JULY, 1924 BULLETIN 233

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE AGRICULTURAL COLLEGE

MANHATTAN, KANSAS

THE RELATION OF FEEDING AND AGE OF CALVING TO THE DEVELOPMENT OF DAIRY HEIFERS

PRINTED BY KANSAS STATE PRINTING PLANT
B. P. WALKER, STATE PRINTER
TOPEKA 1924
10-3555

SUMMARY.

1. Exclusive feeding of alfalfa hay failed to produce a satisfactory development of Holstein heifers, nor did it prove an economical feed for the production of milk.

2. Alfalfa hay and corn silage failed to produce an entirely satisfactory development of Holstein heifers, and these feeds were not sufficient for the maximum or the most economical production of milk.

3. Alfalfa hay, silage, and grain constituted the best ration tried for growth and milk production.

4. Animals bred to calve at 24 months of age did not develop as well as the animals on the same feed bred to calve at 30 months of age. However, their milk-producing ability was not affected by early calving.

5. No specific injurious effects upon the ability of the animals to reproduce were noted due to feeding Holstein heifers alfalfa hay exclusively from six months of age through two lactation periods.

6. The inadequate development and low production of the animals that were not fed grain was perhaps due to their inability to consume sufficient roughage to supply the necessary energy.

7. From the results of this experiment it appears that a more economical method of raising Holstein heifers would be essentially the plan followed in Lot III with grain eliminated from the ration from weaning time until within three or four months of freshening.

TABLE OF CONTENTS.

THE RELATION OF FEEDING AND AGE OF CALVING TO THE DEVELOPMENT OF DAIRY HEIFERS.[1]

O. E. REED,[2] J. B. FITCH, AND H. W. CAVE.

PRELIMINARY STATEMENT.

There is a wide range of conditions under which profitable dairy animals can be produced. Satisfactory methods of feeding and caring for cows producing milk have become fairly well established, but methods of handling dairy heifers up to the time of freshening are not so well standardized.

Many factors influence the development of a heifer into a profitable dairy cow. One of the most important, probably, is the inherent tendency to produce milk. It is perhaps this factor which causes some heifers to become profitable cows, even when mistreated during the growing period and when they do not conform to accepted standards of size and appearance at calving time.

Other factors that may influence the value of a dairy heifer are: Feed, age at freshening, size of animal, and care of animal. All are closely associated and are influenced to some extent by the breed of the animal. The price of feeds will not only determine in part the kind of feed used, but also affect the amount used. Feed prices, therefore, are important factors in the development of dairy heifers.

FINDINGS OF PREVIOUS INVESTIGATORS.

That there is a wide diversity of opinion regarding the handling of dairy heifers among breeders of dairy animals has been pointed out by Eckles [3] from information obtained through a questionnaire answered by 301 breeders. While these breeders would undoubtedly have agreed to certain generally accepted principles of feeding cows, there were wide differences of opinion as to the methods of feeding heifers.

The factors that influence the development of dairy heifers are difficult to measure on account of the length of the growing period

1. Contribution No. 48 from the Department of Dairy Husbandry.

2. From the beginning of the experimental work herein reported, July 1, 1914, to August 1, 1918, the senior author was in charge of the Department of Dairy Husbandry, Kansas Agricultural Experiment Station.

3. Eckles, C. H. The ration and age of calving as factors influencing the growth and dairy qualities of cows. Mo. Agr. Expt. Sta. Bul. 135:1-91. Figs. 26. 1915.

and of the absence of definite standards of comparison. As a result of the questionnaire mentioned above, Eckles started investigations in 1906, which have been of great value in obtaining a definite knowledge of the factors influencing the growth of dairy heifers.

His conclusions were that it is possible to influence the rate of growth, size when mature, and type, to some extent, by the liberality of the ration during the growing period and by the age at first calving. Within limits of variation, even far beyond the normal, the character of the ration with reference to amount of nutrients supplied does not exert any appreciable effect upon the milking functions of the cow when mature. The age at first calving is a factor of some importance with reference to development of the milking functions of the cow. Calving at an extremely early age is detrimental to the best development of the milking function, while nothing is gained by too great delay.

Woll,[4] of the California Agricultural Experiment Station, fed alfalfa hay and green alfalfa to dairy heifers beginning at one and one-half years of age. They were fed through two lactation periods and their growth, production, and calving records compared with those fed alfalfa hay, silage, and grain. The mixed ration supplied 2.08 pounds digestible true protein and 15.4 therms of energy daily, while alfalfa supplied 2.05 pounds digestible true protein and 9.9 therms energy daily. The heifers on the mixed ration gained more rapidly, were larger when they calved, and produced more butterfat in the two lactation periods during which records were kept.

Woll found no evidence to support the belief that there is any connection between an exclusive alfalfa diet and abortion or sterility. Haring,[5] of the California Agricultural Experiment Station, had previously investigated this question and likewise found no evidence against alfalfa.

Foster and Latta,[6] of the New Mexico Agricultural Experiment Station, compared alfalfa hay alone with alfalfa hay and grain for milk production for two 30-day periods. The cows fed grain produced 13.7 per cent more milk, and made an average gain in weight of 171 pounds, as compared with a gain of 93 pounds per cow for those fed alfalfa hay alone.

---

4. Woll, F. W. Alfalfa as a sole feed for dairy cows. Jour. Dairy Sci., Vol. 1, No. 6, pp. 447-461. 1918.

5. Haring, C. M. Report of California Agricultural Experiment Station, year ending June 30, 1915. *In* Ann. Rpt. of Director, pp. 1-76. Reference, p. 34.

6. Foster, Luther, and Latta, R. W. Economic feeding for milk production in New Mexico. New Mex. Agr. Expt. Sta. Bul. 98:1-34. Reference, Part II, Alfalfa plus grain versus alfalfa alone. p. 18.

Foster and Meek,[7] of the New Mexico Agricultural Experiment Station, fed two groups of cows through four 25-day periods, using the reversal method to compare alfalfa and grain with alfalfa, silage, and grain. They concluded as a result of their experiment that "the addition of a 30-pound ration of corn silage to an alfalfa hay and grain ration made a saving of 30 per cent of the hay, but it did not reduce the cost of the ration. It required three tons of silage to replace the one ton of alfalfa hay. Considering the hay at $10 per ton and the silage at $3.50 per ton, there was little difference in the cost of the two rations. But the milk production of the alfalfa ration was 4 per cent greater than that of the silage ration, and the butter production, 2.4 per cent greater."

In a few instances the experimental work herein reported may be comparable to the experimental work done by Eckles. One phase of the work herein reported may be analogous also to the work reported by Woll.

PLAN OF EXPERIMENT.

The experiment was started early in July, 1914, with four groups of grade Holstein heifers. The chief factors under consideration were: (1) The effect of the exclusive feeding of alfalfa hay, and alfalfa hay and corn silage on heifer development, and (2) a comparison of the size and milk production of heifers calving at 24 months of age with those calving at 30 months of age.

Rations Fed.—The heifers were fed their mothers' milk for the first week of their lives, after which they received herd milk for four weeks and were then gradually changed to skim milk. They were fed 16 pounds of skim milk daily up to the age of six months, when the feeding of milk was discontinued.

The heifers in Lot I were fed alfalfa hay in addition to the milk, beginning at two weeks of age, the amounts depending upon their appetite. After six months of age they received alfalfa hay exclusively.

The heifers in Lot II were started on alfalfa hay at about the same age as those in Lot I, and on silage as soon as they would eat it. However, until three months of age, they consumed but very little silage. The amount of silage eaten materially increased when they were taken from milk at six months of age.

The heifers in Lots III and IV were started on alfalfa and grain at two weeks of age and were started on silage as soon as they would

7. Foster, Luther, and Meeks, J. R. Dairy cow feeding experiments. New Mex. Agr. Expt. Sta. Bul. 122:1-40. Referente, Experiment No. 2, Corn silage versus alfalfa hay. p. 25. 1920.

eat it. Some of the calves ate silage at one month of age, but in most cases they were three to four months old before they ate it readily. It was not until the skim milk was removed from the ration that they ate as much as two pounds per head per day. The grain mixture used was made up of 400 pounds of corn chop, 200 pounds of wheat bran, and 100 pounds of old process linseed oil-meal. All lots were fed in a barn and turned into a dry lot during the day.

Feed Records.—The amount of feed consumed by each animal was recorded. The alfalfa hay fed to each calf was weighed in amounts sufficient to last for several days and placed in a covered box to be fed as needed. The alfalfa hay was all ground before being fed. The grain for each calf was weighed out into buckets and the animals fed from the buckets. When the animals became older these feeds were weighed at each feeding, as were the silage and the milk fed. Any unused feed was weighed back.

Composition of Feeds.—To determine the composition of the feeds used a six months' composite of the alfalfa hay, linseed oil-meal, corn chop, bran, and of the entire grain mixture was taken. A small amount of alfalfa for the composite was taken at the time of grinding the hay. A small amount of the other feeds was taken each time a batch of feed was mixed.

Salt.—The animals had salt before them at all times, salt rolls or salt bricks being used for this purpose.

Body Measurements.—In order to record the development of the animals they were measured soon after birth and for each month thereafter. The following measurements were taken: Height of withers, width of hip joints, width of pin bones, heart girth, and barrel girth. The measurements were made monthly. Two sets of animal calipers and a tape line were used to make the measurements. An average of three readings was taken, when the animal was in a normal posture, for each measurement. These measurements were taken as nearly as possible under the same conditions each time. After two measurements of the height of withers were made, the animal was moved and a third measurement taken. The measurements were reported in inches.

