THE REPRODUCTIVE PERFORMANCE OF HEREFORD HEIFERS ON DIFFERENT LEVELS OF WINTER FEEDING AND SUMMER GRAZING

By

JAMES MARVIN DUGGER

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1949

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

THE REPRODUCTIVE PERFORMANCE OF HEREFORD HEIFERS ON DIFFERENT LEVELS OF WINTER FEEDING AND SUMMER GRAZING

Thesis Approved:

E. J. Turman
Thesis Adviser

Joe Whiteman

D. L. Wagner

D. Durham
Dean of the Graduate College

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. E. J. Turman, Professor of Animal Science, for his patient guidance and counsel during the course of this study and in the preparation of this thesis.

Appreciation is also extended to Dr. J. V. Whiteman, Professor of Animal Science, and Dr. D. G. Wagner, Associate Professor of Animal Science, for their suggestions and assistance in the preparation of this thesis.

Acknowledgement is extended to Dr. L. S. Pope, former Department Head and Professor of Animal Science, for his suggestions and assistance in the early stages of this course of study.

A special thanks goes to the author's wife, Ninah, and son, Richard, for their encouragement and understanding during the course of this study and an extra special thanks to the author's daughter, Judith, for typing the rough drafts of this manuscript.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The practice of calving commercial beef heifers at two years of age creates several management problems in the handling of heifers from the time they are weaned until they are safe in calf. If heifers are to calve as two year olds, they must have reached puberty by the time they are 15 months of age. Studies have shown that several factors can influence the age when puberty is reached, with the single most important factor being the nutritional level the heifers receive from weaning until reaching puberty. This is especially true of spring heifers weaned in the fall and expected to reach puberty near the end of the winter feeding period.

Studies at the Oklahoma Station have shown that mature cows can be carried through the winter on levels of supplemental feed that are lower than ordinarily recommended without drastically affecting their reproductive performance. In fact, such levels may increase the lifetime percentage of calf crop weaned and usually increases the lifespan of the cow. The effect of such levels imposed on heifers during their period of growth and development is usually more adverse than is observed with cows that have reached maturity. However, relatively little information is available on the most economical level of winter feeding that will enable heifers to reach puberty by the time they are 15 months old.

Many ranchers winter at a low level with the expectation that summer

gains will be large enough to offset the effects of this low wintering level. This poses the question of what would be the effect on reproductive performance if summer gains are lower than normally expected due to drought or other adverse conditions.

The trials reported in this thesis were initiated to determine the effects of four levels of winter feeding and two levels of summer grazing concerning the occurrence of first estrus and breeding performance of 105 yearling beef heifers.

CHAPTER II

REVIEW OF LITERATURE

Literature pertaining to the effects of plane of nutrition on beef females has previously been reviewed by Thomas (1952), Shroder (1954), Zimmerman (1958), Zimmerman (1960), Pinney (1963), and Smithson (1963). This review will be concerned primarily with studies affecting heifers from weaning through first parturition.

Work at the Fort Reno Livestock Research Station

Research was initiated at the Fort Reno Livestock Research Station in 1949 on the effects of different levels of supplemental winter feed for beef cows running on dry native grass pasture. The wintering levels used in the initial study from 1949 to 1955 were defined in terms of daily allowances of supplemental concentrates as follows:

Low level - 1 lb. of cottonseed cake.

Medium level - 2.5 lb. of cottonseed cake.

High level - 2.5 lb. of cottonseed cake plus 3 lb. of whole oats.

In 1955, and in all subsequent trials at Fort Reno, the winter feed levels were defined in terms of the amount of supplemental feed needed to obtain rates of gain from November to mid April as follows:

Low level - no gain during the winter period.

Moderate level - 0.5 lb. gain per day.

High level - 1.0 lb. gain per day.

Zimmerman (1960) summarizing 5 years study of weaner heifers wintered on the above levels, reported that the low, medium, and high levels produced gains of 8, 90, and 155 pounds, respectively. The summer weight gains of these heifers were inversely proportional to winter gains with the low level group gaining 296 lb., the medium level group 264 lb., and the high level group 234 lb. The reproductive performance of these heifers, as measured by dates of first calving, showed the group wintered at the high level calved 10 days earlier than those wintered on the medium level and 17 days earlier than the low level group. The average birth weights corrected to bull equivalent for calves born to these heifers were 66.2 lb., 72.1 lb., and 74.6 lb. for calves from the high level group.

Pinney (1963), reported that the average daily feed intake per heifer that was required to obtain the desired weight changes was:

Low level - 0.25 lb. of cottonseed meal

Medium level - 1.58 lb. of cottonseed meal and 0.69 lb. of milo

High level - 2.26 lb. of cottonseed meal and 4.28 lb. of milo

He also reported that heifers wintered at the high level calved 11 days earlier than those wintered at the medium level and 19 days earlier than heifers wintered at the low level.

Pinney (1963) reported on the birth weights obtained on two trials from heifers wintered at the three levels. In trial I, the average birth weights of calves from the low, medium and high level heifers were 61.7, 70.8 and 74.6 lb. respectively. In trial II, the birth weights of the calves from the low, medium and high level heifers were 56.2, 75.7 and 70.0 lb., respectively.

Turman et al. (1964) reported a study involving the same wintering

levels as those used by Pinney, (1963). He found that a low level of nutrition for heifers up to two years of age was invariably associated with:

(a) delayed breeding of yearling heifers

(b) lighter weaning weights of calves, and

(c) a larger incidence of open heifers at both ages

In addition, he reported that heifers fed at the high level prior to calving dropped calves which averaged 14 lb. heavier at birth than did the low level heifers (76 lb. vs 62.5 lb.). The average date of re-breeding of lactating 2-year old heifers was 16 days earlier for the heifers carried on the high level the preceding winter.

Turman et al. (1968) investigated the age and weight at puberty of some Angus and Angus-Hereford crossbred heifers. Seventy four Angus heifers were self-fed a 60 percent concentrate ration starting one week after weaning. These heifers gained 2 lb. per day after weaning and reached puberty at an average of 267 days of age and 514 lb. in weight. Twenty six Angus and 27 crossbred heifers were maintained on native grass pastures receiving 1 1/2 lb. of cottonseed meal per head per day, plus ground milo as needed to obtain approximately 0.5 lb. per day per herd gain. The Angus heifers reached puberty at an average age of 375 days and a weight of 474 lb., and the 27 Angus-Hereford crossbred heifers reached puberty at an average of 383 days of age and weight of 459 lb. In this study, the occurrence of estrus was determined by use of vasectomized bulls running with the heifers.

Work at Other Stations

Joubert (1954) working in the Union of South Africa, studied supple-

mental feeding vs no supplement during the winter months with a limited number of heifers of both dairy and beef breeds. The development of the low plane unsupplemented heifers was significantly retarded. Puberty was delayed 221 days in the low nutritional group. Heifers on the unsupplemented group did not reach puberty until 641 days of age, compared to the supplemented group which reached puberty at 420 days. The low plane heifers made greater increases in growth and weight during the following summer than did the heifers receiving the winter supplement. The calves from the low plane heifers were 7.5 lb. lighter at birth than those from the supplemented group. The average age at first calving was 32 months of age. The inter-calving period was 14.4 months from the high plane heifers and 18.4 months for the low plane heifers.

Joubert (1954) in a further study on the effects of high and low nutritional planes, used 28 heifers, half of which received winter supplement with the other half being carried on natural grazing. Out of a total of 239 heat observations made over a 10 month period, 161 were in the high plane group and only 78 in the low plane group. Of the low plane heifers which eventually cycled, 85.7% had been in an anestrus condition for as long as 218 days during the winter and did not show estrus until after summer grazing started. However, the number of services required per conception was lower in the low plane heifers that did cycle indicating the low nutritional plane caused no detrimental effect on fertility.

Warnich et al. (1956) divided 20 yearling heifers into four groups and individually fed 4 levels of protein for 140 days. Levels fed were:

Group 1 - NRC recommended level
Group 2 - 64% NRC recommended level
Group 3 - 31% NRC recommended level
Group 4 - 10% NRC recommended level

One half of the heifers had exhibited estrus before the experiment began. Heifers in groups 1 and 2 gained an average of 136 lb. and 111 lb., respectively, during the 140 days while the heifers of groups 3 and 4 lost an average of 4 lb. and 100 lb., respectively. All of the heifers in groups 1 and 2 were observed in estrus during the trial compared to 3 heifers in group 3 and none in group 4. The ovaries of the anestrous heifers had no luteal tissue and no follicles were larger than 10 mm in diameter.

Wiltbank et al. (1957) working at Fort Robinson, Nebraska, studied the effect of different combinations of energy and protein on the occurrence of estrus in open heifers. They divided 54 Angus heifers averaging 391 lb. into 9 lots with three lots (I, II, III) being full fed, 3 lots (IV, V, VI) receiving approximately 2/3 the amount of the full fed lots and the remaining 3 lots (VII, VIII, IX) fed at a level to maintain weight. Within each energy level, one lot received 0.23 lb. digestible protein per cwt., (I, IV, VII), one lot received 0.15 lb. digestible protein per cwt., (II, V, VIII), and one lot 0.06 lb. digestible protein per cwt., (III, VI, IX). The rations were pelleted and the heifers on limited feed were fed individually.

The feed levels and average daily gain per lots for the 250 days were:

Lot No.	Level of Energy	Level of Dig. Protein	Average Daily Gain
I	Full feed	0.23 lb./cwt.	1.54 lb.
II	Full feed	0.15 lb./cwt.	1.38 lb.
III	Full feed	0.06 lb./cwt.	0.29 lb.
IV	2/3 full feed	0.23 lb./cwt.	0.77 lb.
V	2/3 full feed	0.15 lb./cwt.	0.92 lb.
VI	2/3 full feed	0.06 lb./cwt.	0.30 lb.
VII	Weight maintenance	0.23 lb./cwt.	0.04 lb.
VIII	Weight maintenance	0.15 lb./cwt.	0.15 lb.
IX	Weight maintenance	0.06 lb./cwt.	0.11 lb.

