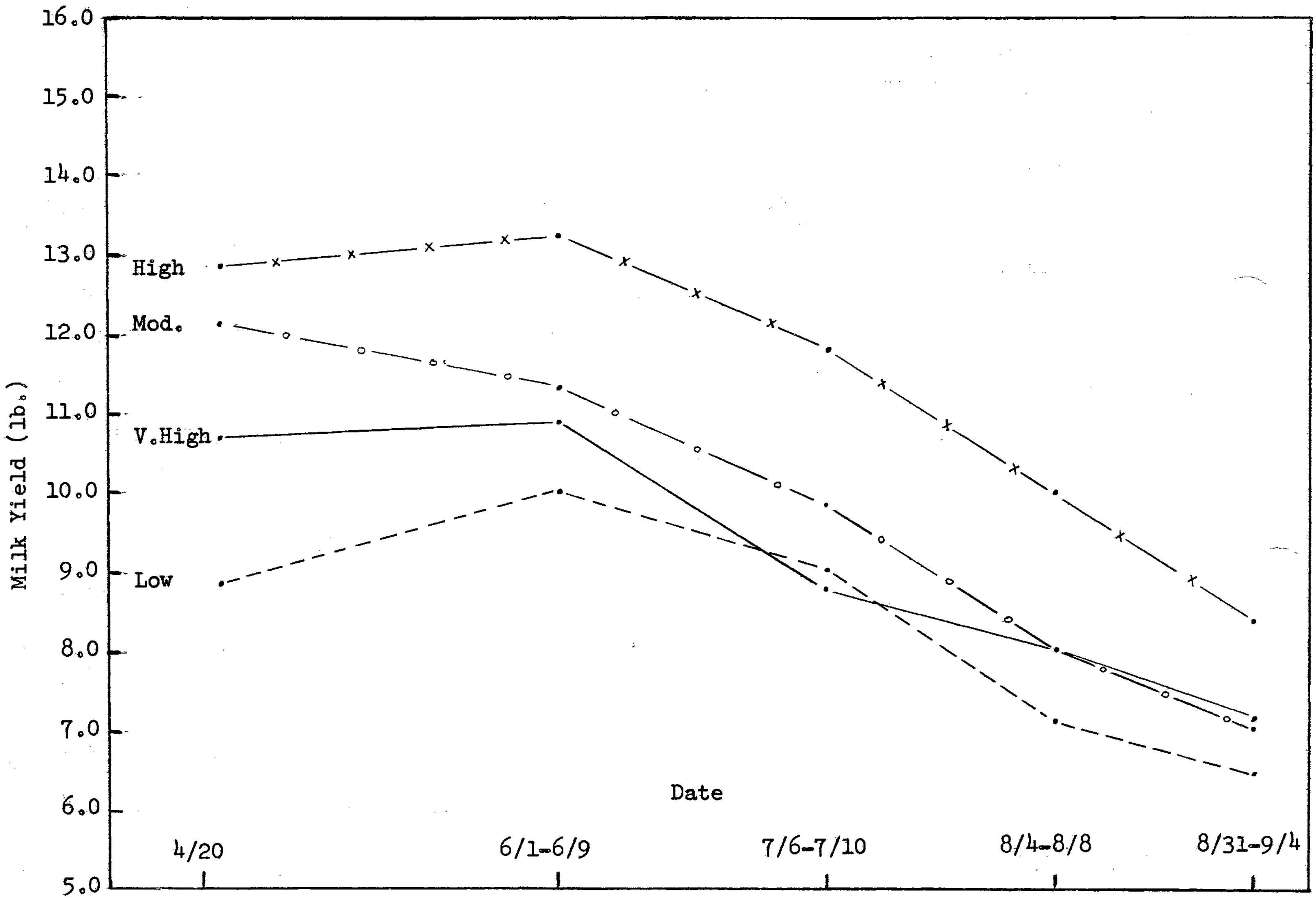

Figure 13. Average Milk Yields of Heifers Receiving Different Levels of Supplement
(Second Calf Crop, Trial II)

