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BELTSVILLE GROWTH STANDARDS FOR HOLSTEIN CATTLE
MATTHEWS, C. A.; FOHRMAN, M. H. 1 OF 1

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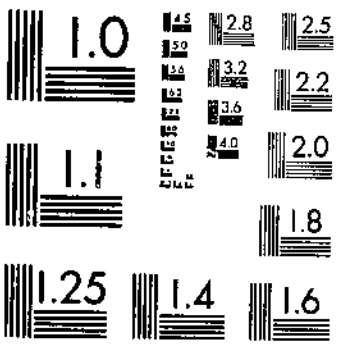

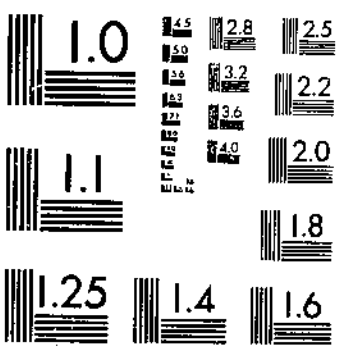

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Beltsville Growth Standards for HOLSTEIN Cattle[1]

By C. A. Matthews and M. H. Fohrman, *Dairy Husbandry Research Branch, Agricultural Research Service*

INTRODUCTION

Normal growth by dairy cattle, as measured by weight, depends on a mixture of the effects of three kinds of conditions, which may be expressed as (1) the inherent maximum capacity for growth, (2) the plane of nutrition and environment, and (3) the weight changes associated with recurring cycles of pregnancy and lactation.

Included in maximum capacity for growth are the effects of sex, breed, inheritance from nearby ancestors, breeding pattern, and chance variation between individuals. It is generally agreed that maximum growth in weight represents a degree of fatness that is undesirable in dairy cattle and a departure from a profitable feeding program. Consequently, good, accepted feeding practices produce a standard rate of growth that is somewhat less than the maximum.

When a given set of weights is used to establish a standard for measuring normal growth, it must be assumed that each of the three kinds of conditions that may have affected the weights was normal. The usefulness of such a standard will depend on the degree of similarity, in respect to these conditions, between the standard and the groups of data that are to be compared with the standard. The effect of differences in a particular condition can be studied most effectively when other conditions are nearly alike. For example, the relative effects of outbreeding, linebreeding, and inbreeding on growth and size might be measured when the conditions of feeding and environment and pregnancy and lactation are nearly alike.

Naturally, a growth standard is more suitable for use in the herd in which it was developed than in another herd. Its use in another herd will depend on an accurate measure and description of the three kinds of conditions that affect weight and rate of growth, and on the degree of similarity between the two herds in respect to these conditions.

Since 1918, when a breeding experiment with Holstein cattle was begun at Beltsville, Md., the Dairy Husbandry Research Branch has

[1] Submitted for publication May 14, 1954.

collected an unusually large volume of weight data on the herd as a part of the experimental work. Weights are available on nearly all animals from birth to maturity and it is possible to tabulate weights by stages of pregnancy and lactation.

Because certain conditions have been maintained rather constant from the beginning, the Beltsville weight data are well adapted for use as growth standards for Holsteins. For example, the herd has been maintained for a study of the laws of inheritance for milk and butterfat production and, therefore, an attempt has been made to use good, practical methods of feeding and management and to keep them constant throughout all the years of the experiment. This has been accomplished with a high degree of success and makes it possible to describe the conditions of feeding and environment involved. Also, no new females have been added to the herd except descendants of the foundation cows, and no culling of female offspring has been practiced.

This presentation of the weight data from Holstein cows, heifers, and bull calves in the Beltsville herd is parallel to a previous study (*7*) [2] on the weights of Jersey cattle in the Beltsville herd. Several new methods were used in presenting weight data for Beltsville Jerseys in order to increase their usefulness as standards of normal growth for all Jerseys. The same methods are used on the Holstein weight data. A more detailed description of some of these methods will be found in connection with the Jersey standards. Many interesting comparisons between the normal rates of growth for Holstein and Jersey cattle are possible with weight data on the two breeds obtained in the same herd and analyzed in the same way.

SOURCES OF DATA AND CONDITIONS AFFECTING THEM

The plan of the breeding experiment with Holstein cattle at Beltsville, Md., and the procedures of feeding and management, has been described in detail elsewhere by Fohrman and Graves (*5*). Their report also included the average weights of the cows and heifers in the first generation.

The degree to which the Beltsville Holsteins are representative of Holsteins throughout the country is indicated by the names of the eight proved sires that were brought in for use in the outbreeding phase of the experiment. Because no females other than descendants of these proved sires have been added to the herd since the beginning of the experiment, the greater part of the inheritance in the herd traces to these proved sires.

The eight sires, in the order of their use, were Denton Colantha Sir Rag Apple 87426, Varsity Derby Matador 234809, Pride of the Bess Burkes 294574, Count Piebe Hengerveld Ormsby 444324, Chief Piebe Ormsby Burke 444088, King Ormsby of Iodak 576357, Douglas Buttercup Hark 660575, and Rose Hill Emperor Governor 743882. The first 2 sires had more than 30 daughters each. The third, fourth, and sixth sires had but 9, 5, and 3 daughters, respectively. The fifth, seventh, and eighth sires had more than 15 daughters each. How-

[2] Italic numbers in parentheses refer to Literature Cited, p. 50.

ever, the daughters of the eighth sire, and to some extent the daughters of the seventh sire, had an influence on the average weights for the younger groups only.

Weights were also obtained on many daughters of sons of these sires that were born and raised in the Beltsville herd. Naturally, the sons of the earlier outcross sires had more offspring represented in these weights than the sons of the later outcross sires.

In 6 generations and 30 years time, the inheritance coming from the foundation cows has been considerably diluted, so the weights of foundation cows were not used in preparing the weight standards reported in this bulletin. Nevertheless, about 85 percent of the influence from the foundation cows came in nearly equal proportions from the daughters or granddaughters of such sires as Piebe Laura Ollie Homestead King 110474, King Segis Pontiac Hero 78210, Star Farm Johanna Lad 45224, Johan Wooderest Lad 11th 103987, and in smaller proportions from daughters of Johanna Korndyke De Kol 45577 and Hazelwood Korndyke Gerben 98063.

Except for losses caused by disease or accident, all female progeny were raised and retained in the herd until they were no longer useful in producing data or offspring for the breeding experiment.

Calves were separated from their dams shortly after birth and were fed whole milk at the rate of 6 to 10 pounds daily to 4 weeks of age and then skim milk in quantities up to 12 pounds daily until they were 6 months old. Animals lacking vigor or that were retarded by sickness were given whole milk a little longer. Calves and heifers were given all the alfalfa or mixed hay they would eat. Grain feeding was increased gradually until the calves were getting 3 pounds of grain daily at 6 months of age or later. From then on the amount fed was maintained at that level for most heifers to 24 months of age.

After the heifers were a year old they were moved from the calf barn to a heifer barn, and silage or pasture in season was added to the ration. At times hay was fed in pens and some of the less aggressive heifers may have suffered from competition with older or larger animals. The heifers, and their weights, were kept under constant observation and measures were taken to correct conditions for heifers that appeared to be retarded.

The greatest difference in the feeding and management of the cows was between those on official production test and those not on test. Cows on test were kept in box stalls, milked three times daily, exercised in a dry lot daily, and never allowed on pasture. They were encouraged to eat all the alfalfa hay and corn silage they would. Then they were fed enough of a 15.5-percent-protein grain mixture to bring their net energy intake up to 10 percent above their requirements.

Cows not on official test were milked twice a day, housed in stanchion barns, and turned on pasture in season. As a rule they were not fed as liberally as cows on test, and occasionally they were used in feeding experiments that resulted in some loss of weight.

Calves were weighed at birth and every 10 days thereafter during their first year. Every 30 days an average was obtained from 3 consecutive daily weights, centering on the date for the third 10-day weighing. After they were a year old, all cows and heifers were

weighed on 3 consecutive days at the beginning of each calendar month. All animals had access to water before they were weighed. Calves and cows on test were weighed after they were fed, but heifers and other cows were weighed before they were fed.

No body measurements were taken to accompany these weights, but detailed measurements that were made in connection with other studies are available at some ages on nearly all of these cows and heifers.

It was the plan to breed heifers to calve for the first time at about 2 years of age, and to breed them thereafter for a calving interval of 14 months following a lactation on test, and for a calving interval of 12 months following other lactations. Estimates of the extent to which this plan was accomplished will be given.