Body Weights.—The animals mere weighed at birth and at the time of the monthly measurements. The monthly weights were recorded on two successive days. In case the two weights varied more than 20 pounds the animal was weighed again on the third day, the

average of the three being recorded as the weight for the month. All weights were taken at 9 a. m.

Experimental Notes. — In addition to the records noted above, any irregularities in the feed and management of the animals or in their condition were noted.

Feed Prices. — In tables where feed costs are given the following prices were used: Whole milk, 25 cents per gallon; skim milk, 40 cents per hundred pounds; grain mixture, $1.50 per hundred pounds; alfalfa hay, $10 per ton; corn silage, $3.50 per ton.

Calving Periods. — It was planned to have the heifers calve as nearly as possible twelve months after the first calving, and to have them dry one and one-half to two months. The heifers in Lots I, II, and III were bred to drop their first calves at 30 months of age. The heifers in Lot IV were bred to calve at 24 months of age.

Production Records. — The milk and fat produced during the first ten months of each of two lactation periods were used as the basis for comparing the different lots. The milk was weighed at each milking. The per cent of butterfat was determined by taking a five-day composite sample near the middle of each month. At the end of the experimental period two representatives of each lot were placed in the regular herd and handled in a normal manner for one lactation period.

Photographs. — Photographs were taken of the calves soon after birth and at six-month periods thereafter. They were taken with the camera at a fixed distance from the animal. This distance was determined by placing the animal so that the side next to the camera was on a line between two permanent stakes.

Heifers Used. — The heifers used in this experiment were obtained from the grade Holstein cows in the college herd and from the grade Holstein cows in the dairy herd at the Fort Hays Branch Experiment Station. The heifers in the various lots were divided as nearly as possible on the basis of breeding and ancestral records. The numbers assigned to each lot, their daily ration, their sires, dams, and dates of birth were as follows:

SIRE, DAM, AND DATE OF BIRTH OF EACH HEIFER USED IN THE EXPERIMENT.

LOT I. Ration: Alfalfa hay.

Heifer No.	Sire (a).	Dam.	Date of birth.
51	Gerben	No. 24	July 3, 1914
52	Carlotta	No. 15 (Hays)	Oct. 17, 1914
53	Carlotta	No. 10 (Hays)	Nov. 1, 1914
54	Canary Paul	No. 16	Nov. 17, 1914
55	Canary Paul	No. 16 (Hays)	Nov. 1, 1915
56	Maid Henry	No. 41	Dec. 12, 1915

LOT II. Ration: Alfalfa and silage.

60	Gerben	No. 19	Aug. 14, 1914
61	Carlotta	No. 6 (Hays)	Sept. 25, 1914
62	Carlotta	No. 5 (Hays)	Oct. 23, 1914
63	Canary Paul	No. 17 (K. S. A. C.)	Mar. 14, 1915
64	Canary Paul	No. 8 (Hays)	Nov. 30, 1915
65	Maid Henry	No. 9	Dec. 15, 1915

LOT III. Ration: Alfalfa hay, silage, and grain.

70	Gerben	No. 37	Sept. 1, 1914
71	Carlotta	No. 2 (Hays)	Sept. 24, 1914
72	Carlotta	No. 17 (Hays)	Oct. 24, 1914
73	Canary Paul	No. 6 (Hays)	Oct. 7, 1915
74	Maid Henry	No. 16	Jan. 5, 1916
75	Canary Paul	No. 9-3 (Hays)	Jan. 3, 1916

LOT IV. Ration: Alfalfa, silage, and grain.
(Bred to calve at 24 *months*)

81	Maid Henry	No. 12 (Hays)	Sept. 29, 1915
82	Canary Paul	No. 15 (Hays)	Oct. 14, 1915
83	Canary Paul	No. 163 (Hays)	Dec. 29, 1915
84	Canary Paul	No. 183 (Hays)	Dec. 30, 1915
85	Canary Paul	No. 22	Mar. 17, 1916
86	Carlotta	No. 11	Oct. 21, 1916

(a) The full names of sires used are as follows:
Gerben—Goldenrod Kalmuck Gerben, 93170.
Carlotta—Sir Carlotta Pontiac Cronus, 45502.
Canary Paul—Canary Paul Fobes Homestead 6th, 117086.
Maid Henry—Maid Henry Pontiac De Kol, 126159.

TABLE I.—Pounds of feed consumed by each animal previous to calving.

HEIFER No.	First year.					Second year.			Total to date of calving.		
	Whole milk.	Skim milk.	Alfalfa hay.	Corn silage.	Grain.	Alfalfa hay.	Corn silage.	Grain.	Alfalfa hay.	Silage.	Grain.
LOT I.											
51	508.0	2,466.0	2,660.0	.....	.....	6,444.9	.....	.....	12,761.9	.....	.....
52	488.0	2,146.0	2,735.8	.....	.....	6,075.7	.....	.....	13,682.3	.....	.....
53	384.0	2,293.0	3,075.9	.....	.....	5,931.0	.....	.....	12,466.9	.....	.....
54	372.0	2,320.0	2,959.0	.....	.....	5,052.0	.....	.....	11,950.6	.....	.....
55	390.0	2,337.0	2,732.4	.....	.....	6,044.3	.....	.....	13,008.7	.....	.....
56	380.0	2,602.0	2,145.0	.....	.....	4,906.9	.....	.....	13,639.4	.....	.....
Average	420.3	2,360.7	2,718.0	.....	.....	5,742.5	.....	.....	12,918.3	.....	.....
LOT II.											
60	376.0	2,453.0	2,897.0	444.0	.....	5,352.0	2,256.0	.....	12,342.0	5,205.1	.....
61	336.0	2,348.0	2,952.0	670.0	.....	5,274.0	2,489.0	.....	11,194.0	5,200.0	.....
62	396.0	2,360.0	2,696.1	808.8	.....	4,931.6	2,588.4	.....	10,232.0	5,484.2	.....
63	354.0	2,231.0	2,119.8	912.0	.....	4,047.2	3,384.2	.....	8,524.0	8,252.2	.....
64	372.0	2,394.0	1,850.9	833.5	.....	3,781.4	5,188.0	.....	7,730.0	10,619.2	.....
65	372.0	2,604.0	1,711.0	839.5	.....	3,288.3	4,535.6	.....	7,940.8	10,717.7	.....
Average	367.7	2,398.0	2,371.0	751.3	.....	4,445.7	3,406.8	.....	9,658.6	7,579.6	.....
LOT III.											
70	436.0	2,398.0	2,934.0	548.0	347.0	5,304.0	2,363.0	1,035.9	10,229.0	4,319.0	1,937.9
71	345.0	2,359.0	3,809.0	676.0	371.4	4,108.0	2,498.0	1,041.0	8,844.0	4,954.0	2,159.4
72	378.0	2,357.0	2,840.0	747.9	435.7	4,764.0	2,470.0	1,085.0	9,739.0	5,136.4	2,266.7
73(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
74	305.0	2,410.0	1,356.5	1,121.9	754.0	3,071.0	5,295.7	1,095.0	5,476.0	8,560.8	2,559.9
75	305.0	2,416.0	1,438.6	1,181.0	752.4	3,646.0	5,472.4	1,107.6	6,241.0	8,982.1	2,668.6
Average	354.0	2,388.0	2,275.6	855.0	532.1	4,178.6	3,619.8	1,072.9	8,085.7	6,423.7	2,184.8
LOT IV.											
81	350.0	2,879.0	1,676.0	556.0	556.0	3,392.0	4,089.0	1,176.0	5,462.0	5,466.0	1,828.0
82	350.0	2,283.0	1,227.0	622.0	615.0	3,284.0	4,401.0	1,156.0	4,625.0	5,296.0	1,811.0
83	350.0	2,400.0	1,487.0	1,025.5	769.3	3,592.5	5,412.8	1,106.5	5,512.5	7,223.3	1,997.8
84	350.0	2,400.0	1,503.0	1,058.0	766.0	3,225.0	5,183.6	1,109.5	4,728.0	6,241.6	1,875.5
85	360.0	2,432.0	1,516.2	1,310.7	857.0	3,616.5	6,032.1	1,033.0	5,962.7	8,923.0	2,127.0
86	350.0	2,304.0	1,743.9	2,175.0	685.5	3,415.8	5,273.1	982.0	6,057.2	9,364.6	1,896.5
Average	351.7	2,449.7	1,525.5	1,124.5	708.2	3,421.0	5,065.3	1,093.7	5,480.1	7,265.0	1,947.1

(a) No. 73 failed to breed; sold.

TABLE II.—Cost of feed consumed by each animal previous to calving.