All heifers in the lots receiving at least a 2/3 full feed and 0.15 lb. of digestible protein per day showed estrus during the 250 days. In contrast, 67% of the heifers in lots receiving at least 2/3 full feed, but only 0.06 lb. of digestible protein per day showed estrus. Of the heifers on maintenance energy levels, only 50% of those receiving the highest level of digestible protein (lot VII) and 33% of those on the lowest level of digestible protein (lot IX) reached puberty. There was no ready explanation for the good performance of the heifers of lot VIII which was on maintenance energy level and 0.15 lb. digestible protein per cwt. and in which 83% reached puberty.

Low nutritional levels have also been shown to adversely affect estrus cycles once puberty has been attained. It requires a long exposure to low levels to cause cessation of cycling, but once they stop, a long period of good nutrition is necessary for them to be reestablished.

Bond *et al.* (1958) placed 6 heifers (group I) at an average weight of 671 lb. on a ration that supplied 3.26 lb. TDN and 0.94 lb. of digestible protein per day for a 42 day period during which the body weight was maintained. They were then reduced to 2.41 lb. TDN and 0.20 lb. digestible protein daily. Estrus had ceased in all heifers 136 days

later following a body weight loss of 131 lb. Three heifers (group II) were also placed on trial with an average body weight of 637 lb. and were fed 77 days on a daily ration containing 2.80 lb. TDN and 0.26 lb. of digestible protein during which time they lost an average of 66 lb. The ration was further decreased to 2.50 lb. TDN and 0.08 lb. digestible protein daily, and at the end of 130 days, a further loss of 108 lb. had occurred. All heifers in both groups were then fed 4.28 lb. TDN and 0.55 lb. digestible protein in concentrates, plus 1.47 lb. TDN and 0.09 lb. digestible protein in hay per day for 152 days. The heifers were then placed on pasture and given an additional 1.94 lb. TDN and 0.25 lb. digestible protein daily. The six heifers of group I needed an average of 228 days with a weight gain of 223 lb. to reestablish estrus while the three heifers of group II needed 179 days and a weight gain of 125 lb. to reestablish estrus.

Warnick (1959) studied the effect of a protein deficiency on reproduction in beef cattle in Florida using 20 heifers receiving equal amounts of energy but varying amounts of crude protein. Five heifers were in each of the four treatment groups receiving the following amounts of crude protein daily. Lot I, 1.06 lb., lot II, 0.65 lb., lot III, 0.28 lb., lot IV, 0.08 lb. The heifers in lot I required on the average 50 days to reach first heat. All heifers bred and had normal embryos when examined 44 days past breeding. The heifers in lot II has an average daily gain of 0.70 lb., also bred and had normal embryos on examination, but required an average of 76 days to reach first heat. The heifers on lot III gained 0.01 lb. per day with only 2 of the heifers showing estrus, none settled and no normal embryos were detected. The heifers in lot IV lost an average of 0.72 lb. per day and at the end of

162 days none had exhibited estrus and there were no normal embryos detected. The ovaries of this group of heifers were apparently inactive.

The daily rate of gain in heifers after weaning appears to be the critical factor in determining the age at which heifers reach puberty. Wiltbank et al. (1959) in studying the age and weight at which Hereford heifers at the Fort Robinson, Nebraska Research Station reached puberty used 125 heifers which had an average daily gain of 0.38 lb. from weaning until grass in the spring (May 1). Only 9% of the heifers reached puberty during this period. The average age at puberty was 434 days and the average weight was 562 lb.

The findings in the above study were confirmed by Arije and Wiltbank (1971), working in Nebraska, who used 298 Hereford heifers to check age and weight at puberty. The heifers ran on native grass and were fed 0.40 kg of 40% protein supplement during the winter. The average daily gain during the wintering period was 0.20 kg, however, when grass started to grow the gain increased to 0.80 kg per day. Sterile bulls were used to detect heat. Heifers did not reach puberty until they started to make faster weight gains after the slow winter growth. The average age at puberty was 436 days, with an average weight of 552 lbs. A high preweaning growth rate and heavy weights were associated with early puberty and a heavy weight at puberty.

Sorenson et al. (1959) studied the influence of underfeeding on Holstein heifers using feed levels based on a percentage of Morrisons TDN standards for heifers. The levels used were: low - 85%; moderate - 100%; and high - 140%. The average age at first estrus was 37.4 weeks for the high level group, 49.1 weeks for the medium group, and 72 weeks for the heifers carried at the low level. The project was terminated at

the end of 80 weeks with only 3 of the 20 low level heifers having shown estrus.

This work was confirmed by Reid et al. (1960), who used the same levels of feeding for Holstein heifers and found there was more than 300 days difference in age at first estrus between heifers on the low and high levels.

Kaltenback et al. (1962) studied the heterotic effects of crossbreeding on age and weight at puberty. He used 40 straightbred heifer calves of the Angus, Hereford, and Shorthorn breeds and 47 crossbreds of the same breeds. The heifers were carried on native pasture supplemented with 1 lb. of 41% protein. There was a significant difference ($P < .05$) of 58 days in ages at which the heifers attained puberty with the crossbreds having an average age of 373 days and the straightbreds being 431 days old at puberty. The crossbreds were also 27 lb. lighter (553 vs. 550) than the straightbreds. There were breed differences among straightbred heifers with average age and weights at puberty, respectively, being: Angus, 382 days and 524 lb., Herefords, 483 days and 615 lb., and Shorthorns, 427 days and 510 lb.

Reynolds et al. (1963) worked in Louisiana with a total of 209 Angus, Brahman, and Zebu cross heifers over a four year period. The average daily gain for the 209 heifers was 0.44 lb. from weaning to one year of age, and from weaning to 18 months the daily gain was 0.78 daily. The average age at puberty was: Angus - 443 days; Brahaman - 816 days; the first cross between these two breeds - 460 days; Brangus - 531 days; and Angus-Africander - 542 days. The weight at puberty of the heifers in the previous study was: Angus - 536 lb; Angus-Africander cross - 623 lb; Brangus - 639 lb; Angus-Brahman cross - 666 lb; and

Brahman - 706 lb. Thus, the results of this study suggests that a daily gain of 0.44 lb. following weaning is not adequate to permit heifers of Zebu breeding to reach puberty by 15 months of age so they may be bred to calve at two years of age.

Clanton et al. (1964) fed 56 Hereford heifers four treatments of varying protein and energy levels to determine effect on age at puberty. The high protein-high energy level was calculated to give one pound per day gain. The average ages at puberty for the four groups were: high protein-high energy, 384 days; high protein-low energy, 469 days; low protein-high energy, 459 days; low protein-low energy, 471 days. Ninety-three percent of the heifers fed the high protein-high energy ration had cycled by 15 months of age while only 36% of the others had cycled.

Wiltbank et al. (1966) studied the effects of heterosis on age and weight at puberty using heifers of the Angus, Hereford, and Shorthorn breeds, and all possible crosses. One group of 182 heifers were placed on a low level of winter feed consisting of 0.45 kg of 40% protein per day while grazing native range resulting in a gain of 0.2 kg daily. Another group of 171 heifers were placed on a high level of nutrition consisting of 2 kg of concentrate daily plus a liberal feeding of grass hay, which gave a gain of 0.4 kg per day. Sterile bulls wearing marking harnesses were used to check for estrus, which was confirmed by the ovaries being palpated 5 to 17 days later to check for ovulation. The means for age and weight at puberty for the two wintering levels are shown as follows:

Low Wintering Level

Age at Puberty, Days

Breed of Dam	Breed of Sire			
	H	A	S	$\bar{X}$
H	457	388	379	408
A	407	396	366	390
S	384	364	413	387
$\bar{X}$	416	383	386	395

Wt. at Puberty, Kg.

Breed of Dam	Breed of Sire			
	H	A	S	$\bar{X}$
H	269	243	230	247
A	261	233	224	239
S	247	234	226	235
$\bar{X}$	259	236	227	240

High Wintering Level

Age at Puberty, Days

Breed of Dam	Breed of Sire			
	H	A	S	$\bar{X}$
H	413	383	283	359
A	228	337	290	322
S	316	314	318	316
$\bar{X}$	355	345	297	332

Wt. at Puberty, Kg.

Breed of Dam	Breed of Sire			
	H	A	S	$\bar{X}$
H	306	291	232	276
A	282	251	247	260
S	276	254	243	258
$\bar{X}$	388	265	240	264

When data from the two wintering levels were combined, the age at puberty decreased 18.7 days for each 0.1 kg. increase in average daily gain from birth to weaning. From weaning to 396 days of age, age at puberty was decreased 41.2 days for each 0.1 kg. increase in average daily gain if the heifers were wintered on the low level. In contrast, heifers wintered on the high level showed little or no effect on variation of age at puberty when average daily gain from weaning to 396 days was analyzed. Thus, variation in the preweaning gains was a most important factor affecting age at puberty in heifers carried on the low wintering level. However, after a certain critical weight is attained, variation in average daily gains has little effect on age at puberty.

Wiltbank et al. (1969) in work similar to his 1966 study, found there was a nutrition X breed interaction on the age and weight at puberty in heifers fed on two levels of feed. Heifers on a high level gained .78 kg. per day and weighed 298.5 kg. at 12 months. Hereford heifers gained slower on both levels while crossbred heifers gained faster on the high levels, but slower than the corresponding straightbred parental groups on the low levels. The average age at puberty on the high feeding level for both crossbreds and straightbreds was 381 days while on the low level the crossbreds reached puberty at 424 days and the straightbreds in 572 days.

Cole and Cupps (1969) state the weight at puberty is quite variable and is dependent on the breed and on the nutrients available to the animal. However, the individual animal variation is larger within a given nutrient level.

Wiltbank (1970) reported heifers fed to gain 1 lb. per day reached puberty at an average age of 318 days for Shorthorns, 337 days for Angus, and 413 days for Herefords.