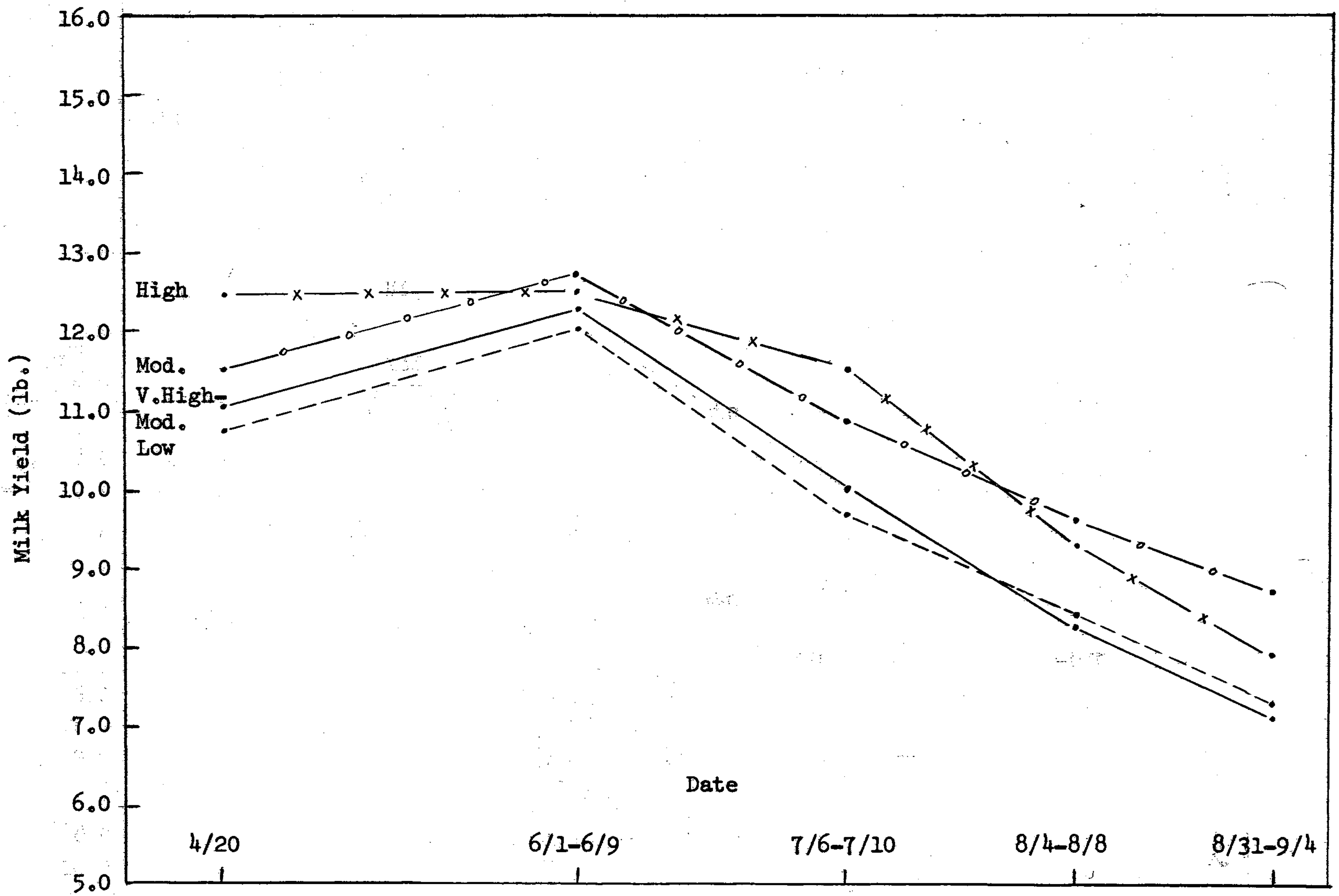

Figure 14. Average Milk Yields of Heifers Receiving Different Levels of Supplement
(Third Calf Crop, Trial I)

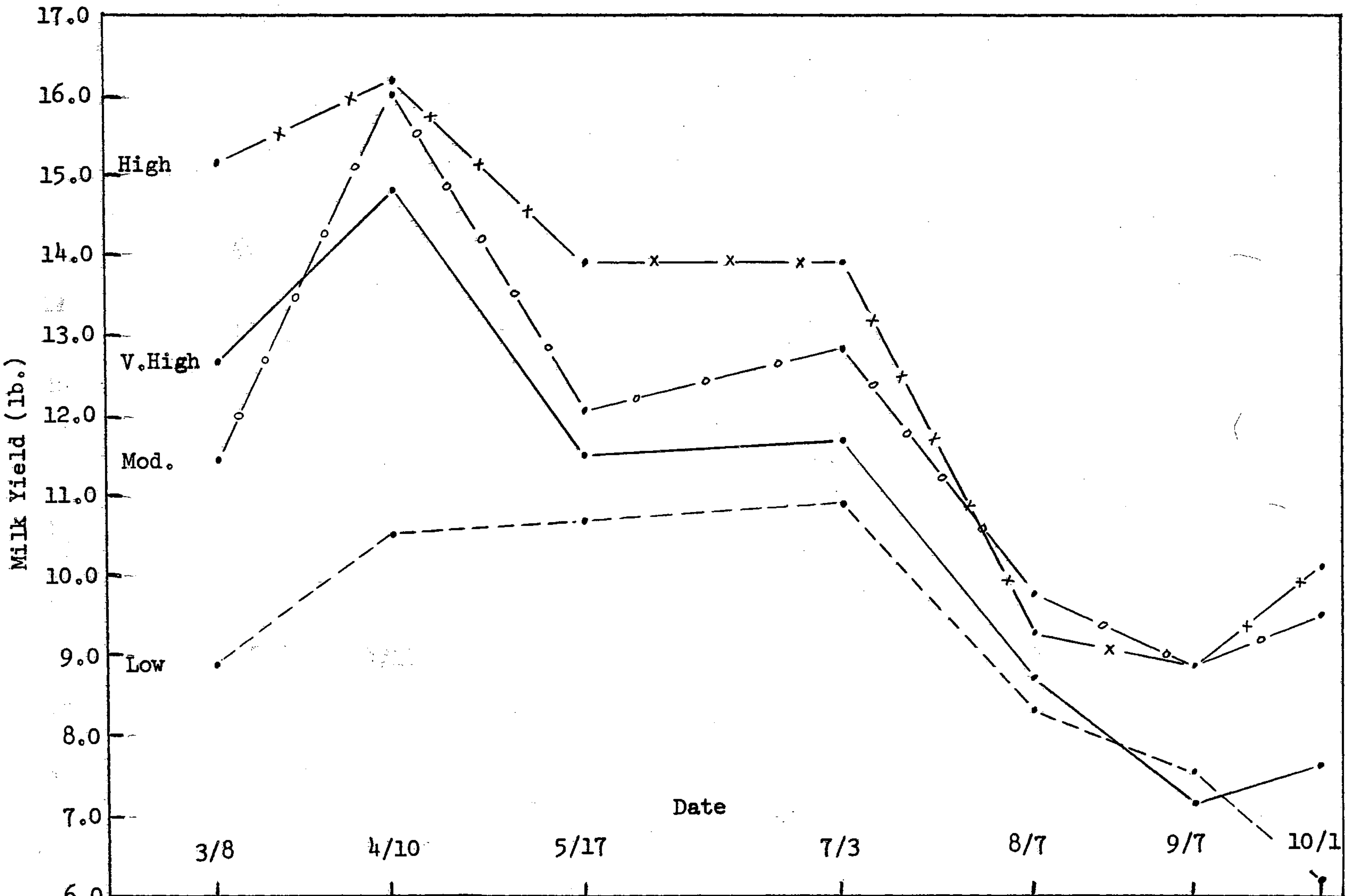

Figure 15. Average Milk Yields of Heifers Receiving Different Levels of Supplement (Third Calf Crop, Trial II)

by the fact that much greater differences in weight gains occurred between treatments in Trial II than in Trial I during the first winter, and also to some extent during the winters previous to collection of milk production data.