HEIFER NO.	First year.	Second year.	Total for two years.	Total previous to calving.
	LOT I.			
51	$37.93	$32.22	$70.15	$88.43
52	35.69	30.38	66.07	90.42
53	34.38	29.65	64.03	81.33
54	34.87	25.26	60.13	89.83
55	31.34	30.22	61.56	82.72
56	28.11	24.55	52.64	85.58
Average	$33.72	$28.71	$62.43	$86.39
	LOT II.			
60	$35.99	$30.71	$66.70	$91.54
61	32.99	30.60	63.59	81.89
62	35.84	29.19	65.03	81.60
63	31.38	25.64	57.02	75.72
64	31.10	27.99	59.09	77.58
65	31.28	24.38	55.66	79.72
Average	$33.10	$28.09	$61.18	$81.34
	LOT III.			
70	$44.09	$46.18	$90.27	$111.00
71	38.15	40.53	78.68	102.63
72	39.28	44.22	83.50	108.71
74	36.56	41.07	77.63	91.77
75	37.07	44.42	81.49	97.04
Average	$39.03	$43.28	$82.31	$102.23
	LOT IV.			
81	$39.35	$41.75	$81.10	$85.98
82	39.23	41.47	80.70	82.35
83	40.52	44.03	84.55	89.92
84	38.91	41.84	80.75	80.75
85	42.93	44.14	87.07	97.54
86	42.17	41.04	83.21	94.49
Average	$40.52	$42.38	$82.90	$88.51

EXPERIMENTAL RESULTS.

EFFECT OF RATION ON EARLY GROWTH AND DEVELOPMENT.

Table I shows the amount of feed consumed by each animal and Table II the cost of feed consumed by each animal previous to calving.

It will be noted that the amount of whole and of skim milk given the animals after being taken from their dams was fairly constant, the average amount of whole milk ranging from 351.7 pounds in Lot IV to 367.7 pounds in Lot I, and the amount of skim milk from 2,360 pounds in Lot I to 2,449 pounds in Lot IV. There was a greater difference in the amount of alfalfa hay eaten, due to the fact that not all of the lots received hay and silage.

There was a slight difference in the feed consumed by Lots III and IV during the first year, Lot IV having consumed slightly more skim milk, grain, and silage, but less hay. This difference in feeding was only temporary and may be due to a change in the feeder, as it does not show up in the other lots, nor is it true of the second year of feeding for this lot. In fact, this lot is noticeably low in hay and high in silage during the second year.

As would be expected, Lot I, on alfalfa hay alone, consumed more hay than any of the other lots, consuming, on the average, 12,918 pounds of alfalfa hay. The quantity, however, is less than that of alfalfa hay and silage consumed in Lot II. The average consumption of hay and silage in Lot II is greater than for Lot III, but not sufficient to offset the 2,184.8 pounds of grain fed, on the average, in Lot III. It appears that the total amount of feed fed during the second year increased with each succeeding group from Lot I to Lot IV. Since the animals in Lot IV were bred to calve at two years of age instead of 30 months, they were fed somewhat heavier as they approached calving.

It will be noted that the cost of raising the heifers was lowest in Lot II, fed alfalfa hay and corn silage, and highest in Lot III, fed alfalfa hay, silage, and grain. The animals in Lot I, fed alfalfa hay exclusively, ranked second in cost of production.

Table III gives the weight at birth, the weight at one year of age and at two years of age, the amount of weight gained during each year, the average daily gain, and the cost per pound of gain for each heifer. The gain in weight of the heifers up to one year of age was made at the lowest cost in Lot III and at the highest in Lot I, Lot IV ranking second. During the second year the cost per pound of

TABLE III.—Gain in weight and cost of gain in weight for each heifer.

HEIFER No.	Weight at birth.	Weight at end of first year.	Gain.	Average daily gain.	Cost per pound of gain.	Weight at end of second year.	Gain.	Average daily gain.	Cost per pound of gain.
				LOT I.					
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*	
51	92	506	414	1.13	$0.0916	848	342	0.94	$0.0942
52	77	424	347	.95	.1028	782	358	.98	.0848
53	90	465	375	1.03	.0917	783	318	.87	.0932
54	86	426	340	.96	.1026	755	329	.93	.0745
55	96	421	325	.89	.0964	783	362	.99	.0843
56	87	339	252	.69	.1115	649	310	.85	.0790
Average	88	430	342	0.94	.0986	767	337	0.93	$0.0852
				LOT II.					
60	81	487	406	1.11	$0.0886	853	366	1.00	$0.0839
61	80	488	408	1.12	.0809	865	375	1.03	.0816
62	78	456	378	1.04	.0948	815	359	.98	.0813
63	86	472	386	1.06	.0813	778	306	.87	.0838
64	98	399	301	.82	.0779	779	380	1.04	.0737
65	94	354	260	.71	.1203	723	369	1.01	.0661
Average	86	443	357	0.98	$0.0927	802	359	0.98	$0.0782
				LOT III.					
70	93	605	512	1.40	$0.0861	1,090	485	1.33	$0.0952
71	85	531	446	1.22	.0855	940	409	1.12	.0991
72	83	556	473	1.30	.0830	983	427	1.17	.1035
74	98	538	440	1.27	.0831	1,025	487	1.33	.0843
75	76	598	522	1.43	.0708	1,035	437	1.20	.1017
Average	87	566	479	1.31	$0.0809	1,015	449	1.23	$0.0964
				LOT IV.					
81	85	516	431	1.18	$0.0913	986	470	1.29	$0.0888
82	83	529	446	1.22	.0880	1,062	533	1.46	.0778
83	82	520	438	1.20	.0925	1,121	601	1.65	.0732
84	79	549	470	1.29	.0826	1,039	490	1.34	.0854
85	100	574	474	1.30	.0906	1,089	515	1.41	.0857
86	100	576	476	1.30	.0886	1,047	471	1.29	.0871
Average	88.2	544	456	1.25	$0.0889	1,057	515	1.41	$0.0826

gain was highest in Lot III, lowest in Lot II, followed by Lots IV and I, respectively.

Up to one year of age the gain in weight of the heifers and the average daily gain were less for Lot I than for the other lots. The animals in Lot III made the greatest gain in weight to one year of age and had the highest daily gain for this period. Lot IV was second and Lot II third.

During the second year Lot IV made the greatest gain; Lot III, second; Lot II, third; and Lot I the least gain. The fact that the animals in Lot IV were bred to calve at two years of age may account for their advantages in weight for this period.

The average birth weights of the heifers in the different lots varied but little, ranging from 86.2 pounds to 88.2 pounds. A difference becomes apparent at the age of 6 months and this becomes more pronounced at 18 and 24 months of age. After this age the influence of gestation causes the weights to vary and apparently cuts down the differences among the lots.

The average body measurements and weights of the heifers in each lot taken soon after birth and at approximately each six months thereafter are given in Table IV.

The heifers in Lot I developed much less rapidly than those in the other lots, especially those in Lots III and IV. This is shown clearly by the differences in weight, heart girth, and barrel girth and to a lesser degree by the height of withers, width of hips, and width of pin bones. At two years of age, for example, Lot I averaged 766.5 pounds per animal as compared with 802 pounds for Lot II, 1,014.6 pounds for Lot III, and 1,076.4 pounds for Lot IV. In all body measurements at this age Lot I ranked lowest or next to the lowest of the four lots. They appeared to be less thrifty than the other lots, and while their handling qualities indicated a thinner skin its condition was not as good as that for the other lots.

Two typical animals from each lot are shown in figures 1 to 8. Three pictures of each animal are shown, taken at approximately 6 months, 24 months, and 48 months of age. Figures 1 and 2 present representative animals from Lot I, fed on alfalfa hay alone. At 48 months of age the animals in this lot averaged 50.9 inches in height and 998 pounds in weight. Figures 3 and 4 present representative animals from Lot II, fed on alfalfa hay and silage. At 48 months of age the animals in this lot averaged 52.2 inches in height and 1,037 pounds in weight. Figures 5 and 6 present representative animals from Lot III, fed on alfalfa hay, silage, and grain. At 48

months of age the animals in this lot averaged 53.4 inches in height and 1,161 pounds in weight. Figures 7 and 8 present representative animals from Lot IV, fed the same as those in Lot III but bred to calve at 24 months of age. At 48 months of age the animals in this lot averaged 51.1 inches in height and 1,087 pounds in weight.

TABLE IV.—Average body measurements and weights of experimental heifers.