Short and Bellows (1971) at the U.S. Range Livestock Station, at Miles City, Montana used 50 Angus x Hereford and 39 Hereford x Angus weaner heifers in the fall of 1967, to study how the difference in age at puberty induced by varying feed intake or weight gain would affect later reproductive performance. The heifers were placed on three wintering treatments consisting of: low level - to gain approximately 0.23 kg. per day; medium - to gain 0.45 kg. daily; and high - a gain of 0.68 kg. per day. The average age at the start of the trail was 210 days and average body weight was 148 kg. Weights were taken approximately every 4 weeks so weight gains could be controlled. On May 7, all

heifers were weighed and placed in the same pasture, with sterile bulls equipped with marking harnesses, used to detect estrus in the heifers. The summer weight gains were inversely proportional to the winter gains with the low level heifers gaining 0.60 kg. per day on pasture; the medium level 0.52 kg. daily and the high level 0.42 kg. per day. Although differences in weight had largely disappeared by the end of the summer, the winter feed level had a marked influence on age at puberty. Age and weight at puberty for the various levels were: low level - 433 days, 238 kg.; medium level - 411 days, 248 kg.; and high level - 388 days, 259 kg. Eighty three percent of the high level group had been in estrus prior to the breeding season which started June 15, while only 24% of the medium group and 7% of the low group had shown estrus. Six of the heifers in the low treatment group failed to express estrus until after the end of the breeding season on August 13. At the end of the trail on October 16, rectal palpation showed 15 of the 30 low level heifers to be pregnant, 25 of 29 medium level heifers were bred, and 26 out of 30 heifers wintered at the high level were pregnant. Thus, it appears that an average daily gain of 0.28 kg. during the wintering period is not adequate for good reproductive performance.

Dunn et al. (1969) at the Fort Robinson Beef Cattle Research Station, Crawford, Nebraska, studied the effects of two pre-calving and three post-calving levels of estimated digestible energy intake upon the reproductive performance of 2 year old Hereford and Angus heifers nursing their first calves. Approximately 140 days prior to calving, 240 bred heifers were placed on two levels of energy intake. The low group received 8.7 Mcals of digestible energy daily and the high group receiving 17.3 Mcals daily. Within 24 hours after calving, heifers of the

low group were divided into two groups; the low-moderate which received 27.3 Mcals and the low-high group which were fed 48.2 Mcals per day after calving. The group carried at the high level prior to calving; the high-low group which received 14.2 Mcals per day, the high-moderate group fed 27.3 Mcals per day and the high-high group which received 48.2 Mcals. The heifers receiving the low levels were individually fed, the high level group animals were group fed prior to calving and ran to self feeders during the post calving trial (after a two to three week adjustment period). The post-calving moderate level group animals were group fed. Grease marked sterilized bulls were used to check cows for estrus, with the cows being bred artifically, the Herefords to a single collection from a Hereford bull, and the Angus to a single collection from an Angus bull. Weights were taken on the heifers starting 1 week after the heifers were assigned to treatments, with weights taken every 28 days and 0 to 7 days prior to calving, and within 24 hours after calving. The pre-calving low level heifers gained 8 kg. during the 140 days prior to calving while those on the high energy level gained 68 kg. At calving the high group lost 56 kg. while the low group lost 47 kg. Post-calving weight changes were as follows: low-high 188 kg.; low-medium 60 kg.; high-high 98 kg.; high-medium 35 kg.; and high-low 28 kg.

Pregnancy rate 120 days after calving was directly related to the post-calving energy level with 87% of those in the high group being bred, compared to 72% in the moderately fed group and only 64% in the low energy group. The pre-calving energy level influenced rebreeding by delaying conception an average of 8 days but 100 days after calving the influence of the pre-calving energy levels had disappeared. In the post-calving low group, of which 64% conceived, 30% of the Herefords and

9% of the Angus failed to show estrus. These findings are in agreement with other workers that the level of energy intake can markedly alter reproductive performance in 2 year old heifers nursing their calves.

Boston et al. (1972) compared the productivity of grade Angus cows with Angus-Holstein crossbreds and found that 2 pounds of cottonseed cubes and 5 pounds of prairie hay fed on native grass pasture during the winter was an inadequate level of nutrition for the crossbred heifers to rebreed while nursing their first calves. There may be breed differences in the nutrition level required for heifers nursing their first calves to rebreed. As the dairy breeds and exotics are used in beef breeding programs more information will be necessary to determine adequate nutrition levels for these to be productive.

CHAPTER III

METHODS AND MATERIALS

In October, 1961, 105 high grade Hereford weaner heifer calves were selected to be placed on trial at the Ft. Reno Livestock Research Station to study their reproductive performance under different levels of winter feeding and subsequent summer grazing. Fifteen heifers were allotted to each of seven groups on the basis of sire, dam's productivity, age, grade, and shrunk weight. The heifers ranged from 7 to 9 months in age, and 350 lbs. to 550 lbs. in weight, with an average age and weight of 231 days and 438 lbs. respectively. The winter treatment period was approximately 170 days in length, from early November until April 15, at which time they were placed on their respective summer grazing programs.

The wintering treatments were as follows:

High level - a gain of approximately 1 lb. per day.

Moderate level - a gain of 0.5 lb. per day.

Low level - no change in weight during the winter period.

Low-High level - no weight change until March 15, then fed at the high level until May 1.

The summer grazing programs were:

Continuous - free access to native grass pasture.

Restricted - access to native grass pasture for three 24 hour periods per week (Monday, Wednesday, and Friday) with confinement to dry lots on the remaining days of the week.

The treatment groups of this study were as follows:

Lot 1. High wintering level - Continuous summer grazing.

Lot 2. High wintering level - Restricted summer grazing.

Lot 3. Moderate wintering level - Continuous summer grazing.

Lot 4. Moderate wintering level - Restricted summer grazing.

Lot 5. Low wintering level - Continuous summer grazing.

Lot 6. Low wintering level - Restricted summer grazing.

Lot 7. Low level until March 15 - Then high level until May 1.

Continuous Summer Grazing

During the period of winter treatment, the heifers grazed native grass pastures with the heifers of lots 1 and 2, lots 3 and 4, and lots 6 and 7 running together in the same pasture, and with lot 5 alone in a fourth pasture. Beginning on October 26, the heifers were weighed at two week intervals following an overnight shrink away from feed and water. The amount of supplemental feed (cottonseed cake and ground milo) was adjusted on the basis of the bi-weekly weights to maintain the desired amount of gain for each group. Feeding was started in lots 1 and 2 on November 18 in order to obtain the desired gain of 1.0 lb. per day, while supplemental feeding for the other lots was delayed until December 19. On March 15, the heifers in lot 7 were removed from the pasture with the lot 6 heifers and raised to the high level with the supplemental feed consisting of sorghum silage, ground milo, and cottonseed cake.

To determine when estrus occurred, vasectomized bulls were placed in each of the three pastures that contained 2 lots of heifers. No bull was available for use in lot 5, therefore, date of first estrus was not

obtained for this group prior to breeding season. The bulls wore a grease-filled harness covering the brisket, or the brisket was painted daily with grease. The heifers were checked daily, and the presence of grease marks on the rump was taken as evidence of the occurrence of estrus.

Weight at first estrus was calculated by interpolating the weights taken at the regular weight period just prior to and just subsequent to the day of first estrus. Fertile bulls were placed with the heifers on May 1 and were likewise equipped with grease-marking harnesses. The heifers were checked several times daily for the presence of grease marks which was considered to be evidence that mating had occurred on that date. The bulls were removed August 14 and the heifers were checked for pregnancy by rectal palpation approximately 45 days later. The calving dates the following year were used to verify breeding dates in all except lot 6. Calving information was not available on the heifers of lot 6 since they were disposed of before the 8 heifers that had been diagnosed pregnant could calve. In the case of 8 cows in which estrus had not been observed, date of calving was used to approximate date of breeding by using a gestation length of 287 days.

Data was analyzed by analysis of variance according to the procedure described by Steel and Torrie (1960). Tests of individual differences of means were determined by least significant differences. Treatment differences for date of conception was tested by least squares.

CHAPTER IV

RESULTS AND DISCUSSION

Winter Weight Changes

The weight changes of the heifers during the course of this trial are given in Table I. Means for winter and summer changes are shown in Table II. Changes during the 173 day wintering period (10-26-61 to 4-17-62) were predetermined by the design of the trial. The average gain per lot was slightly higher than desired; however, the difference between lots was approximately as desired. The high level heifers, scheduled to gain 1.0 lb. per day, gained a total of 201 lbs. per heifer, or 1.16 lb. per day. The medium level heifers, scheduled to gain 0.5 lb. per day, gained 114 lbs. per head, or 0.66 lb. per day. The low level was designed to permit no loss or gain during the winter period. Low level heifers in lot 5 lost 18 lbs., while those in lot 6 gained 11 lbs. The average for both low groups closely approximated the weight change desired.

The feed level provided the heifers of lot 7 was designed to determine whether a short period of no gain would have a detrimental effect if the heifers were provided a chance to compensate by a "flushing" period prior to the breeding season. As can be seen in Table I, these heifers gained a total of 10 lbs. in the winter period prior to March 15 when they were changed from the low to the high level. During the 33 day flushing period, the heifers gained 39 lb. an average daily

TABLE I

WEIGHTS OF YEARLING HEREFORD HEIFERS MAINTAINED ON DIFFERENT LEVELS OF WINTER FEEDING AND SUMMER GRAZING

Item	Level of Supplemental Winter Feeding						
	High		Moderate		Low		Low-High
	Continuous Summer Grazing	Restricted Summer Grazing	Continuous Summer Grazing	Restricted Summer Grazing	Continuous Summer Grazing	Restricted Summer Grazing	Continuous Summer Grazing
Lot No.	1	2	3	4	5	6	7
No. of Heifers	15	15	15	15	15	15	15
Avg. Body Wt. (lbs.)							
Oct. 26, 1961	437	438	438	438	439	436	438
Mar. 15, 1962	564	570	505	519	438	453	448
Apr. 17, 1962	637	640	538	566	421	447	487
May 2, 1962	647	652	568	585	442	445	527
Aug. 14, 1962	794	742	737	704	655	609	706
Avg. gain per hfr. (lbs.) winter (10-26-61 to 4-17-62)	200	202	100	128	- 18	11	49
Avg. gain per hfr. (lbs.) summer (4-17-62 to 8-14-62)	157	102	199	138	234	162	219

gain of 1.18 lb. This gain was maintained until May 1 when they were placed on their summer program of continuous grazing.

TABLE II

MEANS FOR WINTER AND SUMMER WEIGHT CHANGES

Item	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7
Winter weight change	200^{a}	202^{a}	100^{b}	128^{b}	11^{cd}	-18^{cd}	49^{c}
Summer weight change	157^{ab}	102^{ab}	199^{ac}	138^{ab}	234^{cd}	162^{a}	219^{c}

^{abcd}Means on the same line bearing different superscript letters differ significantly ($P < .05$).

The winter weight changes were significantly different between treatment groups when tested by least significant difference.