In general, milk production was directly related to winter feed level from Low through High levels with the Very High treatment, or Very High-Moderate treatment, depressing milk flow below that of the Moderate level at almost every sampling. For the third calf crop, Trial II (Figure 15) sampling covered a much longer portion of the lactation than in the previous year. Thus, more of the total lactation curve is represented. It can be seen that much larger differences between treatments occurred early in the spring when the cows were still under the influence of winter treatment than later during the summer grazing period. The Low group reached peak production at a later date than the other groups, presumably because of their later calving date. When average total milk production is expressed on a 210-day basis for all years and trials, the Low, Moderate, High and Very High groups yielded 1,886, 2,224, 2,395 and 2,003 lb., respectively. However, expressing total milk yield this way probably gives the Low level regime some advantage because of an earlier stage of lactation at time of sampling.

In order to determine how much of the variation in gains of the calves was associated with variation in milk yield of the dams, correlation coefficients were calculated (Table XII). These are reported on a within-treatment basis in order to remove the effect of winter feed level from the pooled correlations. The variables correlated for each period were the average of the two estimates of milk flow taken at the start and finish of the particular period, with the daily gain of the calves for

TABLE XII

CORRELATION COEFFICIENTS[1] OF AVERAGE DAILY MILK YIELD AND AVERAGE DAILY CALF GAIN BY PERIODS AND BY DIFFERENT LEVELS OF SUPPLEMENT

Calf Crop and Feed Level of Dam	Degrees of Freedom	4/20-27 to 6/1-9	6/1-9 to 7/6-10	7/6-10 to 8/4-8	8/4-8 to 8/31-9/4	Birth to Weaning
2nd Calf Crop, Trial II						
Low	9	0.59	0.61*	0.26	-0.21	0.40
Moderate	11	0.76**	0.73**	0.81**	0.09	0.89**
High	12	0.61*	0.07	0.53*	0.16	0.68**
Very High	10	0.76**	0.01	0.50	0.39	0.72**
Pooled	42	0.71**	0.23	0.54**	0.16	0.71**
3rd Calf Crop, Trial I						
Low	11	0.76**	0.00	0.08	0.11	0.71**
Moderate	12	0.71**	0.22	0.26	0.84**	0.92**
High	14	0.46	0.49*	0.27	0.55*	0.84**
V. High-Mod.[2]	13	0.31	0.83**	0.37	0.11	0.77**
Pooled	50	0.49**	0.09	0.27*	0.45**	0.82**
		5/17 to 7/3	7/3 to 8/7	8/7 to 9/7	9/7 to 10/1	Birth to Weaning
3rd Calf Crop, Trial II						
Low	8	0.62*	-0.04	0.15	0.31	0.77**
Moderate	11	0.61*	0.29	-0.01	0.40	0.56
High	9	0.84**	0.24	0.64*	0.45	0.91**
Very High	12	0.70**	0.50*	0.58*	-0.10	0.86**
Pooled	40	0.70**	0.27	0.30*	0.22	0.80**

[1]Correlations for second Calf Crop (Trial II) and third Calf Crop (Trial I) were taken from Van Cotthem (1962).

[2]For the winter preceding the third Calf Crop the Very High group in Trial I was wintered at the Moderate level.

*P $<$ or $\simeq$ 0.05

**P $<$ or $\simeq$ 0.01

that period. The correlation for the period of birth to weaning involved the average daily gain of the calf for this period and the average quantity of all 24-hour milk yields for the dam.

Within trials and treatments the correlations were variable. However, in most cases the correlations for the first period were higher than for subsequent periods. This is true in all cases when the correlations are pooled. That the relationship between milk yield and calf gain is higher earlier in the lactation period has been reported previously (Gifford, 1953; Howes et al., 1958; Furr, 1962; Velasco, 1962). This has been explained as resulting from less dependence of the calf on the dam's milk as the calf grows older and becomes better able to utilize forage. Also, errors in determining individual milk production would seem to be greater as the calf becomes older and larger, in view of the technique of weighing the calf before and after nursing. In the present study it was observed that urination and defication occurred more frequently among older calves following nursing. Any such error in accurately determining weight of the calf before and after nursing would tend to lower the correlation coefficients.

The pooled correlations for the entire birth to weaning period are higher than several reported in the literature. In the present study, the average yield of milk over the entire lactation accounted for approximately 50 to 67 percent of the variation in calf gain. Lampkin and Lampkin (1960) reported lower correlations of 0.67 and 0.56 for steer and heifer calves, respectively, for the same variables through 36 weeks of lactation. Knapp and Black (1941) found a similar correlation of 0.52 for gain of the calf and milk consumed prior to weaning. Furr (1962), however, reported values ranging from 0.75 to 0.91 for six groups of fall-calving cows, which agree with those in the present study. The possibility exists that the present correlations are biased as a result of differences in stage of lactation both between and within treatment groups.

In most cases, correlations between gain and milk consumption were higher for the birth to weaning period than for any of the individual monthly periods. This is not too surprising when one considers the decrease in error of determining calf gain over a longer period of time and also the increase in accuracy of determining milk yield from an average of several observations. Both of these factors should increase the accuracy of the measurements and thus, result in higher correlations if the relationship is a real one.

Since several measures of cow size were available, it was of interest to determine the relationship between these various measures and milk yield of the cows. Mature size of the cows was estimated by the measurements and weights taken at 4.5 years of age for Trial II and 5.5 years of age for Trial I. Also, the relationship between birth weight of the calf and subsequent milk yield of the cow was of interest since it has been speculated that larger calves at birth might induce greater milk yields as a result of more vigorous nursing and greater consumption. A positive correlation, however, does not preclude the possibility that other factors common to both birth weight and milk yield might result in a relationship between these two factors, e.g. hormonal relationships. In addition, the relationship between winter and summer gains and milk yield was of interest.