AGE.	Number.	Height of withers.	Heart girth.	Barrel girth.	Weight.	Width of hips.	Width of pin bones.
			LOT I.				
		Inches.	*Inches.*	*Inches.*	*Pounds.*	*Inches.*	*Inches.*
Birth (*a*)	6	30.1	33.4	34.7	88.0	7.0	3.1
6 mos.	6	38.7	45.7	56.2	322.1	11.1	4.2
12 mos.	6	42.0	50.9	64.2	430.2	13.7	4.8
18 mos.	6	45.8	57.0	70.7	599.8	15.7	5.8
24 mos.	6	48.2	62.6	77.4	766.5	17.6	6.2
30 mos.	6	49.4	65.0	83.2	911.5	19.0	7.0
36 mos.	6	49.9	66.3	81.5	870.7	19.5	6.9
42 mos.	6	50.7	67.2	84.1	951.5	20.2	7.1
48 mos.	6	50.9	68.9	85.9	997.8	20.7	7.0
54 mos.	6	51.0	69.3	86.4	987.3	21.1	7.2
60 mos.	5	51.3	70.3	88.1	1,058.9	21.3	7.3
			LOT II.				
Birth (*a*)	6	30.5	33.2	34.4	86.2	6.9	3.0
6 mos.	6	38.6	45.0	55.0	306.1	10.9	4.1
12 mos.	6	42.8	51.8	64.0	442.7	13.4	4.9
18 mos.	6	46.7	58.5	70.6	643.9	15.9	5.9
24 mos.	6	49.2	64.9	76.5	802.0	17.5	6.8
30 mos.	6	50.6	70.1	88.6	1,061.4	19.5	7.2
36 mos.	4	51.3	67.4	78.5	874.0	19.7	7.1
42 mos.	3	51.8	69.3	85.0	998.3	20.0	7.3
48 mos.	3	52.2	70.5	83.6	1,036.7	20.9	7.2
54 mos.	3	52.7	71.5	84.0	1,047.3	21.1	7.4
60 mos.	3	52.5	71.4	90.3	1,155.9	21.4	7.4
			LOT III.				
Birth (*a*)	5	30.3	33.1	35.6	87.0	6.9	3.1
6 mos.	5	39.6	47.6	57.4	346.2	11.1	4.2
12 mos.	5	44.8	56.8	69.3	565.5	14.4	5.4
18 mos.	5	48.7	64.5	76.6	800.2	17.0	6.5
24 mos.	5	50.6	70.8	84.8	1,014.6	18.6	7.1
30 mos.	5	51.7	72.7	85.4	1,090.3	20.1	7.6
36 mos.	5	52.3	72.7	86.3	1,076.0	20.4	7.4
42 mos.	5	52.9	74.7	88.4	1,201.5	21.1	7.5
48 mos.	5	53.4	75.1	86.5	1,161.1	21.6	7.3
54 mos.	5	53.3	73.8	87.4	1,167.3	21.6	7.6
60 mos.	4	53.2	75.1	90.0	1,250.4	21.8	7.6
			LOT IV.				
Birth (*a*)	6	31.2	34.7	38.1	88.2	7.6	3.0
6 mos.	6	39.1	47.0	56.2	340.5	11.3	4.0
12 mos.	6	44.4	55.9	67.3	557.0	14.4	5.4
18 mos.	6	48.3	64.3	75.7	806.0	17.1	6.3
24 mos.	6	50.3	70.6	88.1	1,076.4	19.2	7.0
30 mos.	6	51.2	69.9	83.4	1,009.5	19.8	7.3
36 mos.	6	51.4	71.7	86.5	1,069.8	20.6	7.2
42 mos.	4	50.8	72.4	85.4	1,032.4	20.4	7.3
48 mos.	4	51.1	72.6	87.7	1,087.5	20.8	7.1
54 mos.	3	51.1	75.1	94.4	1,266.8	21.5	7.4

(*a*) Except weights, which were taken at birth, the average age at which first measurements were taken is as follows: Lot I, 2.7 weeks; Lot II, 3.2 weeks; Lot III, 2.8 weeks; and Lot IV, 5.1 weeks.

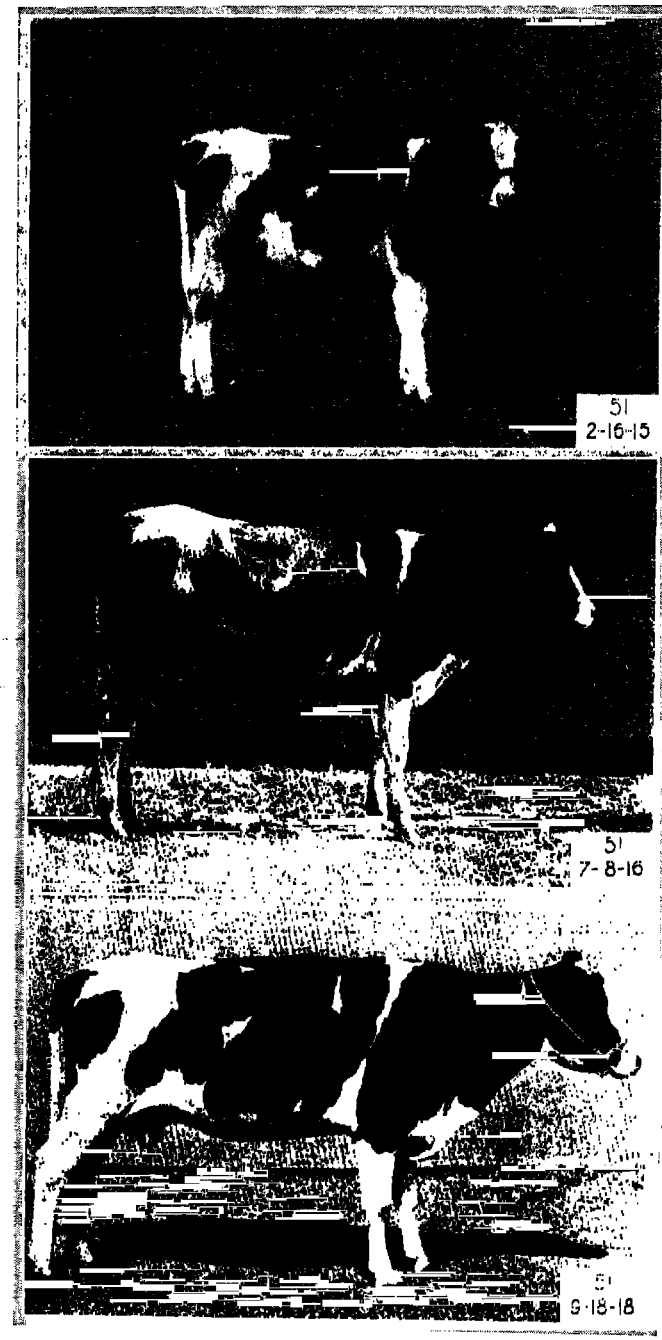

FIG. 1.—A representative of Lot I at approximately 6 months, 24 months, and 48 months of age.

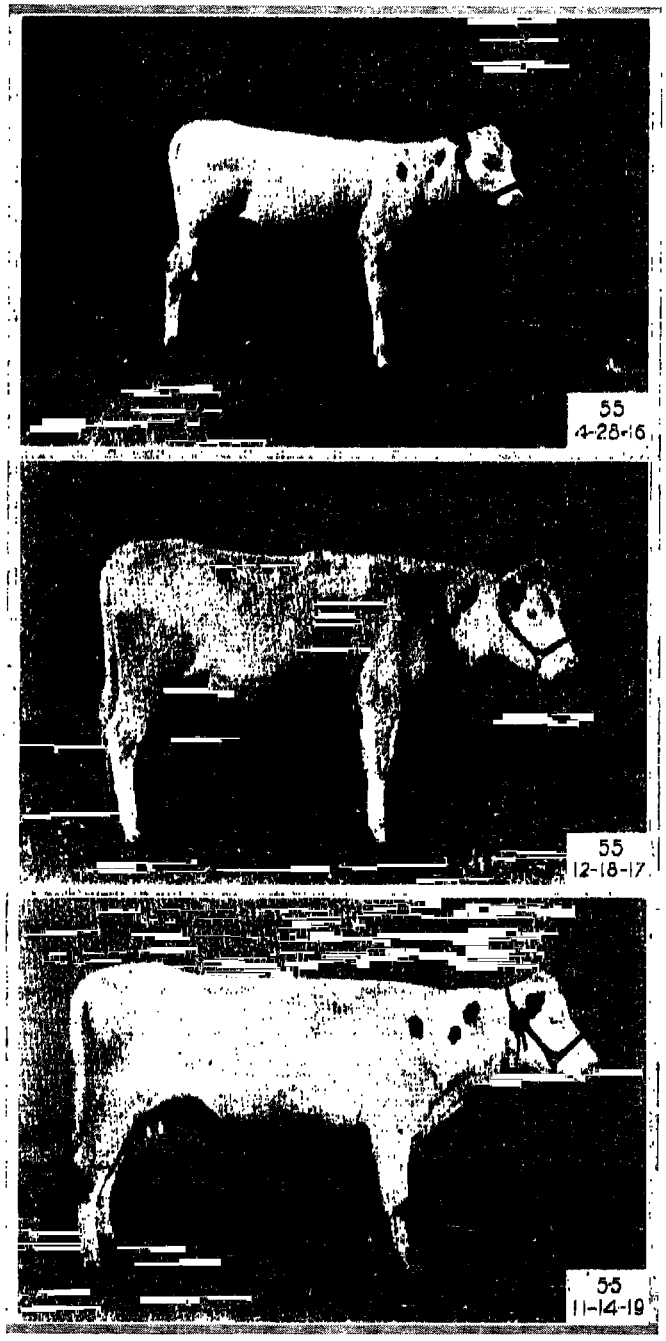

FIG. 2.—A representative of Lot I at approximately 6 months, 24 months, and 48 months of age.

FIG. 3.—A representative of Lot II at approximately 6 months, 24 months, and 48 months of age.

FIG. 4.—A representative of Lot II at approximately 6 months, 24 months, and 48 months of age.