The analysis of variance revealed highly significant ($P < .01$) differences in winter weight changes, (Table III).

TABLE III

ANALYSIS OF VARIANCE FOR WINTER WEIGHT CHANGE

Source	d.f.	M.S.	F.
Treatments	6	88,481.59	119.4599**
Error	98	740.68	

Summer Weight Change

The heifers, with the exception of lot 7, were placed on their respective summer programs on April 17. Summer gains were calculated from

this date until August 14, the date the bulls were removed from the pasture, thus, ending the breeding season. Summer weight changes are also shown in Table I, and mean weight differences in Table II.

The high winter level heifers allowed continuous summer grazing for the 119 day period gained an average of 157 lb. The other high winter level group restricted to three days of grazing per week gained an average of 102 lb. during the summer.

The two groups wintered at the moderate level gained considerably faster during the summer; the group allowed continuous grazing gained an average of 199 lb. per head, while the group restricted to grazing three days per week gained an average of 138 lb. per head.

The two groups that made little or no gain during the winter period made the largest summer gains with the group allowed free access to grass gaining 234 lb. per head during the 119 day period. The group on restricted grazing gained an average of 162 lb.

Comparing restricted versus continuous grazing, the cattle allowed free access to grass outgained the restricted cattle approximately 47%, with winter treatment having no effect on these differences. It is interesting to note the heifers consumed enough forage in three days grazing per week to make two thirds the gain of heifers allowed free access to grass.

Analysis of variance for summer weight gain (Table IV) revealed highly significant ($P < .01$) differences in summer weight changes.

The heifers that had been on the low-high wintering level showed a gain of 219 lb., but this is an over estimate since they were carried on the high level feeding program until May 2. Therefore, 39 lb. of their summer gain was the result of supplemental feed, consequently they gained

TABLE IV

ANALYSIS OF VARIANCE FOR SUMMER WEIGHT CHANGE

Source	d.f.	M.S.	F.
Treatment	6	52,690.00	18.245**
Error	98	2,877.89	

179 lb. by continuous grazing on pasture.

It is interesting to note the average summer gain of the heifers wintered at the low level and allowed to graze only three days per week was 5 lb. greater for the summer season than the heifers that had been carried on the high wintering level and allowed continuous grazing during the summer. Joubert (1954) reported that during the summer heifers fed on a low plane of nutrition derived greater benefits from grazing and showed higher actual and relative gains than cows wintered on a high plane of nutrition.

Age and Weight at Puberty

The average age and weight at puberty of the heifers in each treatment group is given in Table V. Individual data for each heifer is given in Appendix tables.

The weights at puberty were directly related to the level of winter feeding with the heifers carried at higher levels being heavier at puberty than those carried at a lower level. The ages of the heifers at puberty were inversely related to their wintering level. The heifers wintered at the high level reached puberty at an average age and weight of 353 days and 544 lbs., the moderate level groups at 380 days and 528

TABLE V

THE EFFECTS OF DIFFERENT LEVELS OF WINTER FEEDING AND SUMMER GRAZING ON REPRODUCTIVE DEVELOPMENT OF YEARLING HEREFORD HEIFERS

Item	Level of Supplemental Winter Feeding						
	High		Moderate		Low		Low-High
	Continuous Summer Grazing	Restricted Summer Grazing	Continuous Summer Grazing	Restricted Summer Grazing	Continuous Summer Grazing[1]	Restricted Summer Grazing	Continuous Summer Grazing
Lot No.	1	2	3	4	5	6	7
No. of Heifers	15	15	15	15	15	15	15
Avg. age at first estrus (days)	359	347	371	389	--	390	400
Avg. wt. at first estrus (lbs.)	550	538	515	541	--	474	497
No. hfrs. in which first estrus occurred before May 1	12	13	11	9	--	10	8
No. hfrs. establishing a regular estrus cycle before May 1	8	11	8	8	--	0	1
No. hfrs. never in heat during breeding season (5-1/8-14)	0	0	0	0	0	7	0

[1] Liberty data not obtained for lot 5.

lb., and those on the low level at 395 days and 485 lb.

Figures 1 and 2 present data showing the effects of levels of winter feeding on the age at which Hereford heifers reach puberty as evidenced by the occurrence of first estrus. All of the heifers on the high level and 90% of those on the moderate level had reached puberty by 15 months while only 70% of those on the low level had reached puberty. The practical implications of these data is obvious since heifers must have attained puberty by 15 months of age if they are to be bred to calve as two-year-olds.

The analysis of variance for age at first estrus is shown in Table VI and for weight at first estrus is shown in Table VII.

TABLE VI

ANALYSIS OF VARIANCE FOR AGE IN DAYS AT FIRST ESTRUS

Source	d.f.	M.S.	F.
Treatment	5	6303.586	1.6636
Error	84	3789.060	

TABLE VII

ANALYSIS OF VARIANCE FOR WEIGHT AT FIRST ESTRUS

Source	d.f.	M.S.	F.
Treatment	5	12,984.9445	2.0888
Error	84	6,216,6063	

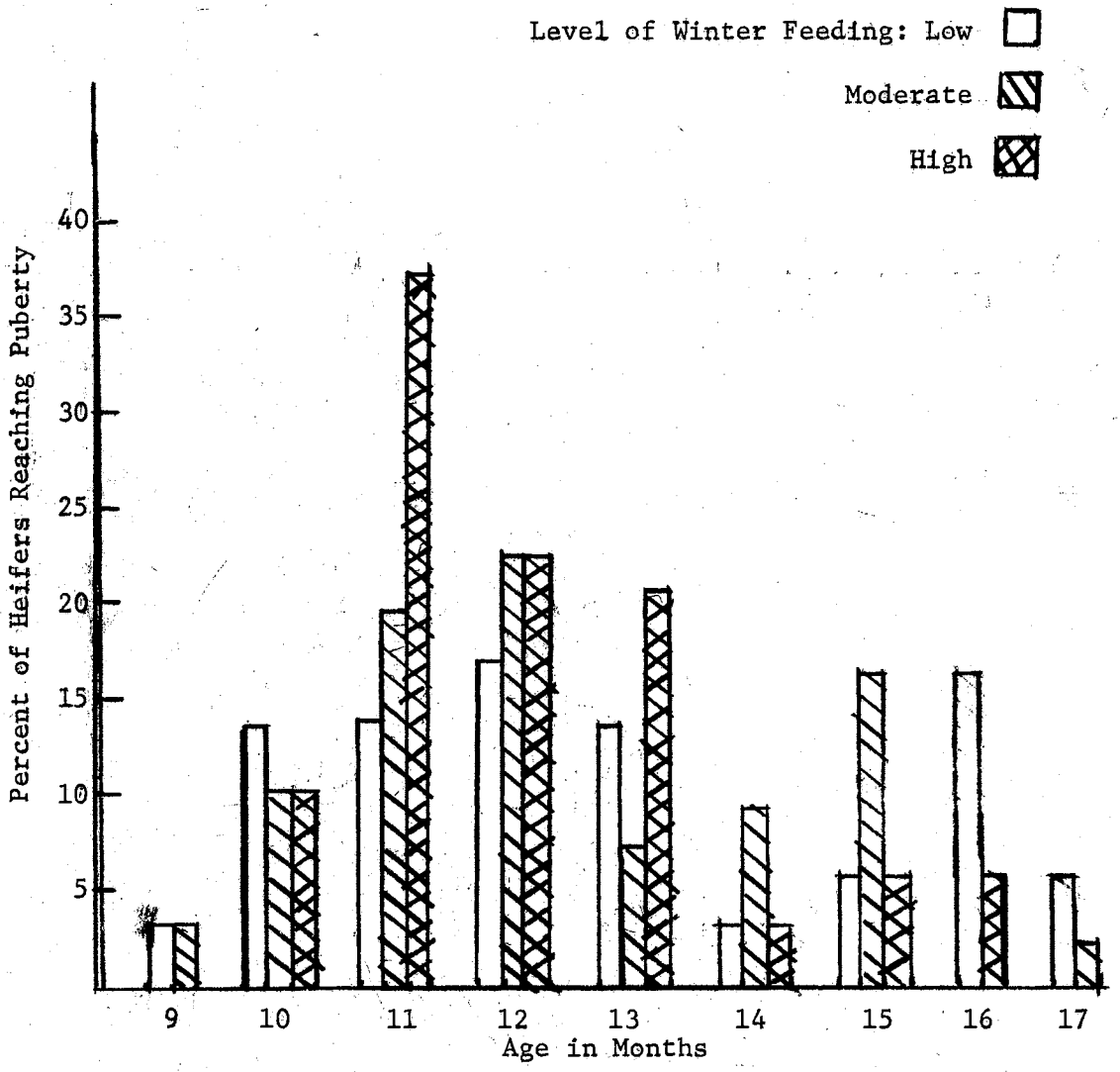

Figure 1. Percent of Heifers Reaching Puberty During Each Month From 9 to 17 Months of Age