In order to reduce the number of factors causing variation between individuals, the weights of twins or inbred animals were not used in preparing these standards. Such a limitation makes it possible at some later date to make a direct comparison between the weights and rates of growth of inbred animals and those of outcross or linebred animals.

A further limitation on the data to be used was the requirement that the average weights for all ages, in the period of months or years for which the rate of growth was studied, be based on the weights from the same animals. Thus, the change in average weight from one age to the next was the actual average gain or loss in weight, and it was not affected by dropping the weights of light or heavy individuals from the set of data between one age and the next.

Since there were fewer animals to be weighed at older ages than at younger ages, the adoption of this requirement made it necessary to divide the data into a number of groups based on the length of time the animals remained in the herd. These groups are referred to as age-limit groups.

It occasionally happened that some weights were not obtained. Such missing weights were estimated in order to avoid the effect on the average weights of dropping or adding individuals between one age and another. Usually, these estimated weights were an average of the weights before and after the omission. A few estimates that involved calving periods were adjusted according to average changes at other calving periods in the cow's life.

GROWTH STANDARDS FOR HOLSTEIN FEMALES BY AGE-LIMIT GROUPS

From Birth to 365 Days of Age

The first age-limit group, which comprises the period from birth to 365 days of age, corresponds to the period of the experiment when calves were weighed at 10-day intervals. This produces a standard that may be useful in connection with experiments and observations when calves are weighed at 10-day intervals. The average actual weights and variations in weight, and the estimated weights and daily gains in weight, for 400 Holstein heifer calves are shown in table 1.

TABLE 1.—*Average and estimated weights and gains, and variations in weight, for 400 Holstein heifer calves by 10-day periods from birth to 365 days of age*

Age	Average actual weight	5-percent fiducial limits	Standard deviation	Coefficient of variation	Estimated standards	
					Weight	Daily gain
Days	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
At birth	96	94.4– 96.7	11.8	12.3	93.6	
10	99	97.5– 99.9	12.1	12.3	99.5	0.59
20	105	104.8–107.4	13.4	12.7	107.7	.82
30	118	116.3–118.9	13.3	11.3	118.1	1.03
40	130	128.8–131.8	15.1	11.6	130.3	1.22
50	145	142.9–146.2	16.6	11.5	144.2	1.39
60	160	158.1–161.8	18.5	11.5	159.5	1.53
70	177	174.8–178.7	19.7	11.1	176.0	1.65
80	194	191.6–196.0	22.0	11.4	193.6	1.76
90	212	209.6–214.3	23.9	11.3	212.0	1.84
100	231	228.0–233.1	26.1	11.3	231.1	1.91
110	250	247.4–252.9	28.2	11.3	250.8	1.97
120	270	267.5–273.4	30.0	11.1	270.9	2.01
130	291	287.6–293.9	32.0	11.0	291.2	2.03
140	312	308.3–314.8	33.4	10.7	311.7	2.05
150	333	329.1–336.0	35.2	10.6	332.2	2.05
160	353	349.3–356.4	36.2	10.3	352.7	2.05
170	374	369.9–377.4	38.3	10.3	373.0	2.03
180	394	389.9–397.8	40.1	10.2	393.1	2.01
190	414	410.2–418.5	42.3	10.2	412.9	1.98
200	433	429.2–437.7	43.3	10.0	432.3	1.95
210	452	447.9–456.6	44.7	9.9	451.4	1.91
220	470	465.4–474.6	46.9	10.0	470.2	1.87
230	488	483.1–492.6	48.2	9.9	488.4	1.83
240	506	500.9–510.7	49.6	9.8	506.3	1.79
250	523	517.3–527.8	53.0	10.1	523.8	1.76
260	539	534.2–544.8	54.0	10.0	540.8	1.71
270	556	550.7–561.4	54.6	9.8	557.6	1.67
280	573	567.0–578.0	56.0	9.8	574.0	1.64
290	590	583.8–595.2	58.1	9.9	590.1	1.61
300	606	600.6–612.2	59.0	9.7	606.1	1.59
310	623	617.1–629.0	60.3	9.7	621.9	1.58
320	639	632.7–644.8	61.4	9.6	637.7	1.58
330	655	649.3–661.5	62.0	9.5	653.6	1.59
340	671	664.2–676.9	64.3	9.6	669.7	1.61
350	687	680.8–693.5	64.7	9.4	686.0	1.64
360	702	696.0–708.9	65.3	9.3	702.9	1.68
365	710	704.0–717.0	65.8	9.3	711.5	1.73

The average actual weights of the 400 calves increased at a remarkably even rate from one 10-day period to the next. The highest gains in average weight were from 120 to 170 days of age, and the lowest gains were during the first 20 or 30 days.

The 5-percent fiducial limits for the average actual weights demonstrate the relative unimportance of slight deviations from a growth standard or a table of average weights. Also, the fiducial limits are used in this study as an approximate measure of how well the estimated weights from this age-limit group or the average weights from other groups coincided with these average actual weights. It is not a standard statistical test of the difference between two means. Actually, the average weight from another sample of the same size and variance could be 40 percent farther from the mean than one of these 5-percent fiducial limits and still not show a significant difference by the *t* test.

The coefficients of variation were highest during the first 30 days after birth and then decreased gradually. Corresponding values for

Jersey calves in the Beltsville herd (*7*) were higher than these during the first 160 days of age but were slightly lower after 240 days of age.

The average of the coefficients of variation for the eleven 30-day periods, when the weights were averages of 3 consecutive daily weighings, was 10.43 percent as compared with 10.55 percent for the 22 preceding and following periods in which the calves were weighed on 1 day only. The reduction in variation by using averages of 3 daily weights appeared to be slight.

The estimated or standard weights in table 1 were calculated by fitting a fourth-degree orthogonal polynomial to the average actual weights, as described by Snedecor (*12*). This procedure gives a flexible curve with the properties of a regression line and a possibility of testing the success of fitting terms of higher degree through the statistical significance of reductions in the sums of squares for the differences between estimated and observed values. The F-value for the first-, second-, third-, and fourth-degree terms from this set of data were 14,171.33, 0.10, 106.88, and 807.51, respectively, showing a highly significant reduction in the sums of squares for all terms except the one representing a parabola. All of the estimated weights are within the 5-percent fiducial limits of the average actual weights.

The estimated daily gains in weight were calculated directly from the estimated weights. They show increases in the rate of gain to about 150 days of age. For a period of 60 days at this time, these Holstein heifers were gaining more than 2 pounds a day. A similar amount of gain is also shown by differences in the average weights. The age for most rapid gains in weight for Jersey calves shown in a previous report (*7*) came about 10 or 15 days later. The skim-milk feeding period ended at about 180 days of age. Since the period of increasingly larger daily gains in weight ended at about 150 days of age and no abrupt decline in the daily gains in average actual weights came after 180 days of age, it does not seem likely that milk feeding had much to do with this trend in average daily gains in weight.

A system of applying grades to the weights of individual heifer calves was designed for the purpose of being able to determine the relative importance of the difference between the weight of individual calves and the standard or estimated weight. For this purpose the standard deviation was accepted as a measure of normal variation in heifer weights, in the same manner that the mean or average was used as a normal or standard weight. There was considerable advantage in using smooth curves for increases in weight with age and for changes in the standard deviation with age. The estimated weights in table 1 furnished a smooth curve for weight, and the fitting of a fourth-degree orthogonal polynomial to the series of standard deviations produced a smooth curve for standard deviation. The factors adapted from a table by Fisher (*4*) were used with the estimated standard deviations in a way that would divide a normally distributed array of data into 10 classes, with an equal number of items in each class.

At each age the estimated weight minus the estimated standard deviation multiplied by 1.28155, 0.84162, 0.52440, or 0.25335 produced the boundary weights between grades 1 and 2, 2 and 3, 3 and 4, and 4 and 5, respectively. The estimated weight became the boundary between grades 5 and 6, and the addition of the same products in reverse order

produced the boundary weights between grades 6 and 7, 7 and 8, 8 and 9, and 9 and 10, respectively. There is no lower boundary to grade 1, nor upper boundary to grade 10. The boundary weights for grades on the weights of Holstein heifers to 365 days of age are shown in table 2.

The first line for weights at birth in table 2 is based on the average birth weight and the standard deviation instead of the values obtained from the curve-fitting procedures. This furnished a standard for grading birth weights that is independent of older weights. All boundary weights carry decimal fractions in order to avoid borderline cases among individual weights when using this table.