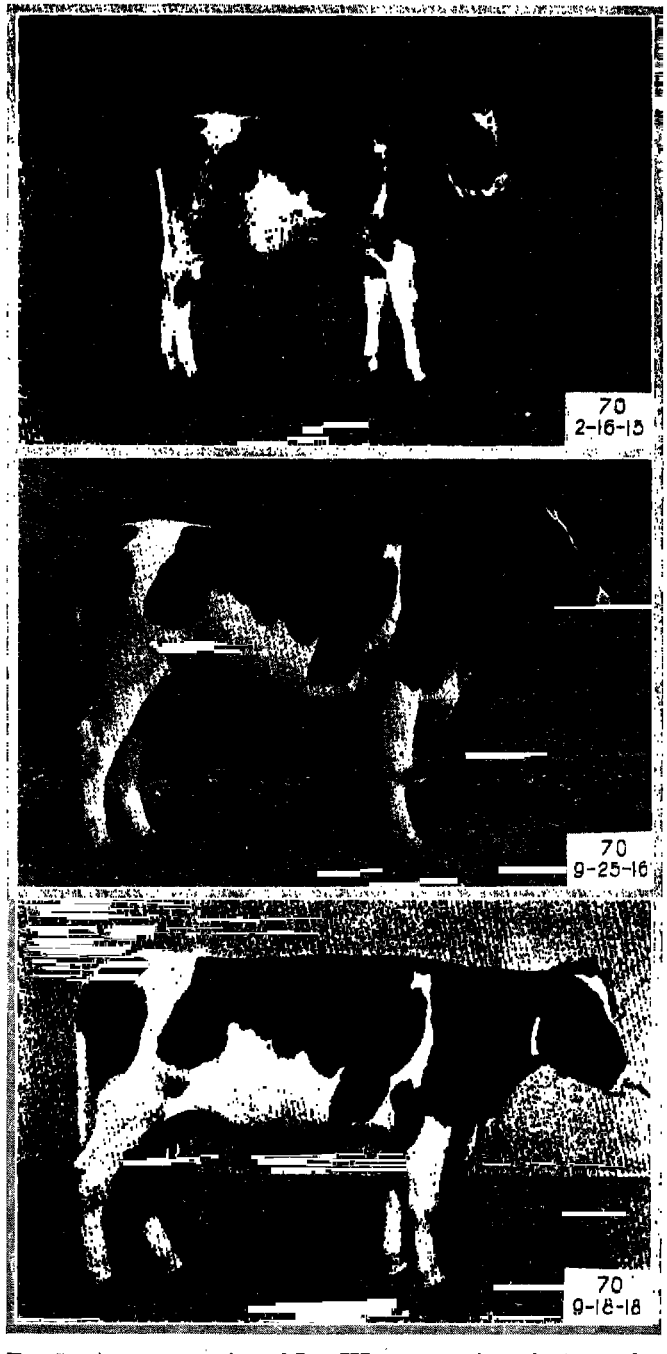

FIG. 5.—A representative of Lot III at approximately 6 months, 24 months, and 48 months of age.

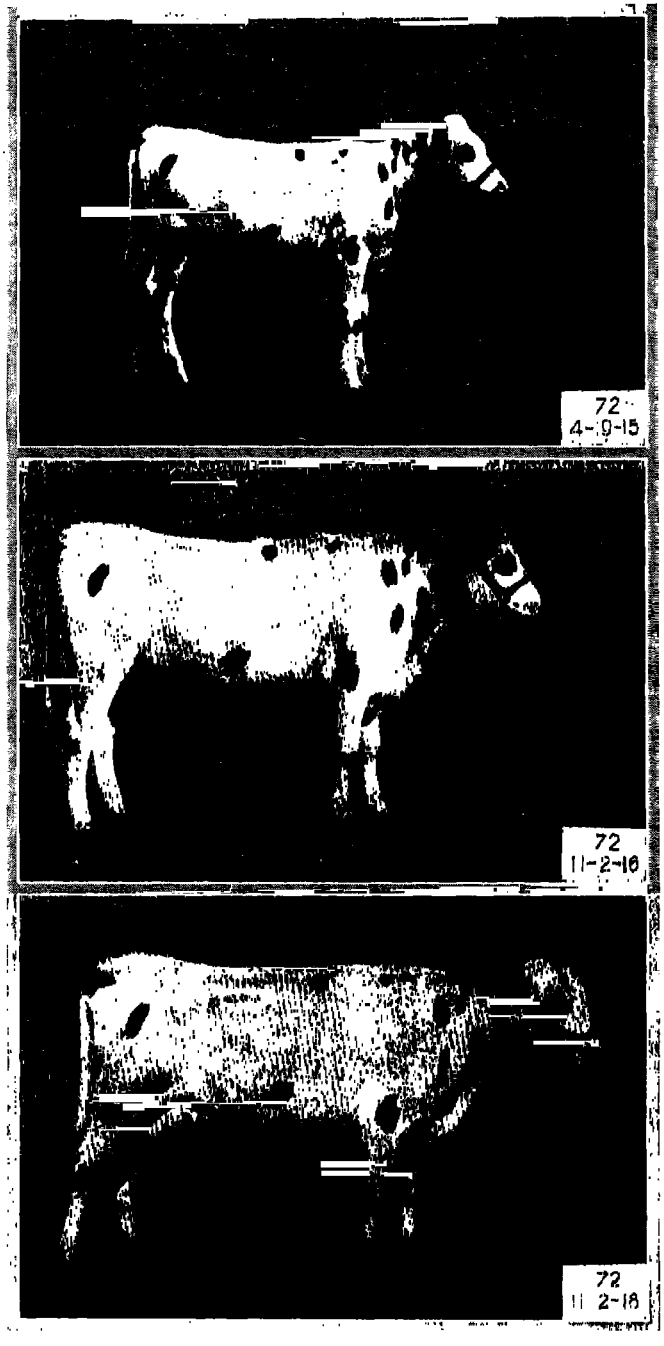

FIG. 6.—A representative of Lot III at approximately 6 months, 24 months, and 48 months of age.

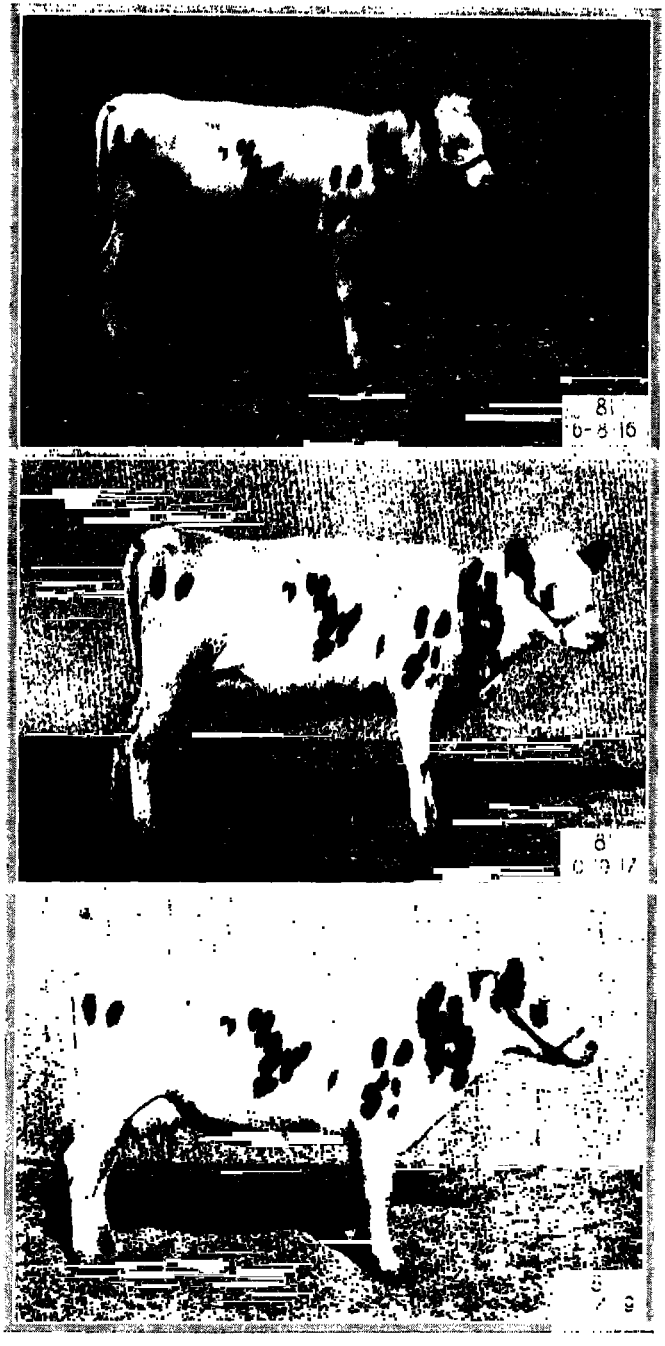

FIG. 7.—A representative of Lot IV at approximately 6 months, 24 months, and 48 months of age.