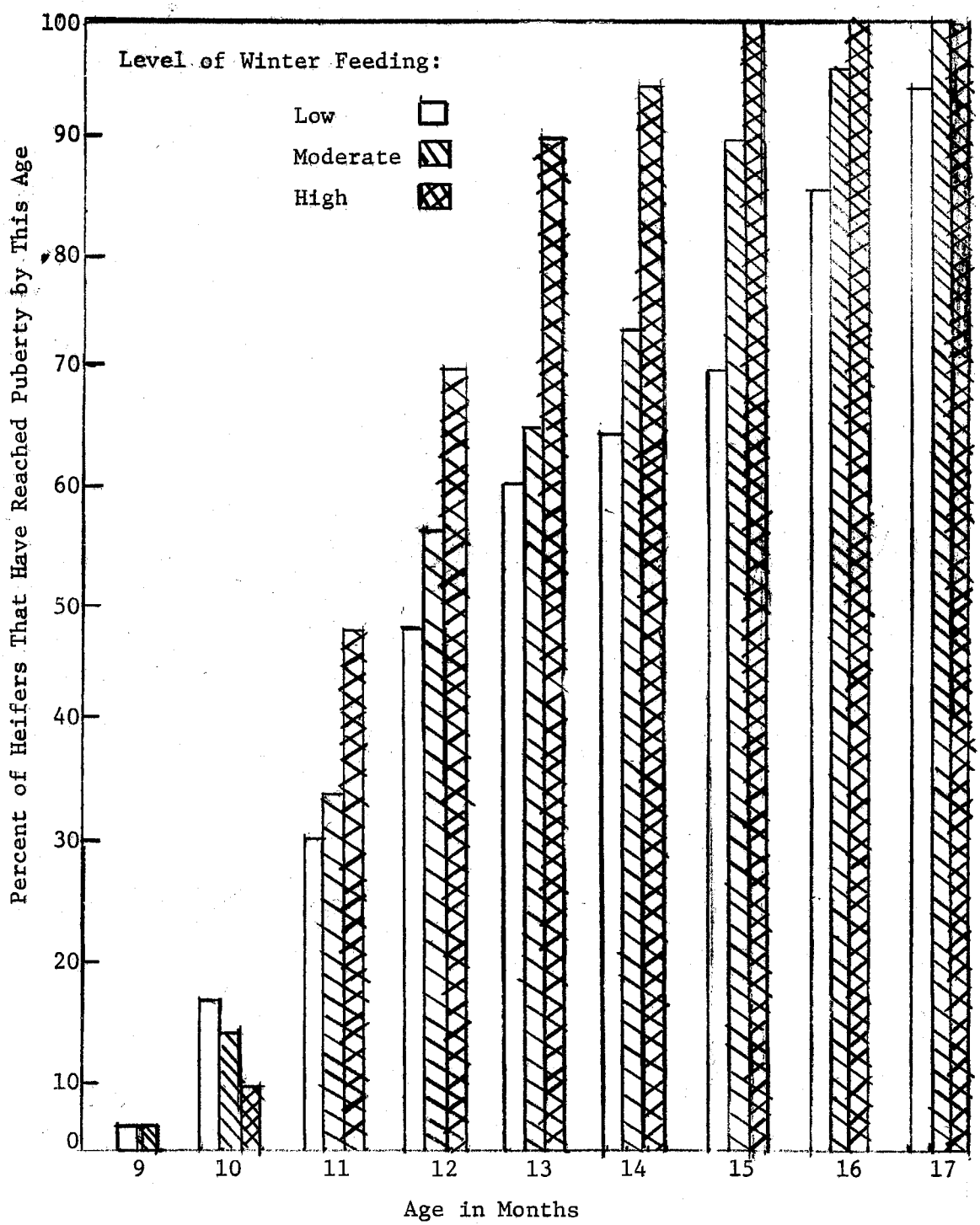

Figure 2. Accumulative Total of Percent of Heifers that Have Reached Puberty by Each Month of Age From 9 to 17 Months of Age

Despite a 42 day difference between the average ages at first estrus of the 90 heifers of the low and high level groups, that were checked for first estrus the analysis of variance revealed no significant difference. This lack of significance was probably due to the extremely wide variation within groups. There was no significant difference in weight of heifers at puberty and there was also a wide variation between heifers within groups. Two heifers in lot 6 (low-restricted grazing) did not attain puberty during the trial. The day following the end of the study was assigned as the date of puberty for these two heifers. Although this resulted in an under-estimate of average age and weight at puberty of heifers in lot 6, it was considered to be a more valid estimate than would have been obtained by omitting these heifers from the analysis.

The age at which first estrus occurs is of less practical importance than the age at which a regular estrous cycle is initiated. Seventy percent of the heifers in this study reached puberty, as measured by the occurrence of first estrus, at a relatively early age (prior to May 1), however, 31 percent of these did not continue to cycle. In several cases, two or more months elapsed between the occurrence of first and second estrus.

As can be seen in Table IV, 83% of the heifers on the high, 67% of the heifers on the moderate level and 60% of the heifers on the low level of winter feeding were observed in estrus before the breeding season started on May 1. Of these heifers that had an observed estrus, 76% of the high level, 80% of the moderate level and only 5.5% of the low level heifers had established a regular cycle.

Although the differences were not significant, winter feed level did appear to have a detrimental effect on the heifers. Low nutritional levels resulted not only in retarded body growth but also in delayed physiological maturity as measured by age at puberty.

Several workers have reported that age of puberty is closely related to feed level. Joubert (1954) found a difference of 221 days in age at puberty between heifers wintered in South Africa at a high plane of nutrition and heifers wintered on a low plane. Reid (1960), in work with Holstein heifers, found over 300 days difference in age at first estrus between heifers on low and high levels of nutrition. Wiltbank et al. (1966) working with both straight bred and cross-bred heifers found that 171 heifers wintered on a high level of nutrition (to gain 0.4 kg. per day) attained puberty at 342 days of age while heifers wintered to gain 0.2 kg. per day averaged 405 days of age at puberty. Wiltbank et al. (1969) found that heifers self-fed to gain 0.78 kg. per day reached puberty at 381 days, while heifers gaining 0.33 kg. per day averaged 498 days at puberty. Turman et al. (1968) found that Angus heifers gaining 2 lbs. per day after weaning reached puberty at 267 days of age. Angus heifers gaining 0.5 lb. per day were 375 days old at puberty, and Angus-Hereford cross-bred heifers gaining 0.5 lbs. daily were 383 days old at puberty.

Restricting summer grazing did not affect the age at puberty of heifers wintered at the high level (lot 2) since most of them (83.3%) reached puberty prior to the time the summer pasture treatments were imposed. However, placing heifers on restricted grazing following wintering at either the moderate (lot 4) or low level (lot 6) of winter feeding did appear to affect age at first estrus. Heifers of lot 4 wintered at the moderate level then placed on restricted grazing were delayed 18 days in reaching puberty when compared to the moderate level group allowed continuous grazing (lot 3). There were no puberty dates obtained on heifers of lot 5 (low wintering level - continuous summer

grazing) for comparison. However, the group wintered at the low level and placed on restricted grazing (lot 6) were delayed in attaining puberty to the same degree as those wintered on the moderate level and restricted in summer grazing (lot 4). The heifers wintered at the low level until March 15 and then flushed reached puberty at even a later date than the low-restricted group (400 days vs. 390 days). It should be pointed out, however, that the average puberty dates for heifers of lot 6 reflect the fact that 4 heifers of the group exhibited estrus at less than 210 days of age. It is significant that none of the 10 heifers of lot 6 that had been observed in estrus prior to May 1 had established a regular cycle with 2 not being observed in estrus by August 14 the end of the breeding season.

This data suggests that in drier regions or in areas where grazing could be a limiting factor, the moderate and low wintering levels may not be adequate for the best reproductive performance in terms of numbers of heifers that attain puberty prior to the onset of the breeding season. This is supported by results reported in the literature.

Wiltbank et al. (1959) found that only 9% of a group of Hereford heifers whose average daily gain from weaning until grass in the spring was 0.38 lb. showed puberty prior to being placed on grass.

Joubert (1954) found that of 14 heifers carried on natural grazing during the winter months with no supplement, 85.7% did not show estrus until summer grazing.

Arije and Wiltbank, (1971) had similar results with Hereford heifers gaining 0.20 kg. per day not reaching puberty until after starting to make faster gains when placed on grass. Obviously, if heifers are to reach puberty by 15 months in order to calve at 2 years of age, adequate

nutrition must be supplied during the critical wintering period.

The average weight at puberty for the 90 heifers checked in this study was 519 lb. This is probably normal for Hereford heifers reared in central Oklahoma. Turman et al. (1968) used 74 Angus heifers that gained 2 lb. per day after weaning and reported a weight of 514 lb. at puberty, while Angus heifers that gained 0.5 lb. per day weighed 474 lb. at puberty. Wiltbank et al. (1959) reported on 125 Hereford heifers that weighed 562 lbs. at puberty. Kaltenbach and Wiltbank (1962) reported that Hereford heifers wintered on native pasture and fed 1 lb. of 41% protein supplement per day weighed 615 lbs. at puberty.

Very little work has been done on how large a heifer should be as a yearling. The data presented in Table VIII indicates the best weights for good reproductive performance. Approximately 15 percent of the Hereford heifers in this study had not cycled by the time they weighed 600 lb., but almost all had cycled by 650 lb. It would appear that if heifers of the English breeds were so managed as to weigh 600 lb. at one year of age, most should be cycling by 15 months of age. For heifers with a weaning weight of 450 lb., at least the high level of winter feeding used in this study would be necessary to insure a yearling weight of 600 lbs. Wiltbank et al. (1969) reported a daily gain of .78 kg. during the wintering period gave a yearling weight of 657 lb.

TABLE VIII

THE WEIGHT AT WHICH HEREFORD HEIFERS REACH PUBERTY AS EVIDENCED BY THE OCCURRENCE OF FIRST ESTRUS

Weight Range	No. Reaching Puberty	Percent of Total Heifers
370 - 400 lbs.	7	7.77
401 - 450 lbs.	15	16.66
451 - 500 lbs.	16	17.77
501 - 550 lbs.	21	23.33
551 - 600 lbs.	17	18.88
601 - 650 lbs.	13	14.44
Over 650 lbs.	1	1.11

Breeding Performance

The breeding performance of the heifers in this study is presented in Table IX.

The reproductive performance of the two groups wintered at the high and moderate levels were quite comparable, although the heifers wintered at the moderate level were approximately one week later on their average date of conception (5-28 vs. 6-3). Restricting the summer grazing did not affect the breeding performance of the heifers within each of the high and moderate wintering groups. Actually, the performance of heifers on restricted grazing was superior to that of those on continuous grazing within these two groups.

However, the low wintered heifers that were restricted on summer grazing had the poorest performance of the 7 groups. The average date of conception for the low level heifers was 35 days later than the high level (5-28 vs. 7-2) and 29 days later than the moderate group (6-3 vs. 7,2). There was also a wide variation within the three low level groups. The heifers that were flushed near the end of the wintering period conceived 20 days earlier than the low level heifers that were restricted on summer grazing (6-12 vs. 7-2). The flushed heifers were also 14 days earlier than the low level heifers that were allowed continuous grazing. The low level heifers allowed continuous grazing conceived 6 days earlier

TABLE IX

THE EFFECTS OF DIFFERENT LEVELS OF WINTER FEEDING AND SUMMER GRAZING ON THE REPRODUCTIVE PERFORMANCE OF YEARLING HEREFORD HEIFERS, EXPOSED TO FERTILE BULLS MAY 1, 1962 TO AUG. 14, 1962

Item	Level of Supplement Winter Feeding						
	High		Moderate		Low		Low-High
	Continuous Summer Grazing	Restricted Summer Grazing	Continuous Summer Grazing	Restricted Summer Grazing	Continuous Summer Grazing	Restricted Summer Grazing	Continuous Summer Grazing
Lot No.	1	2	3	4	5	6	7
No. of Heifers	15	15	15	15	15	15	15
Percent of Heifers settled at 1st service	60%	69%	71%	67%	80%	88%	64%
Avg. date of conception	6-3	5-21	6-8	5-28	6-26	7-9	6-12
Services per conception	1.57	1.43	1.53	1.39	1.47	1.125	1.43
No. settled	14	14	15	14	11	8	14

than those restricted to grazing 3 days a week. The analysis of variance for date of conception appears in Table X.