To use the boundary weights in table 2, simply locate, on the line for the heifer's age, the boundary weights between which her weight occurs and then give her weight the grade shown at the top of the space between these two columns. For example, a Holstein heifer calf weighing 265 pounds at 100 days of age would be given the grade of 10, which would indicate that she was in a class heavier than 90 percent of the Beltsville Holstein heifers at that age. Another heifer weighing 640 pounds at 330 days of age would be graded 5. Although her weight was 13.6 pounds less than the standard, and incidentally well below the 5-percent fiducial limits in table 1, it was within the boundaries of one of the two middle grades in table 2. Theoretically, 80 percent of the Holstein heifers weighed at this age would be given grades indicating wider deviations from the standard or estimated weight.

In actual practice, the theoretical distribution of an equal number of weights in each of the 10 grades is only approached. For example, the theoretical distribution of grades for the weights of 400 Holstein heifers at 180 days of age would have been 40 heifer weights for each grade from 1 to 10. Actually, the number of weights in each of the 10 grades was 46, 30, 23, 29, 44, 45, 58, 49, 43, and 33, respectively.

This departure from a theoretical distribution of 40 observations for each grade may have been caused by the occurrence, in the data on which table 1 was based, of a greater number of very low weights than would be expected in a normal distribution. As a result, there was a high frequency for grade 1 weights, and a greater spread between boundary weights permitted higher frequencies for the middle grades.

If a heifer were weighed a few days earlier or later than the ages shown in table 2, it would be well to make an adjustment in her weight for the difference in age. If, for example, a heifer weighed 526 pounds at 245 days of age, the difference in days from 240 (5 days) would be multiplied by the corresponding estimated daily gain in table 1 (1.79 pounds) and the product (9 pounds) subtracted from her weight to give an adjusted weight of 517 pounds at 240 days of age. This would be graded 6.

If the average weights of a group of Holstein heifers were to be compared to this standard, it would be preferable to test the significance of the differences by applying such methods as the t test or analysis of variance to the average weights instead of using the grades. The grades shown in table 2 were intended to be a means of estimating the relative sizes of individual heifers. Nevertheless, the grades for several heifers might be combined, irrespective of age, to obtain an early indication of the relative size of the offspring of a certain sire,

TABLE 2.—*Boundary weights by 10-day periods between grades for the weights of Holstein heifers*

Age	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9	Grade 10
Days	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	
At birth [1]	80.4	85.6	89.4	92.6	95.5	98.5	101.7	105.5	110.6	
At birth	79.6	84.4	87.9	90.9	93.6	96.4	99.4	102.9	107.7	
10	84.2	89.4	93.2	96.5	99.5	102.5	105.8	109.6	114.9	
20	90.9	96.7	100.9	104.4	107.7	111.1	114.6	118.8	124.5	
30	99.7	106.1	110.6	114.5	118.1	121.7	125.6	130.2	136.5	
40	110.2	117.1	122.1	126.3	130.3	134.3	138.5	143.5	150.4	
50	122.2	129.7	135.2	139.8	144.2	148.5	153.2	158.6	166.2	
60	135.5	143.7	149.7	154.7	159.5	164.2	169.3	175.2	183.5	
70	149.9	158.9	165.3	170.9	176.1	181.2	186.7	193.1	202.1	
80	165.3	175.1	182.0	187.9	193.6	199.2	205.1	212.1	221.8	
90	181.5	188.2	199.5	205.9	212.1	218.0	224.5	235.8	242.5	
100	198.4	209.6	217.7	224.7	231.1	237.6	244.6	252.7	263.9	
110	215.7	227.8	236.5	243.9	250.8	257.8	265.2	273.9	285.9	
120	233.4	246.3	255.6	263.5	270.9	278.3	286.2	295.5	308.4	
130	251.4	265.1	274.9	283.4	291.2	299.1	307.5	317.4	331.1	
140	269.5	283.9	294.4	303.5	311.7	320.1	328.9	339.4	353.9	
150	287.6	302.9	313.9	323.4	332.2	341.1	350.5	361.5	376.8	
160	305.7	321.8	333.5	343.4	352.7	361.9	371.9	383.5	399.7	
170	323.6	340.6	352.8	363.2	372.9	382.7	393.2	405.4	422.3	
180	341.4	359.1	371.8	382.9	393.1	403.3	414.3	426.9	444.7	
190	358.9	377.5	390.8	402.2	412.9	423.5	434.9	448.3	466.8	
200	376.1	395.4	409.4	421.2	432.3	443.5	455.3	469.2	488.5	
210	393.1	413.1	427.6	439.9	451.4	462.9	475.3	489.8	509.8	
220	409.6	430.4	445.4	458.2	470.2	482.1	494.9	509.9	530.7	
230	425.8	447.3	462.8	476.1	488.4	500.8	514.1	529.6	551.1	
240	441.7	463.9	479.9	493.5	506.3	519.1	532.8	548.8	570.9	
250	457.2	480.1	496.5	510.6	523.8	536.9	551.1	567.5	590.4	
260	472.3	495.9	512.8	527.3	540.8	544.4	568.9	585.8	609.4	
270	487.2	511.4	528.8	543.7	557.6	571.5	586.3	603.8	627.9	
280	501.8	526.6	544.5	559.7	573.9	588.2	603.5	621.3	646.1	
290	516.3	541.6	559.9	575.5	590.1	604.7	620.3	638.6	663.9	
300	530.6	556.5	575.2	591.1	606.1	620.9	636.9	655.6	681.5	

310	544.9	571.3	590.4	606.7	621.9	637.1	653.4	672.5	698.9
320	559.1	586.1	605.6	662.2	637.7	653.2	669.8	689.3	716.3
330	573.6	601.1	620.8	637.8	653.6	669.4	686.3	706.1	733.6
340	588.2	616.2	636.3	653.6	669.7	685.8	702.9	723.1	751.1
350	603.3	631.7	652.2	669.7	686.1	702.4	719.9	740.4	768.8
360	618.8	647.7	668.5	686.3	702.9	719.5	737.3	758.1	786.9
365	626.8	655.8	676.8	694.7	711.5	728.3	746.2	767.2	796.2

[1] Based on average instead of estimated birth weights.

to discover evidence of unsatisfactory results from a particular feeding and management program, or to observe by differences in successive grades to what extent some heifers may be recovering from earlier sickness or retarded growth.

From Birth to 21 Months of Age

The weights of 372 of the Holstein heifers included in the previous age-limit group were available for studies on normal growth in weight from birth to 21 months of age. After 21 months, the average weights began to be affected by the number of heifers that were pregnant. The average actual weights and measures of variation for the first 11 months in table 3 are the average values at corresponding 30-day periods. The estimated weights were calculated by fitting a fifth-degree orthogonal polynomial to the average actual weights, after the 30-day weights had been adjusted to the basis of a calendar month of 30.4375 days, by adding the product of the difference in days multiplied by the corresponding estimated daily gains shown in table 1.

TABLE 3.—*Average and estimated weights and gains, and variations in weight, for 372 Holstein heifers by months from birth to 21 months of age*[1]

Age	Average actual weight	Two-thirds fiducial limits	Standard deviation	Coefficient of variation	Estimated standards	
					Weight	Daily gain
Months	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*
At birth	96	91.8– 97.2	11.6	12.1	94.9	
1	118	117.2– 119.8	12.8	10.8	120.8	0.85
2	164	159.3– 167.0	17.8	11.0	162.9	1.38
3	213	211.1– 215.8	22.8	10.7	216.0	1.74
4	272	269.5– 275.1	28.3	10.4	275.3	1.95
5	337	333.0– 338.2	32.7	9.8	337.5	2.04
6	396	392.6– 400.3	37.6	9.5	399.8	2.05
7	457	450.1– 459.0	42.3	9.3	460.2	1.98
8	508	506.4– 513.1	46.8	9.2	517.3	1.88
9	559	553.1– 564.9	51.7	9.3	570.3	1.69
10	609	603.1– 614.7	57.1	9.4	618.9	1.40
11	658	652.2– 664.2	58.6	8.9	663.2	1.45
12	714	707.1– 720.0	61.7	8.7	703.5	1.33
13	740	733.9– 746.8	63.6	8.6	740.7	1.22
14	771	767.0– 780.0	65.8	8.3	775.5	1.11
15	805	798.6– 811.6	65.9	7.9	808.8	1.10
16	841	831.5– 845.2	66.7	7.9	841.8	1.08
17	874	866.3– 880.7	70.2	8.0	875.2	1.10
18	912	901.0– 919.6	73.8	8.1	909.8	1.14
19	946	938.3– 954.1	79.2	8.4	946.2	1.20
20	985	976.8– 994.0	84.3	8.6	984.6	1.26
21	1,027	1,015.7–1,033.4	86.9	8.5	1,024.9	1.32

[1] All data between birth and 12 months of age, except the estimated standards, are for 30-day periods instead of calendar months.