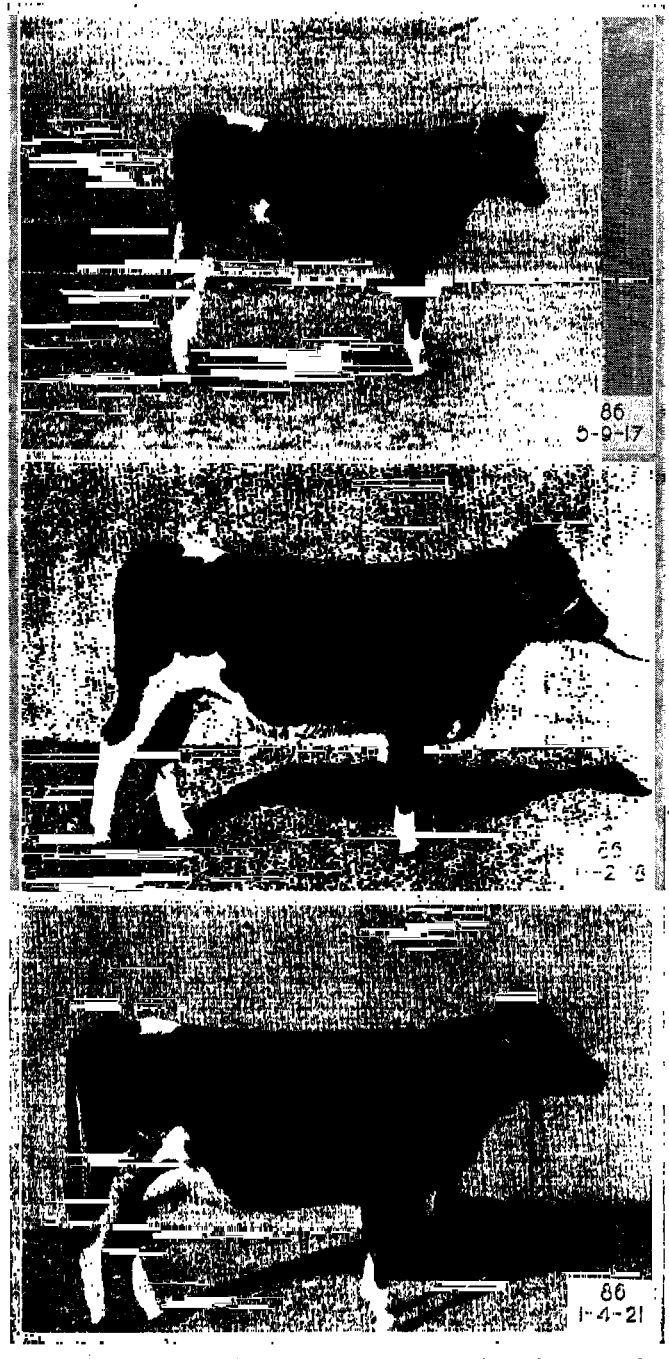

FIG. 8.—A representative of Lot IV at approximately 6 months, 24 months, and 48 months of age.

Eckles[8] has found that heavy-fed heifers reached maturity at an earlier age than those of the same age that received a lighter ration. This was also observed in comparing Lots I and III. The heifers in Lot I at 24 months of age were 48.2 inches in height of withers and weighed 766.5 pounds, while the heifers in Lot III at only 18 months of age were 48.7 inches high at withers and weighed 800.2 pounds.

The animals in Lot IV, calving at 24 months of age, seemed to reach a constant height and weight at an earlier age than in other lots. The only difference between Lots III and IV was the difference in calving age, and the height measurements and weights show but little difference up to 36 months of age; but when mature the animals in Lot III were larger than the table of weights indicated.

In comparing the lots as to body measurements a fair comparison can be made only up to 30 months of age, as at 36 months some of the animals had dropped out of some of the lots.

There is but little variation in the height of withers for the first measurements of the various groups. At 6 months of age the difference is still slight, but from 6 to 24 months of age the growth is rapid and a difference shows up among the various groups. At 48 months of age the growth as indicated by the height of withers becomes quite constant in all the lots with the exception of Lot IV. In this lot the growth in height becomes quite constant at 30 months of age.

Lot III showed the greatest development as indicated by heights of withers, while Lot I showed the least. The widest variation shown was 2.9 inches between Lots I and III at 18 months of age. Relatively small variations were shown between Lots I and II and between Lots III and IV. This may be observed by comparing figures 1 and 2 with 3 and 4 and figures 5 and 6 with 7 and 8.

A difference in the heart girths of the animals in the various groups is also evident, the heart girth in Lot III increasing noticeably faster than in the other lots. The increase in the size of the heart girth follows quite closely the trend of the height of withers and body weight.

In barrel girth the measurements are very irregular in all groups. The heifers in Lots III and IV show a greater barrel girth up to 24 months of age, but after that age there is no consistent difference among the lots.

8. Eckles, C. H. The ration and age of calving as factors influencing the growth and dairy qualities of cows. Mo. Agr. Expt. Sta. Bul. 135:1-91. Fig. 26. 1915.

In the width of hips there is apparently a difference between 6 and 36 months of age in that Lots III and IV have wider hips than the other lots.

The width of the pin bones is quite irregular, but the measurements indicate that Lot III has the widest pin bones, followed by Lots II, IV, and I in the order named.

Eckles[9] in his studies with growing heifers used 21 body measurements on each animal, monthly. After studying the data on a large number of heifers he decided that the height of withers served as well as any other measurement as an index to skeleton growth. The results obtained in this experiment seem to indicate that the height of withers along with the weight of the animals is the best index in determining growth.

EFFECT OF RATION ON OFFSPRING.

The weight of the calves from the experimental heifers, together with the weight of the dams at calving time, is given in Table V. It will be noted that the heifers in Lot I weighed less at calving time than those in the other three lots. Those in Lot III were heaviest, followed by Lots IV and II in the order named. This relation holds true for both the first and second calvings.

It is quite apparent that the calves produced by the heifers in Lot I, on alfalfa alone, were noticeably smaller than the calves produced by the heifers in the other lots. The largest calves were produced by Lot III, but the difference between Lots II, III, and IV is probably less than the experimental error.

In all lots the average weight of the second calf was greater than the first, but in almost every case the percentage weight of the calf, based on the weight of the dam, was greatest for the first calf. The exception to this is the average weight of the second calves for the heifers in Lot III. This probably can be accounted for by the fact that the first calves in Lot III consisted of four heifers and one bull, whereas the second calving in Lot III was made up of three bulls and one heifer. The average percentage weights of the calves appear to decline with succeeding calves.

EFFECT OF THE RATION ON THE PRODUCTION OF MILK AND BUTTERFAT.

In Table VI are given the age at calving and the 10 months' production of each of the animals for the first and second lactation periods.

There was a slight deviation from the plan regarding age of calving as indicated in the table. The variations, however, are not

9. Loc. cit.

TABLE V.—Data showing effect of ration on offspring.

HEIFER NO.	First calving.			Second calving.			Averages.		
	Weight of dam.	Weight of first calf.	Per cent.	Weight of dam.	Weight of second calf.	Per cent.	Average weight of dam.	Average weight of calf.	Per cent.
				LOT I.					
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	
51	935	(*a*)75.0	8.02	1,159	(*a*)100.0	8.63	1,047.0	87.5	8.36
52	877	69.0	7.87	870	(*a*)92.0	10.57	873.5	80.5	9.22
53	855	(*a*)97.0	11.34	1,025	(*a*)92.0	8.97	940.0	94.5	10.05
54	777	(*a*)85.0	10.94	992	77.5	7.81	884.5	81.0	9.16
55	851	(*a*)80.0	9.40	910	98.0	10.77	880.5	89.0	10.11
56	860	84.0	9.75	900	68.0	7.55	880.0	76.0	8.64
Average	859	81.6	9.50	976	87.9	9.00	917.6	84.8	9.24
				LOT II.					
60	960	(*a*)93.0	9.68	1,060	92.0	8.68	1,010.0	92.5	9.16
61	1,025	(*a*)91.0	8.87	1,120	(*a*)92.0	8.21	1,072.5	91.5	8.53
62	932	82.0	8.80				932.0	82.0	8.80
63	830	(*a*)91.0	10.96				830.0	91.0	10.96
65	927	75.0	8.09	1,050	92.0	8.76	988.5	83.5	8.45
Average	935	86.4	9.24	1,077	92.0	8.54	966.6	88.1	9.11
				LOT III.					
70	1,175	83.0	7.06	1,413	(*a*)110.0	7.78	1,294.0	96.5	7.46
71	930	78.0	8.03	1,060	86.0	8.11	995.0	82.0	8.24
72	1,079	85.0	7.87	1,005	(*a*)90.0	8.95	1,042.0	87.5	8.38
74	1,036	(*a*)95.0	9.17				1,036.0	95.0	9.17
75	1,057	90.0	8.51	970	(*a*)93.0	9.58	1,013.5	91.5	9.03
Average	1,055	86.2	8.16	1,112	94.7	8.52	1,076.1	90.5	8.41
				LOT IV.					
81	990	(*a*)89.0	8.99	1,084	(*a*)86.0	7.93	1,037.0	87.5	8.44
82	840	94.0	11.20	1,081	86.0	7.95	960.5	90.0	9.37
83	1,040	(*a*)100.0	9.61				1,040.0	100.0	9.61
84	930	(*a*)79.0	8.50	1,060	(*a*)114.0	10.75	995.0	96.5	9.70
85	1,039	95.0	9.13				1,039.0	95.0	9.13
86	1,060	90.0	8.49	1,181	90.0	7.62	1,120.5	90.0	8.03
Average	983	91.1	9.26	1.101	94.0	8.54	1.032.0	93.2	9.03

(*a*) Bull calf.

TABLE VI.—Data on milk and butterfat production for first ten months of the first and second lactation periods.