TABLE X

ANALYSIS OF VARIANCE FOR DATE OF CONCEPTION

Source	d.f.	M.S.	F.
Treatments	6	2958.7009	9.9547**
Error	82	297.2170	

Since differences in the date of conception were highly significant ($P < .01$) it would appear that the level of nutrition affects breeding performance more than it does the age or weight at which heifers reach puberty. The groups wintered at the high and moderate levels and the group that was flushed had a total conception rate of 94.6%. The low level heifers that were allowed continuous grazing had 73.3% conceiving during the breeding season while only 53.3% of the low level group restricted in grazing settled. Two heifers of this group did not exhibit estrus during the entire trial and 5 others that had exhibited estrus prior to breeding season were not detected in heat during the breeding season. However, the eight heifers that had an observed estrus all settled with 88% of them conceiving to the first service. These data suggest that if low levels of nutrition have an effect on reproductive performance it is in causing a complete suppression of the reproductive function resulting in cessation of cyclic activity. However, the fact that a very high percentage of the eight heifers that did cycle conceived on the first service indicates low levels of nutrition are not detrimental to fertility of the heifers that do cycle.

TABLE XI

ANALYSIS OF VARIANCE FOR CONTINUOUS VS. RESTRICTED GRAZED ANIMALS FOR DATE OF CONCEPTION

Source	d.f.	M.S.	F.
Treatment	5	931	3.132*
Error	82	297.2170	

There was a significant difference ($P < .05$) for the two treatment groups on continuous vs. restricted grazing in favor of the heifers that were restricted. This was partially due to the fact the restricted heifers settled on fewer services.

Bond et al. (1958), found that after heifers had been fed extremely low levels of energy and protein long enough for cessation of estrus and ovarian activity to occur one group of heifers required 228 days during which they gained 223 lb. to re-establish estrus, and another group needed a gain of 125 lb. in 179 days to re-establish estrus. Warnick et al. (1959) also found that extremely low levels of nutrition caused cessation of estrus, but the effects were not detrimental to fertility when adequate nutrition was made available.

The group of heifers (lot 7) that was maintained at the low level during the first part of the wintering period and then raised to the high level had a satisfactory breeding performance. They conceived about a week later than the heifers wintered at the moderate level (6-3 vs. 6-12). These observations indicate that heifers may be carried at a low level for part of the winter and their breeding performance not be adversely affected if they can be raised to a high level 2 or 3 months prior to the breeding season. This information could be helpful to

ranchers who because of adverse conditions may have to carry heifers for a temporary period of time at a subnormal level.

Calving Performance

In this study, the heifers wintered at the high level had an average calving date 12 days earlier than the heifers wintered at the moderate level, and 25 days earlier than the two groups wintered at the low level that had calving information. Unfortunately, the group of heifers that had been carried on the low level-restricted grazing (lot 6) were disposed of before the 8 head that were bred had an opportunity to calve. The analysis of variance for day of year at calving for heifers in this study are given in Table XII.

TABLE XII

ANALYSIS OF VARIANCE FOR DAY OF YEAR AT CALVING

Source	d.f.	M.S.	F.
Treatments	5	1706.620	6.3820**
Error	71	267.413	

There was a 35 day difference between the earliest calving group, (lot 2, Feb. 26) and the latest calving group (lot 5, April 2). In addition to delayed calving, 4 of the heifers in this group plus 7 in the low-restricted group were open and failed to produce a calf. Thus, 37% of the heifers of the low levels that were open at the end of the

TABLE XIII

MEANS FOR WEIGHT AND AGE AT FIRST ESTRUS, DATE OF CONCEPTION, AND DAY OF YEAR AT CALVING

Item	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7
Weight at first estrus	550.27	538.67	515	540.67	1	474.33	497
Age at first estrus	360	346	371	389	1	390.4	400
Date of conception	154	141	159[b]	148	190[c]	177[bc]	163[b]
Day of year at calving	66	57	75[b]	68	2	92[b]	78[b]

1 - Estrus dates were not obtained on lot 5.

2 - Heifers of lot 5 were disposed of before calving.

[a]Jan. 1 is number 1 for day of year.

[bcd]Means on the same line bearing different superscript letters differ significantly ($P < .05$).

breeding season.

These results are in agreement with other workers. Turman et al. (1964), found that a low level of nutrition for heifers up to two years of age was usually associated with:

(a) Delayed breeding of yearling heifers.

(b) Lighter weaning weights of calves.

(c) Delayed rebreeding of two-year-old heifers, with a higher percentage of open heifers at both ages.

Warnick (1959), found that heifers fed crude protein at or below requirements for body maintenance either failed to show heat or ovulation, or if bred, failed to settle.

Pinney (1963), found that heifers wintered at a low level (no weight gain or loss) had a delayed calving date of an average of 19 days over heifers carried at the high level (1.0 lb. per day gain). In addition, the average birth weight of the calves was 13 lbs. heavier from the heifers carried at the high level. The weights were an average of 59 lb. for the calves born to the heifers that had been carried at the low level and 72 lb. for those born to the heifers carried at the high level.

CHAPTER VII

SUMMARY

A total of 105 weaner Hereford heifer calves were allotted on the basis of sire, dams productivity, age, grade and shrunk weight to 7 groups of 15 head each in the fall of 1961 to study the effects of four levels of winter feeding and two levels of summer grazing. Two lots were placed on each of three levels of winter feeding during the wintering period November 15 to April 15:

High - to gain approximately 1.0 lb. per day

Moderate - to gain approximately 0.5 lb. per day

Low - to neither gain nor lose weight during the period

The heifers, with the exception of lot 7, were placed on their summer grazing program on April 15 with 15 heifers from each wintering level having access to continuous grazing and the other 15 from each wintering level being allowed to graze only 3 days per week. (Monday, Wednesday, and Friday). The seventh lot was placed on the low level from November 15 until March 15 at which time they were placed on the high level until the start of the breeding season on May 1. They were then placed on a continuous grazing program.

Vasectomized bulls were used prior to May 1 in all but one group to detect estrus. Fertile bulls were placed with all groups on May 1. Age at puberty was defined as age at occurrence of first estrus. Weight at puberty was calculated by interpolation from body weights taken at two

week intervals.

Average age and weight at first estrus for heifers in the various wintering groups were: High - 353 days and 544 lb.; Moderate - 380 days and 525 lb.; and Low - 395 days and 485 lb. Restricting summer grazing did not affect age at first estrus in the heifers wintered at a high level since most of them (25 of the 30) had reached puberty prior to the start of the breeding season. However, in the heifers wintered at the moderate level there was a 17 day delay in the group restricted in summer grazing compared to those allowed continuous summer grazing (3-14 vs. 3-31). The only difference in the breeding performance of heifers on the high and moderate levels was a 1 week earlier conception date for the high level groups. Restricting summer grazing had no apparent effect on the breeding performance.

The group of heifers changed from low to high level on March 15 were comparable to the groups wintered at the moderate and high levels except for an average conception date 9 days later than the moderate level heifers (6-3 vs. 6-12).

The low level of winter feeding did not prove to be adequate for satisfactory reproductive performance. Only 73.3% of the low level group on continuous summer grazing conceived and only 8 of the 15 heifers (53.3%) wintered at the low level and restricted in their summer grazing conceived. The remaining 7 were not observed in estrus during the breeding season although 5 had shown estrus once prior to the breeding season. Seven of the 8 that were bred settled on the first service indicating subnormal nutrition either causes complete suppression of the reproductive function, or has no detrimental effect on fertility.

LITERATURE CITED

Ariji, G. F. and J. N. Wiltbank. 1971. Age and weight at puberty in Hereford heifers. J. Animal Sci. 33:401.

Bond, J., J. N. Wiltbank, and A. C. Cook. 1958. Cessation of estrus and ovarian activity in a group of beef heifers on extremely low levels of energy and protein. J. Animal Sci. 17:1211 (abstract).

Boston, A. C., G. H. Deutscher, J. V. Whiteman and R. R. Frahm. 1972. Comparison of productivity of young Angus-Holstein crossbred and grade Angus cows. Okla. Agri. Exp. Sta. M.P. No. 87.

Clanton, D. C., D. R. Zimmerman and R. C. Albin. 1964. Effect of protein and energy on growth and pubertal age in beef heifers. J. Animal Sci. 23:870 (Abstract).

Cole, H. H. and P. T. Cupps. 1969. Reproduction in Domestic Animals. 2nd Edition. Academic Press. New York and London.

Dunn, T. G., J. E. Ingalls, D. R. Zimmerman and J. N. Wiltbank. 1969. Reproductive performance of 2-year-old Hereford and Angus heifers as influenced by pre- and post-calving energy intake. J. Animal Sci. 27:719.

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

Joubert, D. M. 1954. The influence of high and low nutritional planes on the oestrous cycle and conception rate of heifers. J. Agri. Sci. 45:164.

Joubert, D. M. 1963. Puberty in female farm animals. Animal Breeder. 31:295. (Abstract).

Kaltenback, C. C. and J. N. Wiltbank. 1962. Heterotic effects on age and weight at puberty in beef heifers. J. Animal Sci. 21:662. (Abstract).

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

Reid, J. T. 1960. Effect of energy intake upon reproduction in farm animals. J. Dairy Sci. 43:103 (Supplement).

Reynolds, W. L., T. M. DeRoven and J. W. High, Jr. 1963. The age and weight at puberty of Angus, Brahman, and Zebu cross heifers. J. Animal Sci. 22:243 (Abstract).

Short, R. E. and R. A. Bellows. 1971. Relationships among weight gains, age at puberty, and reproductive performance in heifers. J. Animal Sci. 32:127.