The average actual weights shown in table 3 are a little higher than, but do not vary more than 3 pounds above, those in table 1. The lowest monthly gain in average actual weight (26 pounds) occurred between 12 and 13 months of age. The monthly gain at this age, like that for Jersey heifers at Beltsville (7), was only a little more

than 50 percent of the average monthly gains during the preceding 3 months. Apparently the change from the calf barn to a herd barn had about the same effect on Holstein heifer weights as it did on Jerseys. Differences in the average weights for subsequent months fail to show a definite period of recovery from these conditions.

Coefficients of variation gradually decreased with age to 15 or 16 months of age and then increased slightly with older ages and with increases in the number of heifers pregnant. After 12 months of age, the coefficients were lower for Holstein heifers than for Jersey heifers at Beltsville (*7*).

The fifth-degree orthogonal polynomial was used to calculate the estimated monthly weights of Holstein heifers from birth to 21 months of age because of its greater flexibility. The F-values for the reduction in the sums of squares by the first-, second-, third-, fourth-, and fifth-degree terms were 1,639.50, 83.90, 0.00, 107.39, and 51.78, respectively. All but the third were highly significant.

In general, Beltsville standard or estimated weights for Holstein heifers are higher than those reported by other investigators. Beltsville weights at 3, 6, 12, and 18 months of age are higher than the Ragsdale (*10*) standards from 234 to 165 heifers by 11.9, 12.6, 11.3, and 7.7 percent, respectively, and higher than the Espe (*3*) standards from 65 to 58 heifers by 18.7, 11.7, 6.3, and 2.8 percent, respectively. They are also higher than the average weights from 30 to 27 heifers in the Kansas station herd (*11*) by 5.4, 11.4, 9.6, and 6.0 percent, respectively, and higher than the standard published by Eckles (*2*) in 1920 by 10.8, 14.6, 26.1, and 32.6 percent, respectively.

Also, these Beltsville standards are higher than the average weights reported by Fohrman and Graves (*5*) on 36 daughters of the first sire used in the Beltsville breeding experiment by 5.5 percent at 90 days of age, 6.0 percent at 180 days, 9.1 percent at 12 months of age, and 6.0 percent at 18 months of age.

On the other hand, these Beltsville standard weights for Holstein heifers are below the average weights reported by Graves and others (*6*) on 91 heifers in a herd at Huntley, Mont., by 5.7, 2.7, 3.2, and 3.6 percent at 3, 6, 12, and 18 months of age, respectively. Also, at the same ages they are 18.8, 8.7, 4.0, and 2.2 percent below the average weights reported by Stauber (*13*) on 10 heifers in a herd at Woodward, Okla. Whole milk and skim-milk feeding continued to older ages in these herds than in the Beltsville herd. At 42 and 54 months of age, the average weights of 47 and 32 cows in the group of 91 heifers in the Huntley herd were 5.4 and 3.9 percent above the Beltsville standard. The average weights of 17 heifers in a herd at Ardmore, S. Dak. (*1*), were 10.2 and 0.8 percent above the Beltsville standards at 3 and 6 months of age, respectively, and 16.1 and 17.3 percent below them at 12 and 18 months of age.

Differences in relative rates of growth shown by Beltsville and other standards may be measured by calculating the percentages of the maximum mature weight for weights at different ages in each standard, and applying these percentages to the maximum weight in the Beltsville standard. Such a set of equivalent weights may be compared directly, or graded according to the boundary weights in

table 4. The equivalent weights from the Ragsdale (*10*) data at birth and at 3, 6, 12, and 18 months of age are 97, 208, 383, 681, and 911 pounds, respectively. Those from the Espe (*3*) data are 95, 194, 382, 706, and 944 pounds, respectively. Corresponding grades of 6, 4, 4, 4, and 6 for the Ragsdale data and 5, 2, 4, 6, and 7 for the Espe data show that the Beltsville standards for Holstein heifers are relatively higher during most of the first year of life.

The same methods show differences in the relative rates of growth of Holstein and Jersey heifers at Beltsville. The equivalent weights calculated from the Jersey estimated weights at Beltsville (*7*) at birth and at 3, 6, 9, 12, and 18 months of age are 77, 193, 390, 574, 712, and 912 pounds, respective'y. The corresponding grades by the Holstein standard are 1, 2, 4, 6, 6, and 6. The grades show the relatively low weights of Jersey heifers at birth and during the first 6 months. For this period the relative monthly gains are higher for the Jersey heifers, but the differences for the remaining months are small. Successive monthly gains of 50, 49, 56, 26, 34, and 31 pounds in the average weights of Holstein heifers from 9 to 15 months of age and corresponding gains of 51, 48, 54, 28, 35, and 28 pounds in the equivalent weights from Jersey average weights at the same ages again show that the transfer of heifers from the calf barn to the same herd barn after 12 months of age affected both breeds alike.

The estimated daily gains in weight (table 3) show a continuous decline from 6 to 16 months of age. Increasing daily gains thereafter probably are the result of increasing numbers of pregnant heifers. At 16 months of age, 14.5 percent of the heifers were pregnant more than 45 days. At 18 months of age, 36.3 percent were pregnant 45 to 105 days, and 14.5 percent were pregnant more than 105 days. At 21 months of age, 19.1 percent were pregnant 45 to 105 days, 22.8 percent were pregnant 46 to 165 days, and 36.3 percent were pregnant more than 165 days.

The boundary weights for assigning grades to the weights of individual Holstein heifers are shown on a monthly basis in table 4. The values in table 4 are based on the standard or estimated weights shown in table 3 and on the results of fitting a fourth-degree orthogonal polynomial to the standard deviations in table 3. The other calculations were the same as those described for table 2. The boundary weights for calendar months in table 4 are slightly lower at most ages than those for the corresponding periods in table 2 because there are differences of a few days in age. Boundary weights at 12 months of age are lower because curve fitting involved the adversely affected weights at 13 and 14 months of age.

With a greater number of days in the age intervals in table 4 than in table 2, it becomes more important to make adjustments for weights obtained at ages a few days over or under an exact number of months. For example, a heifer weighing 785 pounds at 14 months and 20 days of age might be expected to gain 11 pounds in the next 10 days (10 days at 1.10 pounds daily), making an adjusted weight of 796 pounds for the age of 15 months. Then a grade of 5 would be given to the weight of this heifer, whereas without this adjustment the grade would have been 4.

TABLE 4.—*Boundary weights by calendar months between grades for the weights of Holstein heifers*

Age	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9	Grade 10
Months	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	
At birth [1]	81.2	86.3	89.9	93.1	96.1	98.9	102.1	105.8	110.9	
At birth	81.7	86.3	89.5	92.3	94.9	97.6	100.4	103.6	108.2	
1	102.9	109.1	113.5	117.3	120.8	124.4	128.2	132.6	138.8	
2	139.4	147.5	153.3	158.3	162.9	167.6	172.6	178.4	186.5	
3	186.1	196.4	203.7	210.1	215.9	221.8	228.1	235.4	245.7	
4	239.1	251.5	260.4	268.1	275.3	282.4	290.1	299.1	311.5	
5	294.7	309.4	319.9	329.1	337.5	345.9	355.1	365.6	380.3	
6	350.6	367.5	379.7	390.1	399.8	409.5	419.9	432.1	449.1	
7	404.9	423.9	437.6	449.3	460.2	471.1	482.8	496.5	515.5	
8	456.5	477.4	492.4	505.3	517.3	529.4	542.2	557.3	578.2	
9	504.4	527.1	543.3	557.3	570.3	583.4	597.3	613.6	636.2	
10	548.5	572.7	590.1	605.1	618.9	632.8	647.7	665.1	689.3	
11	588.9	614.4	632.8	648.5	663.2	677.9	693.6	711.9	737.5	
12	625.9	652.6	671.8	688.2	703.6	718.9	735.3	754.5	781.2	
13	660.2	687.8	707.7	724.8	740.7	756.6	773.7	793.6	821.2	
14	692.3	720.9	741.5	759.1	775.5	791.9	809.5	830.1	858.6	
15	723.3	752.7	773.8	791.9	808.8	825.8	843.9	865.1	894.4	
16	753.7	783.9	805.7	824.4	841.8	859.2	877.8	899.6	929.8	
17	784.3	815.5	837.9	857.2	875.2	893.1	912.3	934.8	966.1	
18	815.5	847.9	871.2	891.1	909.8	928.4	948.3	971.7	1,004.1	
19	847.5	881.4	905.8	926.7	946.2	965.7	986.5	1,010.9	1,044.8	
20	880.2	916.1	941.9	963.9	984.6	1,005.2	1,027.3	1,053.1	1,088.9	
21	913.1	951.5	979.2	1,002.8	1,024.9	1,047.1	1,070.7	1,098.3	1,136.7	

[1] Based on average instead of estimated birth weights.