HEIFER NO.	First lactation period.				Second lactation period.			
	Age at calving.	Milk.	Test.	Fat.	Age at calving.	Milk.	Test.	Fat.
				LOT I.				
	Months.	*Pounds.*	*Per cent.*	*Pounds.*	*Months.*	*Pounds.*	*Per cent.*	*Pounds.*
51	29.5	5,341	3.8	208	49.3	4,085	3.7	151
52	32.5	3,988	3.7	149	44.5	3,931	3.7	145
53	30.5	3,827	3.5	136	48.5	4,976	3.5	177
54	30.5	3,514	3.3	116				
55	29.8	4,104	3.4	138	45.0	4,038	3.3	134
56	34.2	3,809	4.0	155	47.0	3,723	3.9	144
Average	31.2	4,097	3.7	150	46.8	4,151	3.6	150
				LOT II.				
60	32.7	5,075	3.4	173	47.2	4,752	3.9	185
61	30.0	5,173	3.2	168	46.9	4,435	3.3	149
65	33.5	3,324	3.7	122	52.6	3,865	3.9	150
Average	32.1	4,524	3.4	154	48.9	4,351	3.7	161
				LOT III.				
70	28.5	5,761	3.8	220	40.7	6,714	3.8	256
71	29.0	6,957	3.7	258	46.0	4,801	3.6	175
72	29.0	7,685	3.9	303	44.4	6,559	4.0	261
74	27.7	4,013	3.8	153	47.3	4,226	4.1	175
75	28.1	6,925	3.1	214	42.8	7,922	3.1	244
Average	28.4	6,268	3.7	230	44.2	6,044	3.7	222
				LOT IV.				
81	25.5	9,509	3.6	340	39.2	10,948	3.4	371
82	24.5	6,311	3.8	241	39.6	7,421	3.5	260
84	23.7	6,616	3.3	215	38.5	8,010	3.4	276
86	26.3	6,347	3.6	229	39.1	8,719	3.5	301
Average	25.0	7.196	3.6	256	39.1	8.774	3.4	302

NOTE.—No. 54 lost a quarter during second lactation, so her record was not used. No. 62 died without completing a record. Nos. 63 and 85 were sold because of failure to breed. No. 64 died at first calving time. No. 83 was discarded because of unsatisfactory breeding.

great, The average time between calving periods for all the lots was 15.5 months instead of 12 months as originally planned. The alfalfa heifers had the lowest average production of any of the lots for both lactation periods, the average butterfat production being 150 pounds for the first ten months' lactation and also 150 pounds for the second lactation. The production for the second lactation period was slightly higher in Lots II and IV, and lower in Lot III, than for the first lactation period. The reduction in Lot III, however, is undoubtedly due to the production of animal No. 71, which for some reason produced considerably lower in her second lactation than in the first. For the two lactation periods it will be noticed that Lots I and II are both lower than Lot III, which is probably the most nearly normal of all lots. Lot IV has the highest production record.

During both lactation periods heifer No. 81 in Lot IV produced much higher than any of the others in this experiment. The elimination of her record, however, does not affect the relative standing of the lots to any material extent, although it does make the difference between Lots III and IV less pronounced, and for the first lactation period the average butterfat production for Lot IV is made less by one pound than the average for Lot III.

The production for Lot IV during the second lactation was somewhat higher than for Lot III but was not sufficient to warrant the extra, amount of feed consumed, as shown in Table VII. In comparing the feed consumed during the second lactation with that consumed during the first lactation it will be seen that the average consumption of feed is greater for all the lots during the second lactation.

TABLE VII.—Pounds of feed consumed during first and second lactation periods.

HEIFER NO.	First lactation period.			Second lactation period.		
	Hay.	Silage.	Grain.	Hay.	Silage.	Grain.
LOT I.						
51	11,925.7	.....	.....	10,228.5	.....	.....
52	8,234.0	.....	.....	9,681.5	.....	.....
53	8,016.5	.....	.....	9,398.5	.....	.....
54	8,192.0	.....	.....	.....	.....	.....
55	8,624.5	.....	.....	9,079.5	.....	.....
56	8,908.0	.....	.....	9,376.0	.....	.....
Average	8,983.5	.....	.....	9,552.8	.....	.....
LOT II.						
60	3,777.0	10,509.3	.....	4,788.0	13,449.0	.....
61	3,967.0	9,936.0	.....	4,805.5	12,035.0	.....
65	4,562.0	8,368.5	.....	4,479.0	10,394.0	.....
Average	4,102.0	9,604.6	.....	4,690.8	11,959.3	.....
LOT III.						
70	4,610.5	9,816.0	1,398.0	3,531.0	9,431.0	1,241.5
71	4,080.5	9,859.0	1,297.5	4,316.8	9,564.8	1,435.0
72	3,820.0	8,870.2	1,310.8	4,279.0	10,339.0	1,749.0
74	3,820.0	7,401.6	930.5	3,633.0	9,112.0	1,652.0
75	4,065.5	8,453.0	1,284.0	3,844.0	10,754.0	1,968.5
Average	4,079.3	8,880.0	1,244.2	3,920.8	9,840.3	1,609.2
LOT IV.						
81	3,307.8	8,509.0	1,584.0	4,556.0	10,782.0	3,174.5
82	3,337.3	7,097.5	1,186.0	4,400.0	11,476.5	2,136.0
84	3,283.0	8,266.0	1,091.0	4,305.5	10,538.0	2,060.0
86	4,328.5	8,668.5	2,448.0	3,767.5	9,893.5	2,828.0
Average	3,564.2	8,110.3	1,577.3	4,257.3	10,672.5	2,549.6

During the first 10 months' lactation the heifers in Lot I consumed on an average 8,983 pounds of alfalfa hay, or an average daily consumption of practically 30 pounds. One of the heifers consumed as high as 45 pounds of alfalfa hay per day and averaged 39 pounds per day during the ten-month lactation period.

TABLE VIII.—Data on cost of feed consumed and value of milk produced.

HEIFER NO.	First lactation period.			Second lactation period.		
	Cost of feed.		Value of milk above cost of feed.	Cost of feed.		Value of milk above cost of feed.
	Total.	Per pound of butterfat.		Total.	Per pound of butterfat.	
LOT I.						
		Cents.			*Cents.*	
51	$59.63	28.9	$95.79	$51.14	33.7	$67.73
52	41.17	27.6	74.88	48.41	33.4	65.93
53	40.08	29.5	71.28	46.99	26.5	97.81
54	40.96	35.3	61.30	.....	.....	.....
55	43.12	31.2	76.30	45.40	33.9	72.11
56	44.54	28.7	66.30	46.88	32.6	61.45
Average	$44.92	29.9	$74.31	$47.76	31.8	$73.02
LOT II.						
60	$37.28	21.5	$110.40	$47.48	25.7	$90.80
61	37.22	22.2	113.18	45.09	30.3	83.86
65	37.45	30.7	59.28	40.58	27.1	71.89
Average	$37.32	24.2	$94.29	$44.38	27.5	$82.18
LOT III.						
70	$61.20	27.8	$106.44	$52.80	20.6	$142.57
71	57.11	22.1	145.33	59.85	34.2	79.85
72	54.28	16.3	168.35	65.73	25.2	125.13
74	46.01	30.1	70.77	58.90	33.7	64.07
75	54.38	25.4	147.13	67.56	23.6	152.97
Average	$54.60	23.7	$127.60	$60.97	27.4	$112.92
LOT IV.						
81	$55.19	16.2	$221.52	$89.27	24.1	$229.31
82	46.90	19.5	136.75	74.12	28.5	141.83
84	47.26	22.0	145.26	70.87	25.7	162.22
86	73.53	32.1	111.16	78.57	26.1	175.15
Average	$55.47	21.7	$153.67	$78.21	25.8	$177.13

The feed cost per pound of butterfat during the first lactation period, as shown by Table VIII, was 29.9 cents for Lot I, 24.2 cents for Lot II, 23.7 cents for Lot III, and 21.1 cents for Lot IV. Thus Lots I and II, although showing a lower feed cost than the others, produced butterfat at a higher cost per pound. A similar difference may be noted when the feed cost per hundred pounds of milk is considered. The cost per pound of butterfat was highest with the alfalfa-fed heifers and the return for milk above feed cost lowest for these heifers.

For the second lactation period the average feed cost, and the average cost per pound of butterfat are in the same relative position as for the first lactation period. It is interesting to note, how-

ever, that the average feed cost per pound of butterfat is higher in all lots during the second period than during the first. In Lot I this difference is 1.9 cents; Lot II, 3.3 cents; Lot III, 3.7 cents; and in Lot IV, 4.1 cents. This may be accounted for by the fact that the animals were in better condition at first calving than at second calving.

While the animals in Lot IV were smaller than those in Lot III and were perhaps less desirable for that reason, it appears (Table VI) that their producing ability had not been sacrificed on account of size. The animals in Lot IV had a slightly higher fat production in both lactation periods than did those in Lot III. This difference, however, in favor of Lot IV should not be attributed to the early calving. It was mentioned in the discussion of the records of the different lots that heifer No. 81 in Lot IV was an exceptionally high producer. With her record excluded the average production of the butterfat for Lot IV is reduced to 229 pounds, or practically the same as Lot III. In the second lactation, however, the exclusion of her record does not change the standing of the lot.