The correlation coefficients between the above mentioned variables and average milk production are shown in Table XIII on a within-treatment basis. The relationship between birth weight of the calves and subsequent

TABLE XIII

CORRELATIONS BETWEEN AVERAGE DAILY MILK YIELD OVER ENTIRE LACTATION AND VARIOUS COW AND CALF TRAITS

	Correlation Coefficient Between Average Milk Yield and:									
	Birth Wt. of Calf	Winter Wt. Loss of Cow[1]	Summer Wt. Gain of Cow[2]	Mature Wt. of Cow[3]	Mat. Wither Height of Cow	Mat. Body Length of Cow	Mat. Hip Width of Cow	Mat. Body Depth of Cow	Mat. Heart Girth of Cow	d.f.[4]
2nd Calf Crop, Trial II										
Low	-0.50	0.19	-0.71	-0.45	-0.66	-0.67*	-0.34	-0.13	-0.18	7
Mod.	-0.16	-0.16	-0.71**	-0.30	0.09	0.20	-0.29	-0.03	-0.29	10
High	0.18	0.28	-0.18	-0.17	-0.31	-0.19	-0.46	-0.60*	-0.22	10
V.High	-0.10	0.20	-0.08	-0.26	0.20	-0.19	-0.30	-0.04	-0.13	10
Pooled[5]	-0.08	0.12	-0.38**	-0.38*	0.00	-0.12	-0.32*	-0.15	-0.19	37
3rd Calf Crop, Trial I										
Low	0.10	0.30	-0.39	-0.73**	-0.60*	-0.55	-0.73**	-0.76**	-0.68**	10
Mod.	0.34	0.04	-0.11	-0.50	0.04	-0.38	-0.53	-0.29	-0.52	12
High	0.43	0.09	-0.38	-0.24	-0.26	0.15	-0.10	-0.51	-0.04	12
V.High	0.21	-0.44	-0.44	-0.37	-0.30	0.11	-0.30	-0.32	-0.56*	12
Pooled	0.32*	-0.14	-0.31*	-0.40**	-0.13	-0.14	-0.36*	-0.45**	-0.38**	46

TABLE XIII---CONTINUED

	Correlation Coefficient Between Average Milk Yield and:									
	Birth Wt. of Calf	Winter Wt. Loss of Cow[1]	Summer Wt. Gain of Cow[2]	Mature Wt. of Cow[3]	Mat. Wither Height of Cow	Mat. Body Length of Cow	Mat. Hip Width of Cow	Mat. Body Depth of Cow	Mat. Heart Girth of Cow	d.f.[4]
3rd Calf Crop, Trial II										
Low	-0.10	0.13	-0.83**	-0.47	-0.52	-0.29	-0.22	-0.44	-0.44	8
Mod.	-0.33	-0.18	0.08	-0.36	-0.20	0.15	-0.60	-0.38	-0.38	10
High	0.51	0.57	-0.62*	-0.43	-0.64	-0.54	-0.50	-0.86**	-0.54	9
V.High	0.37	-0.06	0.04	-0.32	0.20	-0.40	-0.23	-0.28	-0.26	12
Pooled	0.08	0.12	-0.25	-0.38*	-0.14	-0.30*	-0.40*	-0.47**	-0.36*	39
Over-All Pooled[6]	0.12	0.01	-0.30**	-0.39**	-0.10	-0.18*	-0.36**	-0.35**	-0.31**	121

[1]Weight loss from early November to mid-April preceding the particular calf crop.

[2]Weight gain from mid-April to early November while nursing the particular calf crop.

[3]All mature weights and measurements were taken in November at 5.5 years of age for Trial I and 4.5 years of age for Trial II.

[4]Degrees of freedom are approximate, since all measurements were not available for each cow.

[5]Pooled on a within-feed level basis.

[6]Pooled on a within-feed level, within-calf crop and trial basis.

*P < .05

**P < .01

milk yield of their dams was inconsistent between trials and calf crops. Within each calf crop the correlation was highest for the High group of cows which might indicate that when sufficient nutrients are available for maximum milk production, there is a positive relationship between these two variables. Owen (1957) found significant correlations in birth weight and subsequent milk yield in sheep ranging from 0.25 to 0.34. Gifford (1953) found evidence that maximum milk production of beef cows is affected by the capacity of the young calves to consume the milk.

Winter weight loss previous to estimation of milk production seemed to have little overall relationship to subsequent milk production. This is not surprising since winter weight gains were highly variable within treatment groups due to variability in calving date. On the other hand, summer weight gain of the cows during the lactation period was consistently negatively correlated with milk yield. This might indicate that heavier milking cows were putting more nutrients into the production of milk and less into fat deposition.

The results of the correlations between body size and milk production are quite surprising. Mature body weight was negatively correlated with milk yield in every case and was the highest relationship found. This is in contrast to a positive relationship of 0.74 reported by Burris and Baugus (1955) between total milk production for one lactation and body weight of mature Hampshire ewes.

Other measurements negatively correlated with milk yield to nearly the same degree were width of hips, body depth and heart girth circumference. Wither height at maturity, while negatively correlated with milk yield, was much lower in its relationship, as was true of length of body. It would appear that measurements affected largely by fatness of the cow were more negatively associated with milk production than measurements which give a more accurate indication of skeletal size, i.e. wither height. One would logically assume that larger cows within a breed or herd should have the ability to yield more milk, but the data does not confirm this. To explain these results, one must assume that better milking cows are also thinner cows, and are smaller, in terms of the measurements taken in this study, especially those influenced greatly by fatness of the cow. Under field conditions it is not uncommon to observe a large calf nursing a thin, light-weight dam. If this relationship is true, selection for greater weaning weight and indirectly for milk production, on the basis of cow weight or size may prove disappointing.