From 12 to 35 Months of Age

There were 307 Holstein cows for which weights were available from birth to 35 months of age. Data from 12 to 35 months of age on this group of cows are shown in table 5. This age-limit group was intended to show the trends in average weight during ages that include the period of first pregnancy and parturition for most cows. Table 5 repeats some of the ages shown in table 3, in order to present a continuous curve of data and to show the extent of the differences between these age-limit groups at corresponding ages.

TABLE 5.—*Growth in weight for 307 Holstein cows from 12 to 35 months of age*

Age		Pregnancy score	Cows on test	Average actual weight	5-percent fiducial limits	Standard deviation	Coefficient of variation	Estimated standards	
								Weight	Daily gain
Year-Month			*Percent*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*
1	0			716	709- 723	61.9	8.6	720.0	
1	1			744	737- 751	63.3	8.5	742.4	0.735
1	2			778	771- 785	62.4	8.0	771.8	.967
1	3			810	803- 817	64.0	7.9	806.3	1.133
1	4			846	838- 853	66.6	7.9	844.0	1.240
1	5			879	871- 886	69.0	8.0	883.4	1.294
1	6	3		917	909- 926	73.3	8.0	923.1	1.303
1	7	7		952	944- 962	76.0	8.3	961.9	1.273
1	8	13		992	983-1,002	85.0	8.6	998.7	1.211
1	9	19		1,031	1,022-1,041	87.3	8.5	1,032.9	1.123
1	10	26		1,074	1,063-1,084	93.2	8.7	1,063.8	1.016
1	11	34	1	1,114	1,103-1,125	95.4	8.8	1,091.1	.897
2	0	27	19	1,123	1,112-1,134	97.8	8.7	1,114.7	.773
2	1	16	38	1,129	1,118-1,141	102.5	9.1	1,131.5	.650
2	2	17	49	1,143	1,132-1,155	104.5	9.1	1,150.8	.536
2	3	14	57	1,159	1,147-1,171	107.0	9.2	1,164.0	.436
2	4	10	65	1,169	1,157-1,181	105.2	9.0	1,174.9	.357
2	5	8	75	1,176	1,165-1,188	103.2	8.8	1,184.2	.307
2	6	6	76	1,193	1,181-1,205	105.2	8.8	1,193.1	.292
2	7	5	80	1,205	1,193-1,217	109.0	9.0	1,202.8	.319
2	8	6	81	1,221	1,208-1,233	110.8	9.1	1,214.8	.394
2	9	7	81	1,237	1,224-1,249	114.0	9.2	1,230.8	.524
2	10	10	82	1,256	1,243-1,269	118.9	9.5	1,252.5	.716
2	11	12	80	1,275	1,261-1,288	120.1	9.4	1,282.3	.977

The average weights in early life for the 307 Holstein cows were slightly higher than those in tables 1 and 3. However, they were within the 5-percent fiducial limits for average weights at all ages shown in table 3, and at all but 30 and 60 days of age in table 1.

Ages are expressed in terms of years and months in table 5, and in several later tables, in accordance with terms commonly used in referring to the ages of dairy cows. However, for ease in discussing the data in these tables, age will frequently be expressed in terms of months alone rather than in years and months.

The data in table 5 for cows on test are expressed as percentages of the total number of cows in the group. It was observed from other tabulations that cows in the Beltsville herd tended to carry more weight during lactations when they were on official test and more liberally fed than they did during other lactations.

The pregnancy score is an attempt to classify in a single term the variations in conditions relating to the number of cows in different stages of pregnancy. The pregnancy score for each age was calculated by adding the number of cows in the group that were pregnant 106 to 165 days, to 2 times the number pregnant 166 to 225 days, to 3 times the number pregnant more than 225 days, and dividing this sum by the total number of cows in the group. Multiplying the result by 20 produced a reasonable number of classes without causing these scores to be confused with percentages. Tabulations had shown that increases in weight with these 3 stages of pregnancy were roughly in the proportion of 1, 2, and 3, and that little change in weight was associated with earlier stages of pregnancy. As an example, the pregnancy score of 34 at 23 months of age was obtained from 63 heifers pregnant 106 to 165 days, 70 heifers pregnant 166 to 225 days, and 105 heifers pregnant more than 225 days.

The average actual weights shown in table 5, like all average weights that have been presented as weight standards, were affected by changes in the numbers in various stages of pregnancy and lactation and by different levels of feeding. The estimated weights, calculated by fitting a fourth-degree orthogonal polynomial to the average actual weights, only served to spread the effects of changes in these conditions over a greater number of months in age. Few individual cows weighed at the same ages would have an exact duplication of the average stage of pregnancy or lactation represented by the data in this table. For this reason no attempt was made to use these data or those from older age-limit groups in preparing a table of boundary weights for assigning grades to the weights of individual cows.

The age of 23 months is the only point in table 5 at which the estimated weights were outside of the 5-percent fiducial limits of the average weights. The estimated weights were lower than the average weights for 3 consecutive months at this point and higher than the average weights from 17 to 21 months and from 25 to 29 months of age.

The effects of pregnancy and calving on the average weights at successive ages are shown in table 6. Weight data from the 307 cows in the 12- to 35-month age-limit group were sorted according to four 60-day stages of pregnancy, the first 90 days after calving, and the first 90 days after an early abortion. Another group consisted of the data for cows and heifers not pregnant more than 45 days or within 90 days after calving. Most of the weights under 27 months of age in this last group were obtained from heifers that were not pregnant or that were pregnant less than 46 days. At older ages most of the weights were from cows that had been in milk more than 90 days.

At all ages the average weights of cows pregnant 166 days or more were higher than the average weights for all cows. The average weights of cows in the first 90 days of lactation and cows and heifers not pregnant more than 45 days were lower than the average weights for all cows. Average weights at other stages of pregnancy were intermediate. For all stages of pregnancy and lactation, there were fairly consistent gains with age.

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TABLE 6.—*Effects of pregnancy and calving on the average weights of Holstein cows in the 35-month age-limit group*

Age	Average weight for all 307 cows	Stage of pregnancy								1 to 90 days after calving		1 to 90 days after an abortion under 226 days		Not pregnant over 45 days or within 90 days after calving	
		45 to 105 days		106 to 165 days		166 to 225 days		226 days or over							
		Animals	Average weight	Animals	Average weight	Animals	Average weight	Animals	Average weight	Animals	Average weight	Animals	Average weight	Animals	Average weight
Year–Month	*Pounds*	*Number*	*Pounds*	*Number*	*Pounds*	*Number*	*Pounds*	*Number*	*Pounds*	*Number*	*Pounds*	*Number*	*Pounds*	*Number*	*Pounds*
1 2	778													307	778
1 3	810	2	898											305	809
1 4	846	46	879											261	840
1 5	879	111	894	2	978									194	869
1 6	917	109	923	46	959									152	901
1 7	952	72	947	111	982	2	1,090							122	928
1 8	992	57	980	109	1,004	45	1,061					1	1,000	95	954
1 9	1,031	63	1,004	70	1,023	111	1,073	2	1,216			1	1,022	60	986
1 10	1,074	50	1,018	57	1,067	109	1,098	43	1,155			2	1,027	46	1,012
1 11	1,114	22	1,030	63	1,083	70	1,121	105	1,170	7	1,056	1	1,089	39	1,057
2 0	1,123	20	1,053	50	1,094	57	1,157	82	1,189	69	1,073	1	1,119	28	1,083
2 1	1,129	18	1,107	22	1,103	60	1,179	54	1,212	125	1,082	5	1,121	23	1,104
2 2	1,143	15	1,115	20	1,135	48	1,187	46	1,247	163	1,108	5	1,129	10	1,090
2 3	1,156	14	1,131	17	1,182	23	1,191	50	1,202	121	1,117	6	1,163	76	1,148
2 4	1,169	13	1,161	15	1,175	17	1,215	36	1,273	92	1,135	3	1,227	131	1,157
2 5	1,176	16	1,162	13	1,217	16	1,258	15	1,303	86	1,144	3	1,233	158	1,171
2 6	1,193	31	1,178	13	1,222	14	1,280	16	1,307	65	1,152	2	1,183	166	1,192
2 7	1,205	51	1,207	17	1,234	13	1,293	10	1,333	40	1,164			167	1,198
2 8	1,221	57	1,228	31	1,232	13	1,300	12	1,361	27	1,197			167	1,204
2 9	1,237	56	1,241	51	1,257	16	1,296	10	1,398	26	1,209	1	1,110	147	1,217
2 10	1,256	58	1,253	56	1,276	30	1,308	10	1,374	20	1,234	3	1,182	130	1,233
2 11	1,275	56	1,263	57	1,291	48	1,334	14	1,358	18	1,258	4	1,219	110	1,240

From 12 to 53 Months of Age

The average actual weights and the estimated weights and the measures of variation for 233 Holstein cows from the ages of 12 to 53 months are shown in table 7. At the ages shown in this table, most cows were well into their second lactation and many were in their third lactation. The estimated weights for these ages make a continuous growth curve for the weights of young cows from ages prior to their first pregnancies.