The animals in Lot I during the first ten months' lactation averaged 13 pounds of 3.7 per cent milk per day. As mentioned above, the average daily consumption of hay was 30 pounds. That this was a very liberal feeding can be seen when the requirements for an 850-pound animal producing 13 pounds of 4 per cent milk per day are compared with the crude protein and energy value of the food furnished[10] by their ration. These items are as follows:

	Digestible crude protein.	Net energy value.
	Pounds.	*Therms.*
Requirements	1.087	9.06
Furnished in 30 pounds of alfalfa hay	3.18	10.26

The average total protein and energy in the feed furnished the animals in Lot I for the first lactation period were more than the protein and energy supplied to the animals in Lot III. These figures are as follows:

Total feed.	Digestible crude protein.	Net energy value.
	Pounds.	*Therms.*
Lot I, 8,983.5 pounds alfalfa	952.2	3,075
Lot II, 4,102 pounds of alfalfa and 9,604.6 pounds corn silage	540.4	2,931

That the animals in Lot II were fed adequately for their production is shown by the following comparison based upon their

10. Armsby, H. P. The use of energy values in the computation of rations for farm animals. U. S. Dept. of Agr. Dept. Bul. 459:1-31. 1916.

average daily production of 15 pounds of 3.5 per cent milk and daily food consumption of 13.6 pounds of alfalfa hay and 32 pounds of corn silage:

	Digestible crude protein. *Pounds.*	Net energy value. *Therms.*
Requirements	1.175	9.60
Furnished by feed consumed	1.792	9.73

The production of Lot II was slightly higher than the production of Lot I, but the difference was very slight, and it would seem that both lots were limited in some factor that was essential for high production. It is possible that the heifers in Lot I were limited on account of net energy. The fact that they were furnished only sufficient net energy for the amount of milk they produced may mean that the energy furnished was a limiting factor in production. In Lot II the heifers' inability to consume sufficient roughage was perhaps the limiting factor in production.

Table IX gives the average digestible crude protein and net energy value furnished the animals in each lot during the first two years of growth and during the two lactation periods.

TABLE IX.—Average digestible crude protein and net energy value supplied the animals in each lot.

	Av. digestible crude protein. *Pounds.*	Net energy value. *Therms.*
LOT I.		
First year	385.227	1,374.854
Second year	608.705	1,965.658
First lactation period	952.251	3,075.052
Second lactation period	1,012.597	3,269.923
LOT II.		
First year	358.052	1,378.619
Second year	508.719	2,063.444
First lactation period	618.263	2,931.246
Second lactation period	628.774	3,507.142
LOT III.		
First year	411.646	1,793.758
Second year	608.674	2,848.753
First lactation period	677.275	3,795.708
Second lactation period	714.216	4,170.886
LOT IV.		
First year	357.648	1,709.916
Second year	547.729	2,835.602
First lactation period	653.613	3,749.091
Second lactation period	839.953	4,901.628

The estimates given in Table IX are based on Armsby's tables on the use of energy values as given in bulletin 459 previously referred to. The most apparent fact brought out in this table is that the animals in Lot I received a ration high in protein at all times.

Lot I is low in energy, but this is not so apparent during growth as during milk production.

Eckles[11] concluded after wintering dairy heifers on alfalfa hay alone that this ration did not furnish sufficient energy for satisfactory growth.

EFFECT OF THE RATION ON SEXUAL MATURITY.

It was planned to determine the effect of the different rations on sexual maturity, but this was overlooked in the early part of the experiment and it was not until some of the animals were of breeding age that this matter was given careful attention. Records are available for only 18 of the 24 animals started on the experiment, and it is possible that in some cases the first period of heat was not noted.

The data at hand can be summarized as follows:

	Number of animals.	Average age at first period of heat.
Lot I	4	19 months
Lot II	4	18 months
Lot III	5	12 months
Lot IV	5	14 months

The youngest age at which an animal came in heat was 10 months, in Lot III; and the oldest age was 21 months, in Lot I. Three animals in Lot III and one animal in Lot IV came in heat before 12 months of age. These figures seem to substantiate the general opinion that well-fed animals reach sexual maturity earlier than poorly fed animals.

EFFECT OF RATION ON REPRODUCTION.

In the alfalfa districts of the western states it is a common practice to feed nothing but alfalfa to dairy animals. This alfalfa may be in the form of alfalfa hay or alfalfa pasture, but is generally a combination of the two. In some of the alfalfa districts referred to some difficulty was encountered in getting dairy animals to breed regularly, and this was eventually checked up to the alfalfa feeding. In Kansas alfalfa is often considered as the best and cheapest feed for dairy cows, and is sometimes used to the exclusion of other feeds.

To study the influence of alfalfa feeding upon the breeding records of the heifers the following data have been assembled, which give the total number of times the animals in each lot were bred:

11. Eckles, C. H. Winter rations for dairy heifers. Mo. Agr. Expt. Sta. Bul. 158:1-58. Fig. 15. 1918.

Lot No.	First Calf. Number of animals.	First Calf. Total times bred.	Second Calf. Number of animals.	Second Calf. Total times bred.
I	6	11	6	15
II	6	12	5	14
III	5	11	5	15
IV	6	10	5	19

These figures indicate that there was no more difficulty in getting the animals in Lot I safely with calf than the animals in the other lots. In fact there was less trouble than indicated by the above table. One animal in Lot I, No. 56, was bred six times, while the other animals in this lot were bred but once. When No. 56 was bred for her second calf one service was sufficient. During the process of the experiment one animal from Lot III, No. 73, and one from Lot IV, No. 85, were sold as nonbreeders. None of the animals aborted.

The results of this experiment indicate that there is no injurious influence upon reproduction from feeding alfalfa exclusively.

EFFECT OF THE RATION ON FINAL GROWTH AND MILK-PRODUCING CAPACITY.

At the end of their second lactation two animals from each lot were placed in the milking herd where they received a ration of alfalfa hay, silage, and grain and some pasture. The animals used were Nos. 53, 56, 60, 61, 75, 76, 81, and 86. Of these Nos. 60,76, and 86 were not used in the comparison. Table X gives the weights and measurements on the animals used in this comparison at the close of the experiment and at the close of the third lactation period.

TABLE X.—Weights and measurements on representative animals at close of experiment and again at close of third lactation period.

Animal No. and Date.	Weight or measurement. Weight.	Withers.	Hips.	Chest.	Barrel.	Pins.
	Pounds.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
No. 53.						
11–10–19	1,037	50.4	20.7	68.9	90.2	7.5
1–16–22	1,228	51.0	21.3	74.0	92.1	7.3
No. 56.						
11–10–19	865	50.4	19.9	65.7	79.1	7.5
1–16–22	1,080	50.4	21.3	70.9	84.6	7.7
No. 61.						
9–12–19	1,245	52.4	21.3	70.1	95.6	7.9
1–16–22	1,331	52.6	22.2	73.2	95.3	7.7
No. 75.						
8–10–20	1,204	51.0	22.2	73.6	91.7	7.3
1–16–22	1,213	51.2	21.5	72.8	90.9	7.5
No. 81.						
1–10–20	1,172	51.2	20.3	72.8	92.1	7.1
1–16–22	1.221	51.2	20.5	74.0	91.7	6.9

All the animals at the end of the experiment, when they were approximately five years of age, seemed to have attained about their maximum growth, as one year in the herd on full feed resulted in only a slight increase in size. However, there was a marked increase in weight, especially in the animals fed alfalfa alone. These animals showed an average gain in weight of 203 pounds, and the animal fed on alfalfa and silage a gain of 86 pounds. Animals Nos. 75 and 81, the representatives of Lots III and IV, respectively, did not show any marked gain in weight. The height of withers of No. 53 increased somewhat but the height of withers for No. 56 did not change. The width of hip increased for both cows, as did the heart girth and barrel girth. It is possible that these measurements may have been influenced somewhat by additional flesh on the animals gained after being put into the milking herd.

The production of the above animals during the second lactation period under experimental conditions compared with the third lactation period in the milking herd, is given in the following tabulation:

	Production.	
	Milk.	Butterfat.
No. 53.	*Pounds.*	*Pounds.*
Second lactation period	4,976	177
Third lactation period	8,562	296
Increase, third lactation	3,586	119
No. 56.		
Second lactation period	3,723	144
Third lactation period	7,820	299
Increase, third lactation	4,097	155
No. 61.		
Second lactation period	4,435	149
Third lactation period	5,521	188
Increase, third lactation	1,086	39
No. 75.		
Second lactation period	7,922	244
Third lactation period	7,107	207
Decrease, third lactation	815	37
No. 81.		
Second lactation period	10,948	371
Third lactation period	11,480	404
Increase, third lactation	532	33

The milk and butterfat production of all animals except No. 75 from Lot III showed an increase as compared with the second lactation period. The increase was especially great for animals No. 53 and No. 56 from Lot I, which had previously been fed alfalfa hay alone. The average increase in production for these two cows was 3,841 pounds of milk and 137 pounds of butterfat. The increase for No. 61 from Lot II was 1,086 pounds of milk and 39 pounds of butterfat. The production of No. 61 was low, and it is possible that this cow was fed close to her capacity on alfalfa hay and silage. Animal No. 75 from Lot III showed a slight decrease during the third lactation period, while No. 81 in Lot IV showed a slight increase. This would indicate that these animals were fed quite close to their requirements when in the experiment.

Table XI gives the average of all the chemical analyses of the various feeds fed during the experiment.

TABLE XI.—Average chemical analyses of feeds fed.

FEED.	Per cent.					
	Moisture.	Ash.	Protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.
Alfalfa	7.67	7.90	13.72	30.86	38.04	1.80
Silage	4.45	6.48	6.47	19.21	61.36	2.03
Grain mix	9.69	3.75	15.56	5.66	61.09	4.24
Bran	8.39	6.78	17.02	9.97	53.68	4.17
Corn chop	9.55	1.78	10.22	2.19	73.61	3.26
Oil meal	12.85	4.57	34.00	10.92	28.23	8.30

10-3555