The fact that a significant correlation coefficient exists does not prove a cause and effect relationship, i.e. do larger cows give less milk because they are large, or are they larger as a result of their lower milk yield?

Pinney (1962) reported that the lifespan of cows in a long-term Oklahoma study was inversely related to winter feed level, with about one year difference in productive lifespan occurring between each of the Low, Medium and High feeding regimes after 13.5 years on test. Thus, it is of interest to examine the effect of feed level on number of cows remaining on test in the present study. In the fall of 1962 at 5.5 and 4.5 years of age for Trial I and II cows, there were a total of 27, 29, 24 and 26 cows remaining in the Low, Moderate, High and Very High treatment groups, respectively, of the original 30 females in each group. While the length of time on test was not sufficient to draw any conclusions in regard to long-term effects, it is noteworthy that fewer cows were remaining on the two higher nutritional regimes. Of interest is the fact that four of the six cows leaving the High level treatment groups were culled for failure to wean a calf in 2 successive years. Despite the fact that nearly twice as many open cows occurred in the Low level groups during the course of this study, only one cow was removed for failure to wean a calf for 2 successive years. Open cows in the High groups tended to be open in successive winters; the converse being true in the case of the Lows. Perhaps the degree of fatness attained by open cows on the High level regime had an adverse effect on subsequent fertility.

Two cows in the High level groups died of unknown cause. Of the four cows removed from the Very High regime, two were lost as a result of calving difficulty at first calving, one foundered as a yearling and one was open for 2 successive years. The only Moderate regime heifer leaving test died of an infected uterus at 2 years of age. In the Low level group three females were removed from test; one for failure to calve for 2 successive years, one as a result of impaction of the abomasum early in the test and another for an extremely unthrifty condition at 3 years of age.

SUMMARY

Studies were initiated in 1957 and 1958 involving a total of 120 Hereford calves to determine the effects of widely differing winter feed levels on growth and productivity of beef females. Results through the third and fourth calf crops are reported. Winter supplemental feed was adjusted at frequent intervals each winter to achieve predetermined weight changes for the Low, Moderate and High treatments. A Very High group was full-fed a fattening ration each winter; in Trial I this group was reverted to the Moderate level after three winters. Heifers were pasture-mated to purebred Hereford bulls from May to mid-August and calved first as 2-year-olds; their calves were weaned in early October of each year.

The average weight gains for the Low, Moderate, High and Very High groups, respectively, were: -12, 96, 144 and 272 lb. for the first winter; and -238, -128, -82 and 162 lb. for the second winter; and -203, -92, -62 and 106 lb. for the third winter followed by similar patterns in subsequent winters. Drastic winter weight losses occurred in the Very High group of cows in Trial I when they were reverted to the Moderate level for the fourth winter.

Body weights and linear size measurements of the cows were directly related to winter feed level at all times, but differences between treatments became smaller with increasing age. Apparently these differences were largely the result of differences in fatness of the cows wintered at

the different levels; the Moderate level appeared to result in maximal skeletal development to 4.5 and 5.5 years of age.

From Low to High treatments, there was a direct relationship between winter feed level and calving date, birth weight, weaning weight, average daily gain and conformation grade of the calves. The Low level regime significantly reduced these measures of productivity in nearly every case, with little difference occurring between the Moderate and High treatments. The Very High regime resulted in earlier calving, similar to that observed with the High regime, but depressed birth and weaning weights, calf gains and milk production to a level no higher than the Moderate regime in most cases.

The Low winter feed level reduced calf crop percentage because of an increased number of open cows; the Very High regime also resulted in a decreased percentage of calf crop weaned as a result of difficult calving at first parturition. All measures of productivity were noticeably less affected by winter feed level as the cows advanced in age. For the fourth calf crop, only slight differences were observed between winter feed regimes for any of the measures of productivity. When the Very High cows in Trial I were reverted to the Moderate level after 3.5 years of age, little effect on productivity was noted despite severe winter weight losses.

Milk production was directly related to amount of winter supplement received by the cows, with the exception that the Very High regime drastically reduced milk flow as compared to the High level. The gains of the calves were correlated with quantity of milk produced by their dams to a greater extent during early lactation; correlation coefficients for the total period from birth to weaning ranged from 0.71 to 0.82 when pooled on a within-treatment basis. Surprisingly, mature body size of the cows, as determined by weight and linear measurements, was consistently correlated in a negative direction with their milk yield. In absolute value, the correlation coefficient was higher for traits easily influenced by fatness of the cows.

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APPENDIX

TABLE XIV

PROBABILITY VALUES OBTAINED FOR F RATIOS OF VARIOUS ORTHOGONAL TREATMENT CONTRASTS

Trait	Trial	Low vs. Mod.,High & V.High	Mod. vs. High & V.High	High vs. V.High
Av. Calving Date				
1st Calf Crop	I	<.005	<.025	>.250
	II	<.250	---	---
2nd Calf Crop	I	<.005	<.250	---
	II	<.005	<.250	---
3rd Calf Crop	I	<.025	---	---
	II	<.050	---	---
4th Calf Crop	I	<.100	<.250	---
Av. Birth Wt.				
1st Calf Crop	I	<.005	---	<.250
	II	<.005	<.100	---
2nd Calf Crop	I	<.025	---	---
	II	<.025	---	---
3rd Calf Crop	I	<.050	---	---
	II	>.050	>.100	<.025
4th Calf Crop	I	---	---	<.250
Av. Corr. Wean Wt.[1]				
1st Calf Crop	I	<.005	---	---
	II	<.005	---	<.250
2nd Calf Crop	I	<.100	---	---
	II	<.005	---	<.050
3rd Calf Crop	I	<.250	---	<.250
	II	>.100	---	<.250
4th Calf Crop	I	---	---	<.250
Av. Uncorr. Wean. Wt.[2]				
1st Calf Crop	I	<.005	<.250	---
	II	<.005	---	>.050
2nd Calf Crop	I	<.005	---	>.250
	II	<.005	<.250	<.025
3rd Calf Crop	I	<.005	---	<.250
	II	<.025	---	---
4th Calf Crop	I	---	---	>.250
Av. Daily Gain of Calves Birth to Weaning				
1st Calf Crop	I	<.025	---	---
	II	<.005	---	---
2nd Calf Crop	I	---	---	---
	II	<.005	---	<.100
3rd Calf Crop	I	---	---	<.250
	II	<.250	---	<.250
4th Calf Crop	I	---	---	---