TABLE 7.—*Growth in weight for 233 Holstein cows from 12 to 53 months of age*

Age	Pregnancy score	Cows on test	Average actual weight	5-percent fiducial limits	Standard deviation	Coefficient of variation	Estimated standards	
							Weight	Daily gain
Year-Month		*Percent*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*
1 0			713	705– 722	63.5	8.9	713.7	
1 1			742	734– 751	65.2	8.8	749.8	1.188
1 2			778	770– 786	63.2	8.1	785.3	1.166
1 3			810	802– 817	63.0	7.8	820.0	1.142
1 4			848	840– 857	67.3	7.9	854.0	1.115
1 5			883	874– 892	69.3	7.8	887.1	1.087
1 6	3		921	912– 931	74.3	8.1	919.2	1.056
1 7	8		958	947– 968	80.0	8.4	950.4	1.024
1 8	12		998	987–1,009	86.6	8.7	980.5	.990
1 9	21		1,039	1,028–1,050	87.4	8.4	1,009.6	.955
1 10	29		1,083	1,071–1,095	93.3	8.6	1,037.6	.918
1 11	36	2	1,122	1,110–1,135	97.6	8.7	1,064.4	.881
2 0	30	13	1,135	1,123–1,148	97.3	8.6	1,090.0	.843
2 1	22	30	1,137	1,124–1,151	105.9	9.3	1,114.5	.804
2 2	18	51	1,147	1,133–1,161	107.1	9.3	1,137.7	.764
2 3	14	59	1,162	1,148–1,176	107.9	9.3	1,159.8	.724
2 4	10	68	1,171	1,158–1,185	106.3	9.1	1,180.6	.684
2 5	5	76	1,178	1,164–1,191	104.3	8.9	1,200.2	.645
2 6	5	78	1,195	1,181–1,209	107.3	9.0	1,216.7	.605
2 7	4	81	1,207	1,193–1,222	111.1	9.2	1,235.9	.566
2 8	6	83	1,225	1,211–1,240	110.3	9.0	1,251.9	.527
2 9	8	84	1,245	1,230–1,260	114.3	9.2	1,266.8	.489
2 10	11	85	1,267	1,252–1,283	120.7	9.5	1,280.6	.453
2 11	14	83	1,286	1,270–1,302	123.2	9.6	1,293.3	.417
3 0	18	71	1,306	1,290–1,322	124.6	9.5	1,305.0	.383
3 1	21	55	1,319	1,303–1,335	127.6	9.7	1,315.6	.350
3 2	21	52	1,330	1,314–1,346	125.2	9.4	1,325.3	.319
3 3	21	50	1,338	1,322–1,354	123.7	9.2	1,334.1	.290
3 4	19	48	1,342	1,326–1,358	122.0	9.1	1,342.1	.263
3 5	19	46	1,348	1,332–1,365	126.7	9.4	1,349.4	.238
3 6	16	48	1,347	1,330–1,364	130.7	9.7	1,356.0	.216
3 7	13	50	1,348	1,331–1,366	133.9	9.9	1,361.9	.196
3 8	11	51	1,351	1,334–1,369	133.5	9.9	1,367.4	.179
3 9	10	51	1,353	1,336–1,371	137.2	10.1	1,372.4	.165
3 10	9	52	1,361	1,343–1,380	140.2	10.3	1,377.1	.155
3 11	9	54	1,370	1,353–1,388	138.0	10.1	1,381.6	.147
4 0	11	51	1,381	1,364–1,399	136.1	9.9	1,386.0	.143
4 1	13	48	1,395	1,377–1,413	139.4	10.0	1,390.3	.143
4 2	16	40	1,403	1,385–1,421	138.7	9.9	1,394.8	.147
4 3	17	36	1,412	1,394–1,430	139.7	9.9	1,399.5	.155
4 4	17	32	1,410	1,392–1,428	138.6	9.8	1,404.6	.167
4 5	18	30	1,411	1,393–1,430	144.3	10.2	1,410.2	.184

For this age-limit group and each older age-limit group, there is the question of how great are the differences at corresponding ages between the average weights for these groups and those for younger age-limit groups comprising a larger number of animals. The average weights for the 233 cows in this 12- to 53-month age-limit group

were nearly the same at birth and at 90, 180, and 270 days of age as those shown in table 1, but they were higher than the average weights from 13 to 21 months of age shown in table 3 and above the 5-percent fiducial limits from 17 to 21 months of age. For a period from 18 to 35 months of age, the average weights of these 233 cows were 6.2 pounds higher than those shown in table 5.

The monthly gains in average actual weight were lowest at 42 and 52 months of age. Decreases in the number of cows on official test or the number in advanced pregnancy may have been responsible to some degree. Monthly gains in the average weight of 206 Jersey cows in the Beltsville herd (*7*) were lowest at 43 and 52 months of age also. The Ragsdale (*10*) and Espe (*3*) data had periods of low monthly gains at approximately 30, 45, and 63 months of age.

The breeding efficiency of the herd may be reflected in the pregnancy scores. On a theoretical basis of a 282-day gestation, less 14 days as the average time from the last weigh day at the first of the month to the date of calving, calving intervals of 12, 13, 14, 15, and 16 months would produce pregnancy scores of 16.9, 15.6, 14.5, 13.6, and 12.7, respectively. The average pregnancy score for all ages in table 7 from 19 to 53 months was 15.1, which would indicate an average calving interval of a little over 13 months.

In general, the coefficients of variation were somewhat higher after 41 months of age. This may have been because there were fewer cows in any one stage of pregnancy or lactation at the older ages.

The estimated weights increased at a gradually diminishing rate throughout all ages shown in table 7. In the process of producing a smooth curve, the most rapid gains were found to be between 12 and 18 months of age, instead of between 18 and 23 months of age as shown by the average actual weights. Nevertheless, the average of the estimated daily gains from 12 to 18 months of age is practically the same as an average of the estimated daily gains for the same ages in table 3. Another result of curve fitting on the data in table 7 is that the estimated daily gains for several months after 2 years of age are higher than the differences in average weights at these ages would indicate. In general, the estimated weights from 12 to 53 months of age appear to be independent of changes in the numbers of cows in various stages of pregnancy, but they have a degree of artificiality that impairs their usefulness for many purposes.

From 30 to 71 Months of Age

Data on the weight of Holstein cows, beginning at 30 months of age, are presented in table 8 for the 167 Holstein cows that reached 71 months of age. This period covered the growth of most young cows from some time in the first lactation to a time approaching maturity.