Shroder, Joseph D. 1954. Further studies on the effects of age at first calving and level of wintering on the productivity of beef cows. M.S. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Sorenson, A. M., W. Hansel, W. H. Haugh, S. T. Armstrong, K. McEntee, and R. W. Bratton. 1959. Causes and prevention of reproductive failures in dairy cattle. I. Influence of underfeeding and overfeeding on growth and development of Holstein heifers. Cornell Agri. Exp. Bul. 936:1.

Steel, R. G. D., and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Company, Inc. New York.

Thomas, O. O. 1952. Relation of nutrition and age of first calving to lifetime performance of beef cows. Ph.D. Thesis, Oklahoma State University, Stillwater, Oklahoma.

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

Turman, E. J., R. H. Edwards, R. L. Willham, and R. E. Renbarger. 1968. The age and weight at puberty of some Angus and Angus-Hereford crossbred heifers. Okla. Agri. Exp. Sta. M. P. 80.

Warnick, A. C., J. F. Hentges, Jr., T. J. Cunha, and J. P. Feaster. 1956. The effect of varying protein intake on reproduction, blood composition, and weight changes of beef heifers. J. Animal Sci. 15:1283 (Abstract).

Warnick, A. C. 1959. Effect of a protein deficiency on reproduction in beef cattle. Florida Agri. Exp. Sta. Animal Husbandry and Nutrition Mimeograph Series N. 59-10. A. H. and Nutr. Mimeograph Series.

Wiltbank, J. N., A. C. Cook, R. E. Dabis, and E. J. Warnick. 1957. The effect of different combinations of energy and protein on the occurrence of estrus, length of the estrous period, and time of ovulation in beef heifers. J. Animal Sci. 16:1100 (Abstract).

Wiltbank, J. N., W. W. Rowden, and J. E. Ingalls. 1959. The age and weight at puberty in Hereford heifers. J. Animal Sci. 18:1562 (Abstract).

Wiltbank, J. N., K. E. Gregory, L. A. Swiger, J. E. Ingalls, J. A. Rothlisberger, and R. M. Koch. 1966. Effects of heterosis on age and weight at puberty in beef heifers. J. Animal Sci. 25:744.

Wiltbank, J. N., C. W. Kasson, and J. E. Ingalls. 1969. Puberty in crossbred and straightbred beef heifers on two levels of feed. J. Animal Sci. 29:602.

Wiltbank, J. N. 1970. Research needs in beef cattle production. J. Animal Sci. 31:755.

Zimmerman, J. E. 1960. Part I. Effect of plane of winter nutrition on growth and reproductive performance of beef heifers. Ph.D. Thesis, Oklahoma State University, Stillwater, Oklahoma.

APPENDIX

LOW LEVEL--CONTINUOUS GRAZING

Tattoo	Heifer No.	Birth Date	Birth Weight	Weaning Wt. 10-5	Wt. 10-26	Wt. 3-15	Wt. 4-17	Wt. 5-2	Wt. 8-14	1963 Calving Date	Calf Birth Wt.	Year Day of Calving	Date of Conception	Services per Conception	Winter Wt. Change lbs.	Summer Wt. Change lbs.
102	1	2-15	58	450	450	490	445	465	635	3-1	56	60	163	1	- 5	190
122	2	3-5	72	470	500	485	455	465	690	3-11	74	70	152	1	-45	235
141	3	3-16	80	455	460	445	430	445	705	4-5	64	95	171	1	-30	275
143	4	3-18	88	475	475	480	450	480	695	Open	Open	--	---	4	-25	245
B229	5	3-7	73	410	425	435	425	460	625	3-1	56	60	175	1	0	200
B493	6	3-7	73	425	440	435	415	435	680	Open	Open	--	---	1	-25	265
5107	7	2-18	63	445	460	445	430	455	655	3-23	57	82	155	1	-30	225
5110	8	2-21	72	455	460	465	440	460	705	4-19	74	109	184	1	-20	265
5114	9	2-22	76	460	470	460	455	485	670	Open	Open	---	---	1	-15	215
5125	10	2-27	74	470	490	465	450	465	670	4-23	80	113	193	2	-40	220
5165	11	5-15	90	380	390	400	395	400	610	4-19	82	109	189	1	5	215
6120	12	3-4	64	425	435	415	395	420	645	3-24	58	83	167	2	-40	250
6150	13	5-8	80	380	395	400	390	410	620	Open	Open	--	---	2	- 5	230
7137	14	3-19	61	314	375	380	380	400	625	4-3	78	93	173	1	5	245
7148	15	3-27	72	287	365	370	365	385	595	5-17	60	137	221	2	0	230
		$\bar{x}$3-7	$\bar{x}$73		$\bar{x}$439	$\bar{x}$438	$\bar{x}$421	$\bar{x}$442	$\bar{x}$655	$\bar{x}$4-2	$\bar{x}$67	$\bar{x}$92	$\bar{x}$177	$\bar{x}$1.47		
												4-2	6-26		-18	234

LOW LEVEL - FLUSHED - CONTINUOUS GRAZING

Tattoo	Heifer No.	Birth Date	Birth Weight	Weaning Wt. 10-5	Wt. 10-26	Wt. 3-15	Wt. 4-17	Wt. 5-2	Wt. 8-14	1st Estrus Date	1963 Calving Date	Calf Birth Wt.	Age in Days at 1st Estrus	Year Day of Calving	Date of Conception	Services Per Conception	Winter Wt. Change lbs.	Summer Wt. Change lbs.	Wt. at Puberty
108	61	2-21	75	420	410	445	475	510	645	7-3	2-25	72	498	56	138	1	65	170	585
111	62	2-25	80	530	530	550	610	640	810	3-12	3-24	68	380	83	165	1	80	200	550
124	63	3-6	76	470	485	475	525	580	770	2-21	3-18	58	352	77	151	1	40	245	455
146	64	3-23	61	450	465	485	535	560	735	2-17	2-28	72	331	59	147	1	70	200	440
B218	65	3-31	76	390	405	385	390	415	620	3-5	4-19	60	339	109	194	3	-15	230	380
B236	66	3-16	72	380	395	420	450	500	690	3-9	3-19	74	358	78	156	1	55	240	415
B468	67	3-19	72	430	445	440	500	525	740	2-12	3-11	74	330	70	150	1	55	240	425
5103	68	2-12	78	475	490	495	540	590	765	6-6	3-11	58	479	70	157	1	50	225	645
5105	69	2-15	74	435	445	450	515	560	715	5-30	4-1	52	469	91	181	2	70	200	575
5117	70	2-24	67	415	415	380	395	430	640	6-4	----	—	465	—	176	2	-20	245	500
5138	71	3-19	82	450	465	485	535	570	745	5-28	----	—	435	—	184	2	80	210	620
6138	72	3-30	88	410	410	445	490	555	740	2-1	3-17	62	308	76	161	1	80	250	400
6143	73	4-2	66	405	410	445	480	510	680	5-27	3-23	68	420	82	160	2	70	200	535
7101	74	1-24	54	368	415	425	455	490	650	2-9	Open	—	380	—	——	2	40	195	405
7127	75	3-11	62	324	385	390	410	465	650	6-6	3-23	84	452	82	157	1	25	240	525
		$\bar{x}$3-7	$\bar{x}$72.2		$\bar{x}$438	$\bar{x}$448	$\bar{x}$487	$\bar{x}$527	$\bar{x}$706		$\bar{x}$78 3-19	$\bar{x}$67 6-12	$\bar{x}$400	$\bar{x}$78	$\bar{x}$163	$\bar{x}$1.47	$\bar{x}$49	$\bar{x}$219	$\bar{x}$497

LOW LEVEL - RESTRICTED GRAZING

115	161	2-26	78	530	550	555	545	530	715	2-27	None	None	366	None	216	-	-20	170	535
123	162	3-6	84	440	460	475	490	470	640	3-8	----	----	367	——	——	-	10	150	470
135	163	3-11	72	460	470	475	450	460	620	2-18	----	----	344	——	180	-	-10	170	455
156	164	4-17	83	400	400	410	420	405	595	2-21	----	----	310	——	——	-	5	175	385
B243	165	2-8	77	435	450	485	470	480	640	2-21	----	----	378	——	196	-	30	170	455
B256	166	3-2	80	415	430	475	460	465	620	6-20	----	----	475	——	171	-	35	160	530
B265	167	3-5	59	370	385	390	400	405	560	7-23	----	----	505	——	204		20	160	520
B497	168	4-22	74	375	390	425	415	420	530	2-16	----	----	300	——	——	-	30	115	385
5104	169	2-13	70	440	440	450	460	445	620	6-18	----	----	490	——	169	-	5	160	550
5115	170	2-22	84	505	515	495	480	480	650	8-15	----	----	539	——	——	-	-35	170	650
5116	171	2-23	76	410	405	430	415	405	590	3-4	----	----	374	——	——	-	0	175	425
5154	172	4-25	74	380	395	410	400	400	585	1-12	----	----	262	——	215	-	5	185	375
6113	173	2-26	68	435	450	475	460	460	610	2-1	----	----	340	——	170	-	10	150	430
6142	174	4-2	74	410	415	440	430	440	580	8-15	----	----	500	——	——	-	25	150	580
7124	175	3-10	58	326	380	400	415	410	580	1-12	----	----	306	——	——	-	30	165	370
		$\bar{x}$3-11	$\bar{x}$74		$\bar{x}$436	$\bar{x}$453	$\bar{x}$447	$\bar{x}$445	$\bar{x}$609				$\bar{x}$390		$\bar{x}$190 7-9		$\bar{x}$11	$\bar{x}$162	$\bar{x}$474