TABLE XIV---CONTINUED

Trait	Trial	Low vs. Mod.,High & V.High	Mod. vs. High & V.High	High vs. V.High
Av. Wean. Grade[3]				
1st Calf Crop	I	<.100	---	---
	II	<.005	---	---
2nd Calf Crop	I	→.050	---	---
	II	<.005	---	---
3rd Calf Crop	I	<.250	---	---
	II	<.050	---	---
4th Calf Crop	I	---	---	→.100
Av. Milk Yield of Cows				
2nd Calf Crop	II	<.100	---	<.005
3rd Calf Crop	I	---	---	---
	II	<.005	---	→.050
Cow Body Wt., 4½ Yrs.	I	---	---	<.250
	II	→.010	<.010	<.005
Cow Body Wt., 5½ Yrs.	I	<.050	---	<.100
Cow Body Msmts., 4½ Yrs.				
Ht. of Withers	I	<.100	---	---
Length of Body	I	---	---	---
Heart Girth	I	<.100	---	---
Depth of Chest	I	---	---	---
Width of Loin	I	<.250	---	<.250
Width of Hips	I	<.250	---	---
Width of Pins	I	---	---	---
Ht. of Withers	II	---	<.250	---
Length of Body	II	<.250	---	---
Heart Girth	II	<.005	<.005	<.005
Depth of Chest	II	<.250	---	---
Width of Loin	II	<.005	<.010	<.005
Width of Hips	II	<.005	---	<.005
Width of Pins	II	---	---	---
Cow Body Msmts., 5½ Yrs.				
Ht. of Withers	I	<.250	---	---
Length of Body	I	<.250	---	---
Heart Girth	I	<.005	---	<.250
Depth of Chest	I	<.250	---	---
Width of Loin	I	<.100	---	---
Width of Hips	I	<.050	---	---
Width of Pins	I	<.050	---	---

[1]Weaning weights were corrected to a 210-day steer equivalent using the methods of Botkin (1952).

[2]Corrected only for sex, to a steer equivalent.

[3]Conformation score: 8=average good, 10=low choice and 11=average choice.

TABLE XV

AVERAGE HEIGHT OF WITHERS (INCHES) AND STANDARD ERRORS OF HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

Trial Number	Level of Wintering	Age in Years and Season of Year[1] ½(F)	1(S)	1½(F)	2(S)	2½(F)	3(S)
I	Low	37.33±.25	41.13±.26	43.77±.33	43.83±.26	45.00±.19	45.23±.19
	Mod.	37.70±.24	41.43±.28	43.93±.22	44.80±.21	45.71±.20	45.70±.23
	High	37.57±.30	41.57±.21	44.21±.36	45.04±.37	46.18±.42	46.07±.37
	V. High-Mod.[2]	37.87±.29	42.33±.31	44.33±.35	46.00±.33	46.87±.43	47.23±.41
II	Low	39.17±.24	41.07±.34	43.54±.26	44.18±.30	45.68±.41	45.25±.41
	Mod.	39.29±.27	41.87±.27	43.90±.32	44.83±.31	46.11±.39	45.39±.44
	High	39.70±.27	42.63±.26	44.63±.23	45.87±.34	46.73±.34	46.58±.29
	Very High	38.87±.39	42.70±.33	44.80±.39	46.35±.46	47.19±.39	46.62±.39

Trial Number	Level of Wintering	Age in Years and Season of Year 3½(F)	4(S)	4½(F)	5(S)	5½(F)
I	Low	46.63±.45	45.80±.33	46.37±.28		45.53±.30
	Mod.	47.10±.21	46.93±.29	46.67±.22		46.00±.21
	High	47.61±.38	47.00±.36	47.11±.27		46.31±.33
	V. High-Mod.	47.89±.34	46.86±.38	47.00±.37		46.04±.31
II	Low	46.38±.45		46.14±.28		
	Mod.	46.29±.29		46.04±.25		
	High	46.62±.33		46.86±.29		
	Very High	47.04±.35		46.73±.45		

[1] S denotes spring and F denotes fall measurement.

[2] The Very-High group in Trial I was reverted to the Moderate level for the fourth and subsequent winters.

TABLE XVI

AVERAGE LENGTH OF BODY (INCHES) AND STANDARD ERRORS OF HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

Trial Number	Level of Wintering	Age in Years and Season of Year[1]										
		½(F)	1(S)	1½(F)	2(S)	2½(F)	3(S)	3½(F)	4(S)	4½(F)	5(S)	5½(F)
I	Low	43.17±.49	42.77±.44	50.93±.31	49.27±.39	51.60±.32	50.20±.63	53.60±.60	52.73±.48	53.87±.53		55.80±.50
	Mod.	42.93±.57	44.63±.64	50.93±.47	50.93±.34	52.57±.56	52.53±.57	53.97±.43	53.60±.30	54.70±.42		56.97±.48
	High	43.14±.47	46.07±.35	51.29±.48	51.68±.41	53.61±.65	54.00±.42	56.18±.53	54.39±.62	54.79±.42		56.46±.45
	V. High-Mod.[2]	43.63±.49	47.73±.44	52.10±.32	54.63±.55	56.30±.77	55.77±.75	56.36±.45	53.96±.45	54.11±.62		56.46±.62
II	Low	43.00±.36	45.75±.41	49.00±.41	48.14±.55	52.32±.68	50.46±.64	54.27±.93		55.59±.71		
	Mod.	43.79±.43	47.50±.32	50.20±.42	51.00±.58	52.93±.31	52.25±.50	55.82±.43		56.73±.63		
	High	44.40±.31	48.90±.35	50.57±.51	52.30±.60	54.30±.73	53.88±.66	56.42±.42		57.18±.50		
	Very High	43.80±.49	49.00±.55	50.87±.46	55.23±.85	53.73±.61	55.04±.84	57.62±.44		58.38±.45		

[1]S denotes spring and F denotes fall measurement.