Most of the average actual weights in the 30- to 71-month age-limit group were a little higher than those in the previous groups. The differences at birth and at 90, 180, 270, and 365 days of age between these average weights and those in table 1 were not more than 2 pounds, but the weights of these cows at 15 and 18 months of age were above the 5-percent fiducial limits for average weights shown in table 3. For the period from 18 to 35 months of age, the average weights of these 167 cows were 7.9 pounds higher than those in table

TABLE 8.—*Growth in weight for 167 Holstein cows from 30 to 71 months of age*

Age	Pregnancy score	Cows on test	Average actual weight	5-percent fiducial limits	Standard deviation	Coefficient of variation	Estimated standards	
							Weight	Daily gain
Year-Month		*Percent*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*
2 6	4	79	1,203	1,186–1,221	113.9	9.5	1,196.9	
2 7	4	83	1,213	1,195–1,232	119.9	9.9	1,219.7	0.748
2 8	6	83	1,233	1,214–1,251	120.0	9.7	1,240.2	.675
2 9	8	84	1,254	1,235–1,273	122.4	9.8	1,258.7	.607
2 10	11	85	1,277	1,258–1,297	129.3	10.1	1,275.3	.545
2 11	14	83	1,295	1,275–1,314	130.2	10.1	1,290.2	.489
3 0	17	71	1,310	1,290–1,330	130.9	10.0	1,303.5	.437
3 1	20	54	1,321	1,301–1,342	132.8	10.1	1,315.4	.390
3 2	20	51	1,333	1,313–1,353	132.5	9.9	1,326.0	.348
3 3	20	49	1,341	1,321–1,361	130.4	9.7	1,335.5	.311
3 4	19	47	1,345	1,326–1,365	125.9	9.4	1,343.9	.277
3 5	19	43	1,354	1,333–1,374	133.7	9.9	1,351.4	.247
3 6	17	44	1,351	1,333–1,376	138.6	10.2	1,358.2	.221
3 7	14	44	1,355	1,333–1,376	139.9	10.3	1,364.2	.199
3 8	12	47	1,353	1,332–1,375	138.5	10.2	1,369.7	.180
3 9	11	47	1,355	1,333–1,377	144.3	10.6	1,374.6	.163
3 10	10	45	1,364	1,341–1,386	147.9	10.8	1,379.2	.149
3 11	10	49	1,376	1,354–1,398	145.3	10.6	1,383.4	.138
4 0	12	46	1,386	1,364–1,408	143.4	10.3	1,387.3	.120
4 1	15	44	1,400	1,378–1,423	148.1	10.6	1,391.1	.122
4 2	17	37	1,409	1,387–1,431	144.6	10.2	1,394.6	.117
4 3	18	34	1,418	1,396–1,440	143.6	10.1	1,398.1	.113
4 4	18	31	1,414	1,392–1,436	143.2	10.1	1,401.4	.111
4 5	19	29	1,414	1,391–1,437	150.0	10.7	1,404.8	.110
4 6	17	26	1,411	1,389–1,434	146.6	10.4	1,408.1	.109
4 7	17	23	1,413	1,391–1,435	143.3	10.1	1,411.4	.109
4 8	16	20	1,411	1,387–1,434	153.4	10.9	1,414.8	.110
4 9	15	21	1,408	1,386–1,431	147.3	10.5	1,418.1	.110
4 10	16	20	1,414	1,392–1,436	143.7	10.2	1,421.5	.111
4 11	15	19	1,411	1,389–1,433	148.9	10.2	1,424.9	.111
5 0	15	19	1,426	1,404–1,448	143.4	10.1	1,428.2	.110
5 1	16	20	1,432	1,411–1,454	140.8	9.8	1,431.6	.109
5 2	16	19	1,434	1,412–1,455	143.2	10.0	1,434.8	.107
5 3	16	18	1,440	1,419–1,462	141.8	9.8	1,438.0	.103
5 4	16	22	1,439	1,417–1,461	145.7	10.1	1,440.9	.098
5 5	17	21	1,446	1,426–1,467	135.4	9.4	1,443.7	.091
5 6	19	22	1,454	1,433–1,476	139.4	9.6	1,446.2	.082
5 7	18	24	1,455	1,433–1,478	145.0	10.0	1,448.3	.071
5 8	17	26	1,449	1,426–1,471	147.1	10.2	1,450.1	.057
5 9	14	26	1,445	1,423–1,468	146.5	10.1	1,451.3	.040
5 10	14	26	1,452	1,430–1,474	145.1	10.0	1,451.9	.021
5 11	12	20	1,452	1,430–1,474	144.6	10.0	1,451.9	−.002

7, and 14.1 pounds higher than those in table 5. From 36 to 53 months of age, these average weights were 4.2 pounds higher than those in table 7. All monthly weights, however, were within the 5-percent fiducial limits for average weights in table 7.

The average actual weights in table 8 showed very little gain from 51 to 59 months of age and irregular monthly gains thereafter. The estimated daily gains avoid these irregularities, but they do show a long period of time when normal gains are very small. Estimated or normal monthly gains in weight at 3, 4, and 5 years of age were 13.3, 3.9, and 3.3 pounds, respectively.

FROM 30 TO 89 MONTHS OF AGE

The data in table 9 show the growth in weight of 110 Holstein cows from shortly after the age of first calving through the age of maximum size.

TABLE 9.—*Growth in weight for 110 Holstein cows from 30 to 89 months of age*

Age	Pregnancy score	Cows on test	Average actual weight	5-percent fiducial limits	Standard deviation	Coefficient of variation	Estimated standards	
							Weight	Daily gain
Year-Month		*Percent*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*
2 6	6	76	1,198	1,175–1,221	122.6	10.2	1,186.2	
2 7	4	82	1,203	1,180–1,227	124.3	10.3	1,207.0	0.714
2 8	6	83	1,223	1,200–1,247	124.9	10.2	1,227.8	.652
2 9	8	84	1,242	1,218–1,265	123.7	10.0	1,245.8	.594
2 10	9	85	1,263	1,238–1,288	131.4	10.4	1,262.3	.540
2 11	12	84	1,279	1,256–1,302	136.1	10.6	1,277.2	.489
3 0	13	75	1,299	1,265–1,316	133.5	10.3	1,290.6	.443
3 1	17	53	1,301	1,276–1,326	134.6	10.3	1,302.8	.400
3 2	18	49	1,316	1,290–1,342	135.6	10.3	1,313.3	.360
3 3	19	40	1,325	1,301–1,349	127.5	9.6	1,323.6	.324
3 4	21	43	1,337	1,313–1,362	130.2	9.7	1,332.5	.291
3 5	21	40	1,346	1,321–1,371	134.3	10.0	1,340.4	.261
3 6	19	42	1,352	1,326–1,378	135.2	10.0	1,347.6	.234
3 7	17	40	1,351	1,325–1,377	136.6	10.1	1,354.0	.210
3 8	14	43	1,349	1,323–1,376	139.2	10.3	1,359.7	.188
3 9	13	43	1,348	1,320–1,376	150.7	11.2	1,364.8	.169
3 10	11	45	1,351	1,322–1,380	154.7	11.5	1,369.5	.153
3 11	10	46	1,362	1,334–1,391	150.9	11.1	1,373.7	.139
4 0	12	43	1,371	1,343–1,400	150.8	11.0	1,377.6	.127
4 1	13	40	1,385	1,355–1,414	156.3	11.3	1,381.1	.117
4 2	16	35	1,396	1,367–1,424	152.0	10.9	1,384.4	.108
4 3	17	32	1,405	1,377–1,434	150.5	10.7	1,387.5	.102
4 4	16	30	1,402	1,375–1,430	146.6	10.5	1,390.5	.097
4 5	17	29	1,401	1,373–1,429	147.3	10.5	1,393.4	.094
4 6	20	27	1,411	1,384–1,438	143.4	10.2	1,396.2	.093
4 7	20	23	1,419	1,392–1,446	142.5	10.0	1,399.0	.092
4 8	18	20	1,407	1,379–1,435	149.3	10.6	1,401.8	.093
4 9	15	21	1,397	1,370–1,423	141.2	10.1	1,404.7	.095
4 10	14	20	1,399	1,374–1,425	134.9	9.6	1,407.7	.097
4 11	14	17	1,395	1,370–1,420	134.0	9.6	1,410.7	.101
5 0	13	16	1,410	1,385–1,435	132.1	9.4	1,413.9	.105
5 1	16	16	1,425	1,398–1,451	139.6	9.8	1,417.2	.109
5 2	14	15	1,417	1,391–1,443	137.3	9.7	1,420.7	.114
5 3	14	13	1,425	1,399–1,451	138.5	9.7	1,424.4	.119
5 4	15	16	1,426	1,399–1,453	143.7	10.1	1,428.1	.125
5 5	17	16	1,436	1,411–1,460	128.4	8.9	1,432.1	.130
5 6	21	16	1,447	1,423–1,471	126.4	8.9	1,436.2	.135
5 7	21	20	1,453	1,427–1,479	137.2	9.4	1,440.5	.140
5 8	20	23	1,440	1,413–1,466	138.1	9.6	1,444.9	.144
5 9	17	25	1,442	1,415–1,469	141.9	9.8	1,449.4	.148
5 10	16	25	1,446	1,421–1,471	130.7	9.0	1,454.0	.152
5 11	13	31	1,443	1,419–1,467	126.8	8.8	1,458.7	.154
6 0	11	34	1,455	1,430–1,480	131.6	9.0	1,463.4	.156
6 1	11	36	1,451	1,427–1,474	124.7	8.6	1,468.2	.156
6 2	11	41	1,463	1,438–1,488	134.9	9.2	1,472.9	.156
6 3	11	44	1,471	1,444–1,498	143.5	9.8	1,477.6	.154
6 4	12	43	1,475	1,449–1,500	133.3	9.0	1,482.2	.151
6 5	15	43	1,490	1,465–1,516	133.8	9.0	1,486.7	.146
6 6	17	43	1,503	1,477–1,530	142.1	9.5	1,490.9	.140
6 7	20	38	1,512	1,485–1,540	146.5	9.7	1,494.9	.131
6 8	19	30	1,513	1,484–1,541	150.4	9.9	1,498.6	.121
6 9	17	45	1,508	1,481–1,535	143.3	9.5	1,501.9	.109
6 10	14	53	1,512	1,486–1,537	135.7	9.0	1,504.8	.094
6 11	13	52	1,510	1,483–1,537	142.3	9.4	1,507.1	.078
7 0	15	47	1,514	1,486–1,542	146.6	9.7	1,508.9	.058
7 1	12	51	1,515	1,487–1,543	140.0	9.8	1,510.0	.037
7 2	9	51	1,498	1,469–1,527	154.4	10.3	1,510.4	.012
7 3	10	49	1,500	1,470–1,529	157.2	10.4	1,509.9	−.015
7 4	9	48	1,506	1,478–1,534	147.4	9.8	1,508.5	−.046
7 5	7	48	1,499	1,471–1,527	148.0	9.9	1,506.1	−.079