MODERATE WINTERING LEVEL - CONTINUOUS GRAZING

Tattoo	Heifer No.	Birth Date	Birth Weight	Weaning Wt. 10-5	Wt. 10-26	Wt. 3-15	Wt. 4-17	Wt. 5-2	Wt. 8-14	1st Estrus Date	1963 Calving Date	Calf Birth Wt.	Age in Days at 1st Estrus	Year Day of Calving	Date of Conception	Services Per Conception	Winter Wt. Change lbs.	Summer Wt. Change lbs.	Wt. at Puberty
129	21	3-8	89	510	510	570	585	630	810	3-10	3-21	68	367	80	146	1	75	225	565
134	22	3-11	74	485	485	585	610	640	775	3-27	3-21	63	381	80	144	2	125	165	595
148	23	3-24	80	445	450	515	565	585	780	5-27	4-24	88	429	114	190	4	115	215	615
B233	24	3-16	77	410	425	500	515	555	725	5-25	4-24	66	435	114	182	4	90	210	625
B252	25	2-24	72	375	390	480	520	550	735	2-9	3-17	72	352	76	169	1	130	215	430
B400	26	2-22	55	365	380	425	455	460	660	8-4	Aborted	--	528	---	216	1	175	205	625
B495	27	3-27	73	370	385	460	500	535	680	1-22	2-25	62	301	56	143	1	115	180	410
5120	28	2-25	60	455	465	530	575	595	735	2-19	3-3	60	359	62	162	2	110	160	500
5126	29	3-1	70	460	455	415	445	480	705	1-19	4-5	74	324	95	180	1	90	260	425
5149	30	3-29	70	390	410	465	500	540	705	1-22	2-23	64	299	54	134	1	90	205	410
5150	31	3-29	78	410	400	515	510	580	760	12-28	2-20	74	275	51	138	1	110	250	395
6108	32	2-24	70	470	475	545	565	605	740	1-5	3-4	68	315	63	138	1	90	175	480
6111	33	2-25	64	455	470	560	610	635	800	2-3	3-4	64	343	63	144	1	140	190	490
6122	34	3-5	78	445	445	515	550	570	775	6-11	3-21	68	463	80	162	1	105	225	650
7111	35	2-24	78	386	425	495	540	555	665	3-25	2-25	68	394	56	135	1	115	125	510
		$\bar{x}$3-8	$\bar{x}$72.5		$\bar{x}$438	$\bar{x}$505	$\bar{x}$538	$\bar{x}$568	$\bar{x}$737	$\bar{x}$3-14		$\bar{x}$68.5	$\bar{x}$371	$\bar{x}$75 3-16	$\bar{x}$159 6-8	$\bar{x}$1.5	$\bar{x}$112	$\bar{x}$199	$\bar{x}$515

MODERATE LEVEL - RESTRICTED GRAZING

101	121	2-14	60	465	455	535	580	595	700	6-12	Open	--	484	--	---	2	125	120	655
133	122	3-10	76	505	510	630	690	705	800	1-10	2-21	60	306	57	139	1	180	110	515
B248	123	3-9	75	395	410	465	520	545	620	6-9	3-18	58	457	77	160	1	110	100	585
B260	124	2-28	80	495	510	610	670	700	840	2-25	Cow Died	--	362	--	133	1	160	170	590
B282	125	4-3	69	345	360	465	500	520	625	5-4	2-13	54	396	44	124	1	140	125	520
5102	126	2-11	78	495	500	515	550	585	710	3-31	3-14	76	413	73	154	2	50	160	535
5113	127	2-22	70	415	410	445	500	535	650	1-25	Open	--	338	--	---	4	90	150	405
5132	128	3-12	73	405	430	515	575	575	700	3-1	2-25	60	354	56	141	2	145	125	495
5148	129	3-29	78	400	400	510	550	575	725	2-27	3-15	74	335	74	156	1	150	175	480
6116	130	2-27	67	515	530	600	620	650	795	2-11	2-16	68	349	47	129	2	90	175	575
6118	131	3-2	79	450	445	565	615	620	730	1-30	3-8	60	334	67	141	1	170	115	490
6145	132	4-11	60	430	450	520	585	585	720	5-30	4-8	46	414	98	180	3	135	135	625
7102	133	2-12	57	333	405	480	515	530	650	6-13	4-1	56	486	91	164	1	110	135	610
7120	134	3-6	60	328	400	485	515	545	650	2-27	2-26	66	358	57	141	1	115	135	460
7140	135	3-22	56	295	350	445	500	515	640	6-9	3-14	64	444	73	160	1	150	140	570
		$\bar{x}$3-7	$\bar{x}$69.2		$\bar{x}$438	$\bar{x}$519	$\bar{x}$566	$\bar{x}$585	$\bar{x}$704	$\bar{x}$3-31		$\bar{x}$61.8	$\bar{x}$389	$\bar{x}$68 3-9	$\bar{x}$148 5-28	$\bar{x}$1.4	$\bar{x}$128	$\bar{x}$138	$\bar{x}$540.67

HIGH WINTERING LEVEL - CONTINUOUS GRAZING

Tattoo	Heifer No.	Birth Date	Birth Weight	Weaning Wt. 10-5	Wt. 10-26	Wt. 3-15	Wt. 4-17	Wt. 5-2	Wt. 8-14	1st Estrus Date	1963 Calving Date	Calf Birth Wt.	Age in Days at 1st Estrus	Year Day of Calving	Date of Conception	Services Per Conception	Winter Wt. Change lbs.	Summer Wt. Change lbs.	Wt. at Puberty
109	41	2-24	62	435	435	530	610	610	760	3-30	2-28	60	399	59	156	1	175	150	570
120	42	3-5	60	415	430	580	665	660	805	3-19	3-8	72	379	67	149	2	235	140	600
152	43	4-1	64	355	370	510	575	575	695	5-16	2-21	63	410	51	136	1	205	120	580
B235	44	3-14	81	410	425	570	655	650	840	5-29	3-10	58	442	69	176	5	230	185	714
B280	45	3-18	78	370	385	505	580	600	720	2-5	Open	--	323	--	---	4	195	140	430
B488	46	3-24	76	360	375	485	535	550	710	2-8	2-24	68	337	55	145	1	160	175	425
5106	47	2-18	78	495	520	520	660	735	845	1-10	2-28	72	326	59	165	1	205	120	540
5122	48	2-26	84	465	470	610	670	695	855	1-13	4-3	83	321	93	177	1	200	185	500
5128	49	3-5	79	380	390	510	600	640	815	5-24	3-14	70	414	73	144	1	210	215	650
5141	50	3-19	78	455	470	570	655	645	805	2-25	3-22	56	343	81	163	2	185	150	560
5143	51	3-26	92	520	525	675	750	755	940	1-10	3-3	68	290	62	138	1	245	190	560
6119	52	3-3	60	495	495	600	690	695	810	2-21	2-28	52	355	59	142	3	195	120	570
6123	53	3-6	76	465	465	625	695	705	850	3-18	3-8	80	377	67	161	1	230	155	630
7117	54	3-3	53	325	385	500	540	570	710	3-9	3-8	60	371	67	149	1	155	170	495
7129	55	3-11	59	352	420	530	595	610	755	1-12	3-8	54	307	67	151	1	175	160	430
		$\bar{x}$=3-10	$\bar{x}$=72		$\bar{x}$437	$\bar{x}$=564	$\bar{x}$=637	$\bar{x}$647	$\bar{x}$794		$\bar{x}$3-3	$\bar{x}$65.4	$\bar{x}$360	$\bar{x}$66 3-7	$\bar{x}$154 6-3	$\bar{x}$1.73	$\bar{x}$200	$\bar{x}$157	$\bar{x}$550.27

HIGH WINTERING LEVEL - RESTRICTED GRAZING

137	141	3-11	64	425	425	550	625	625	730	1-10	Open	--	305	--	---	3	200	105	440
145	142	3-23	82	470	470	565	650	675	780	4-13	2-23	78	375	54	159	1	180	130	635
150	143	4-1	66	410	410	560	610	620	690	2-13	3-3	74	318	62	146	2	200	80	525
157	144	4-25	78	365	365	460	525	540	645	5-20	3-1	48	390	60	140	1	160	120	565
B241	145	3-17	80	435	450	615	695	740	840	1-13	2-28	65	312	59	137	1	245	145	510
B247	146	3-9	80	420	435	635	705	725	820	2-5	3-8	84	333	67	146	1	270	115	540
B281	147	3-20	79	340	355	480	550	570	645	4-1	2-27	70	376	58	148	2	195	95	515
B489	148	2-8	70	425	440	545	620	650	750	1-14	3-6	60	340	65	147	2	180	130	495
5121	149	2-25	82	495	505	675	725	730	845	2-28	3-6	63	368	65	147	2	220	120	645
5123	150	2-26	80	445	465	560	635	635	705	2-24	3-8	66	363	67	146	1	170	70	545
5124	151	2-28	68	440	460	590	635	635	735	1-22	2-18	72	328	49	134	1	175	100	515
5137	152	3-14	66	435	440	570	660	660	740	1-24	2-21	60	316	51	134	2	220	80	490
6101	153	2-8	70	470	470	645	715	715	770	1-24	2-12	67	350	42	129	1	245	55	550
6102	154	2-10	60	515	505	595	680	680	765	1-4	2-15	54	328	46	132	1	175	85	520
7155	155	4-14	63	293	375	500	565	580	675	5-13	2-26	?	394	57	133	2	190	110	590
		$\bar{x}$3-11			x438	$\bar{x}$570	$\bar{x}$640	$\bar{x}$652	$\bar{x}$742		$\bar{x}$2-26	$\bar{x}$66.2	$\bar{x}$346	$\bar{x}$57 2-26	$\bar{x}$141 5-21	$\bar{x}$1.53	$\bar{x}$202	$\bar{x}$102	$\bar{x}$538.67

VITA

James Marvin Dugger

Candidate for the Degree of

Master of Science

Thesis: THE REPRODUCTIVE PERFORMANCE OF HEREFORD HEIFERS ON DIFFERENT LEVELS OF WINTER FEEDING AND SUMMER GRAZING

Major Field: Animal Science

Biographical:

Personal Data: Born at Mazie, Oklahoma, June 15, 1923, the son of Mr. and Mrs. Dick Dugger. Married Ninah McReynolds June 6, 1948 and have two children, Richard and Judith.

Education: Received the Bachelor of Science degree from Oklahoma State University, Stillwater, Oklahoma, in May, 1949 with a major in Animal Science.

Experience: On the farm training instructor 1949-1950. Herdsman at Red Oak Farms, Rocky Comfort, Mo., 1951. Herdsman at C. T. Ranch, Miami, Oklahoma 1952-1954. Manager of Sieteco Angus Farm, Broken Arrow, Oklahoma 1955-1956. Assistant Manager of Angus Valley Farms, Tulsa, Oklahoma 1957-1965. Beef Herdsman at Oklahoma State University 1966-1972.