[2]The Very High group in Trial I was reverted to the Moderate level for the fourth and subsequent winters.

TABLE XVII

AVERAGE CIRCUMFERENCE (INCHES) AND STANDARD ERRORS OF HEART GIRTH OF HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

Trial Number	Level of Wintering	Age in Years and Season of Year[1]					
		½(F)	1(S)	1½(F)	2(S)	2½(F)	3(S)
I	Low	52.67±.66	54.20±.67	66.03±.55	59.33±.42	67.12±.67	62.53±.48
	Mod.	53.53±.76	57.93±.75	68.53±.53	63.07±.60	69.77±.53	67.40±.46
	High	53.33±.73	59.00±.62	68.32±.53	65.07±.72	69.43±.64	69.07±.84
	V. High-Mod.[2]	53.20±.66	64.90±.62	69.13±.64	75.00±.75	74.60±.90	77.57±.89
II	Low	54.67±.39	53.14±.61	65.08±.47	58.96±.51	66.89±.74	64.08±.52
	Mod.	53.87±.58	56.60±.49	65.90±.50	62.93±.51	67.82±.81	67.08±.59
	High	54.53±.38	60.70±.26	68.07±.31	66.97±.53	70.97±.75	68.69±.96
	Very High	54.63±.56	65.70±.59	68.87±.50	74.50±1.08	72.50±.94	75.46±1.12

Trial Number	Level of Wintering	Age in Years and Season of Year				
		3½(F)	4(S)	4½(F)	5(S)	5½(F)
I	Low	69.07±.84	66.13±.55	72.42±1.33		70.23±.62
	Mod.	71.37±.63	68.93±.52	74.88±.64		74.00±.57
	High	72.14±.83	70.82±.88	74.52±.82		74.54±.82
	V. High-Mod.	75.07±.72	68.89±.71	73.14±.68		73.00±.84
II	Low	70.90±.99		70.25±.95		
	Mod.	72.59±.55		73.57±.81		
	High	73.46±.57		74.64±.62		
	Very High	77.02±.67		79.85±.91		

[1]S denotes spring and F denotes fall measurement.

[2]The Very High group in Trial I was reverted to the Moderate level for the fourth and subsequent winters.

TABLE XVIII

AVERAGE DEPTH OF CHEST (INCHES) AND STANDARD ERRORS OF HEIFERS
RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

Trial Number	Level of Wintering	Age in Years and Season of Year[1]					
		½(F)	1(S)	1½(F)	2(S)	2½(F)	3(S)
I	Low	20.03±.23	19.77±.20	23.30±.22	22.17±.21	23.93±.29	23.60±.11
	Mod.	20.20±.16	20.67±.24	23.43±.20	22.60±.18	24.93±.20	24.57±.20
	High	20.39±.27	21.04±.18	23.68±.24	23.07±.28	25.11±.29	24.82±.25
	V. High-Mod.[2]	20.53±.17	22.60±.21	23.83±.21	25.50±.21	26.37±.27	27.67±.30
II	Low	20.37±.13	20.71±.14	23.43±.20	22.00±.21	24.71±.29	23.96±.20
	Mod.	20.46±.15	21.57±.19	23.73±.17	23.13±.17	25.18±.31	24.50±.24
	High	20.53±.19	21.87±.15	24.23±.13	24.00±.22	25.77±.30	25.50±.15
	Very High	20.50±.21	23.07±.25	24.67±.19	26.08±.38	26.27±.30	26.69±.32

Trial Number	Level of Wintering	Age in Years and Season of Year				
		3½(F)	4(S)	4½(F)	5(S)	5½(F)
I	Low	25.70±.27	24.67±.19	25.27±.32		25.17±.23
	Mod.	26.57±.19	25.73±.18	25.30±.19		25.83±.23
	High	26.68±.27	25.86±.24	25.36±.22		25.92±.25
	V. High-Mod.	27.25±.28	25.25±.29	25.11±.25		25.38±.22
I	Low	24.08±.38		25.05±.28		
	Mod.	24.39±.19		25.73±.33		
	High	24.65±.21		26.23±.25		
	Very High	25.58±.32		26.54±.28		

[1]S denotes spring and F denotes fall measurement.

[2]The Very High group in Trial I was reverted to the Moderate level for the fourth and subsequent winters.

TABLE IXX

AVERAGE WIDTH OF LOIN (INCHES) AND STANDARD ERRORS OF HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

Trial Number	Level of Wintering	Age in Years and Season of Year[1]					
		½(F)	1(S)	1½(F)	2(S)	2½(F)	3(S)
I	Low	8.25±.15	8.47±.15	11.23±.14	10.93±.10	11.40±.15	11.35±.15
	Mod.	8.27±.15	8.97±.20	11.45±.18	11.17±.23	12.53±.15	12.50±.19
	High	8.08±.11	9.14±.13	11.46±.13	11.45±.26	12.39±.17	12.82±.21
	V. High-Mod.[2]	8.02±.15	10.82±.15	11.80±.20	13.88±.27	14.32±.23	16.12±.31
II	Low	7.73±.12	8.95±.24	11.19±.14	10.09±.17	13.21±.29	10.81±.19
	Mod.	8.20±.11	9.93±.21	12.07±.17	11.28±.19	13.82±.34	12.62±.23
	High	8.45±.10	10.60±.14	12.68±.15	12.07±.18	14.53±.22	12.36±.19
	Very High	8.18±.12	12.07±.25	12.77±.14	14.08±.31	14.83±.26	14.65±.28

Trial Number	Level of Wintering	Age in Years and Season of Year				
		3½(F)	4(S)	4½(F)	5(S)	5½(F)
I	Low	14.32±.31	11.80±.25	12.85±.30		12.54±.17
	Mod.	14.77±.25	13.08±.23	13.33±.33		12.97±.24
	High	14.68±.27	12.84±.23	13.62±.32		13.21±.33
	V. High-Mod.	15.36±.24	13.02±.23	13.12±.24		13.06±.22
II	Low	12.25±.43		12.44±.32		
	Mod.	13.04±.15		13.21±.19		
	High	12.90±.22		13.39±.20		
	Very High	14.19±.25		14.71±.21		

[1]S denotes spring and F denotes fall measurement.

[2]The Very High group in Trial I was reverted to the Moderate level for the fourth and subsequent winters.

TABLE XX

AVERAGE WIDTH OF HIPS (INCHES) AND STANDARD ERRORS OF HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

Trial Number	Level of Wintering	Age in Years and Season of Year[1]					
		½(F)	1(S)	1½(F)	2(S)	2½(F)	3(S)
I	Low	13.43±.19	13.98±.19	17.89±.19	16.85±.17	19.03±.19	18.20±.20
	Mod.	13.40±.19	14.92±.24	18.13±.18	17.48±.36	19.97±.20	19.40±.28
	High	13.43±.19	15.16±.20	18.12±.19	18.05±.23	20.00±.27	19.93±.30
	V. High-Mod.[2]	13.27±.21	16.63±.21	18.60±.14	20.58±.22	21.63±.34	23.01±.33
II	Low	13.42±.14	13.88±.17	17.87±.13	16.39±.22	18.93±.22	18.31±.23
	Mod.	13.57±.15	15.00±.20	18.37±.22	17.83±.19	19.80±.31	19.67±.18
	High	13.27±.13	15.67±.13	18.58±.13	18.65±.19	20.15±.27	19.92±.46
	Very High	13.57±.16	16.62±.18	19.03±.19	21.12±.31	20.86±.32	22.00±.26

Trial Number	Level of Wintering	Age in Years and Season of Year				
		3½(F)	4(S)	4½(F)	5(S)	5½(F)
I	Low	19.75±.42	19.47±.21	20.97±.30		20.98±.20
	Mod.	21.12±.26	20.50±.22	21.53±.30		21.73±.28
	High	21.34±.32	20.82±.31	21.57±.32		21.75±.33
	V. High-Mod.	21.91±.27	20.41±.20	21.32±.29		21.46±.29
II	Low	20.02±.35		20.69±.29		
	Mod.	20.88±.22		21.69±.31		
	High	20.81±.23		21.45±.30		
	Very High	21.96±.25		22.75±.24		

[1] S denotes spring and F denotes fall measurement.

[2] The Very High group in Trial I was reverted to the Moderate level for the fourth and subsequent winters.

TABLE XXI

AVERAGE WIDTH OF PIN BONES (INCHES) AND STANDARD ERRORS OF HEIFERS RECEIVING DIFFERENT LEVELS OF SUPPLEMENT

Trial Number	Level of Wintering	Age in Years and Season of Year[1]					
		½(F)	1(S)	1½(F)	2(S)	2½(F)	3(S)
I	Low	8.02±.13	8.57±.19	10.80±.14	9.47±.14	12.03±.28	10.80±.17
	Mod.	8.05±.12	9.17±.17	11.00±.09	10.62±.12	11.83±.15	12.07±.22
	High	7.88±.08	9.57±.14	11.25±.12	10.73±.14	11.84±.24	12.64±.31
	V. High-Mod.[2]	8.05±.15	10.05±.15	11.32±.12	12.27±.18	12.70±.23	14.25±.33
II	Low	8.03±.17	8.36±.16	11.08±.18	10.20±.22	11.27±.22	10.46±.21
	Mod.	8.30±.11	9.35±.10	11.57±.15	11.60±.16	11.84±.28	11.69±.18
	High	8.23±.12	10.23±.09	12.00±.15	12.12±.15	12.45±.31	11.42±.14
	Very High	8.37±.12	10.50±.13	11.92±.17	12.56±.26	12.42±.23	12.42±.22

Trial Number	Level of Wintering	Age in Years and Season of Year				
		3½(F)	4(S)	4½(F)	5(S)	5½(F)
I	Low	11.93±.33	11.08±.19	12.32±.25		12.29±.18
	Mod.	12.68±.23	11.87±.14	12.53±.13		12.78±.15
	High	12.64±.24	12.32±.21	12.55±.25		12.77±.22
	V. High-Mod.	12.98±.22	11.93±.16	12.57±.19		12.63±.19
II	Low	11.42±.30		12.38±.26		
	Mod.	12.36±.15		12.59±.15		
	High	12.25±.18		12.66±.19		
	Very High	13.04±.19		12.77±.17		

[1]S denotes spring and F denotes fall measurement.

[2]The Very High group in Trial I was reverted to the Moderate level for the fourth and subsequent winters.

VITA

Don Ovid Pinney

Candidate for the Degree of

Doctor of Philosophy

Thesis: EFFECT OF EXTREMES IN WINTER NUTRITION ON GROWTH AND REPRODUCTIVE PERFORMANCE OF BEEF FEMALES

Major Field: Animal Nutrition

Biographical:

Personal Data: Born in Monmouth, Illinois, September 12, 1937, the son of Merlyn O. and Violet M. Pinney.

Education: Received the Bachelor of Science degree from the University of Illinois, with a major in Animal Science in May, 1959. Entered the Graduate School of Oklahoma State University of Agriculture and Applied Science in June, 1959, and completed requirements for the Master of Science degree in May, 1962.

Experience: Raised on a farm in western Illinois; Graduate Assistant in Animal Husbandry at Oklahoma State University, 1959-1963.

Date of Final Examination: July, 1963.