The average actual weights of the cows in the 30- to 89-month age-limit group were below the 5-percent fiducial limits for the average weights at 270 days of age in table 1 and at 12 months of age in table 3, but they were slightly higher than the average weights in table 3 at 15 and 18 months of age. At most of the ages after 30 months, the average weights in table 9 were below those in tables 7 and 8, but not below the 5-percent fiducial limits. From 18 to 35, 36 to 53, and 54 to 71 months of age, the average weights in table 9 were 10.1, 11.8, and 8.7 pounds, respectively, below those in table 8. From 18 to 35 and 36 to 53 months of age, the average weights in table 9 were 2.2 and 7.6 pounds below those in table 7.

There was considerable irregularity in the average actual weights for successive ages in table 9. The first average weight above 1,500 pounds was at 78 months of age, and it appeared that the period of maximum weight was passing by at 89 months of age.

The 5-percent fiducial limits for the average actual weights in this age-limit group cover wider ranges than those in previous groups, largely because of decreases in numbers and only slightly because of increases in the standard deviations. For example, the averages of the ranges between the 5-percent fiducial limits for weights from 30 to 35 months of age are 25.2, 29.8, 37.5, and 43.8 pounds, respectively, for the 35-, 53-, 71-, and 89-month age-limit groups. The averages of the corresponding standard deviations are 112.9, 114.5, 122.6, and 127.2 pounds.

The relative number of animals available for each age-limit group was affected by the policy of removing cows from the herd as soon as they were no longer needed for experimental data. Out of 400 heifers at 12 months of age, only 76.8, 58.3, 41.8, and 27.5 percent were available for weighing at 35, 53, 71, and 89 months of age, respectively. However, these values are higher than corresponding values for Jersey cows at Beltsville (*7*), much higher than similar values in the Ragsdale (*10*) data, and definitely lower than similar values for 89 months of age reported by Espe (*3*).

In comparison with other standards, these 110 cows had an average weight of 1,509.4 pounds for ages from 81 to 87 months. At corresponding ages, the 19 to 24 Holstein cows in Espe's report (*3*) had an average maximum weight of 1,416 pounds, and the 25 to 30 cows in Ragsdale's report (*10*) had an average maximum weight of 1,401 pounds. Morgan and Davis (*8*) reported an average weight of 1,509 pounds, for periods covering 9 months before and 3 months after parturition, for the eighth or later lactations.

A comparison of the rates at which Holstein and Jersey females approach maturity under like conditions in the same herd was made from these data, and from data on the normal growth of Jersey cows at the Beltsville station (*7*). With maximum estimated weights of 1,091.8 pounds at 86 months of age for Jersey cows and 1,510.4 pounds at the same age for Holstein cows, the percentages of these maximum weights attained by Jersey and Holstein females, respectively, were 47.14 and 46.58 percent at 12 months of age, 60.37 and 60.24 percent at 18 months, 80.56 and 78.99 percent at 30 months, and 92.22 and 91.76

percent at 48 months. These percentages show little reason for planning to breed Holstein heifers at a later age than Jersey heifers. The percentages of the maximum weights attained by Jersey heifers at 12, 15, 18, and 30 months of age were reached by Holstein heifers about 7, 6, 2, and 74 days later.

The rates of gain in weight as shown by the estimated daily gains in table 9 decreased gradually to 55 months of age, increased again to 73 months of age, and then decreased to losses in weight at 87 months of age. An almost identical trend was shown in a similar table in the report on the weights of Jersey cows at Beltsville (*7*). It might be suspected that conditions of herd management or the method of calculating the smooth curve of estimated weights was responsible to some extent for such apparent trends. However, the average monthly gains in the average actual weights for 7-month periods centering at 33, 44, 55, 73, and 87 months of age were 15.9, 3.6, −0.9, 4.7, and −1.6 pounds, respectively. These values show that something more than the methods of calculating the smooth curve of estimated weights was responsible for the low rates of gain at 55 months of age. At this age, when estimated gains in weight were low, the relative numbers of cows on test were decreasing and the pregnancy scores were passing a temporary peak and beginning to decline.

Irregular trends in the rates of growth are shown also in the data reported by Espe (*3*) and Ragsdale (*10*), even in the average gains for 7-month periods. The data from both sources showed low monthly gains in weight for 7-month periods centering at 30 and 42 months of age and losses in weight for periods centering at 63, 72, and 87 months of age. Relatively high gains for cows over 5 years old were found for 7-month periods centering at 78 months of age.

From 48 to 107 Months of Age

Data that were available on 55 Holstein cows from birth to 107 months of age made it possible to study the changes in weight at advanced ages. The data from 48 to 107 months of age on these cows are shown in table 10.

The average actual weights in early life of the cows in the 48- to 107-month age-limit group were much like those in the 30- to 89-month age-limit group. They were slightly below the 5-percent fiducial limits in table 1 for average weights at 270 and 365 days of age, but they were 5 pounds above the average weights at 18 months of age in table 3. The average weights of these cows from 18 to 35, 36 to 53, 54 to 71, and 72 to 89 months of age were 4.4, 22.5, 13.7, and 2.0 pounds lower, respectively, than those shown in table 9. The average weights from 47 to 53 months of age were below the 5-percent fiducial limits shown in table 9, and the average weights at these ages, some average weights at earlier ages, and the average weights from 57 to 65 months of age were below the 5-percent fiducial limits in table 8. Since there was less difference between these age-limit groups at older ages, it is possible that the difference at these earlier ages was largely due to different procedures in feeding and management.

TABLE 10.—*Growth in weight for 55 Holstein cows from 48 to 107 months of age*

Age	Pregnancy score	Cows on test	Average actual weight	5-percent fiducial limits	Standard deviation	Coefficient of variation	Estimated standards	
							Weight	Daily gain
Year-Month		*Percent*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*
4 0	9	38	1,335	1,295–1,375	147.9	11.1	1,362.6	
4 1	12	33	1,349	1,308–1,391	152.8	11.3	1,362.0	−0.020
4 2	14	27	1,361	1,321–1,401	148.1	10.9	1,362.3	.007
4 3	16	27	1,373	1,330–1,417	161.0	11.8	1,363.2	.032
4 4	19	25	1,374	1,333–1,415	152.3	11.1	1,364.9	.055
4 5	19	25	1,372	1,331–1,413	140.4	10.2	1,367.3	.076
4 6	23	22	1,393	1,357–1,429	132.0	9.5	1,370.1	.095
4 7	24	20	1,409	1,372–1,447	139.3	9.9	1,373.6	.112
4 8	22	18	1,397	1,356–1,439	152.2	10.9	1,377.4	.127
4 9	15	18	1,370	1,341–1,416	142.3	10.3	1,381.7	.140
4 10	14	15	1,375	1,338–1,412	136.9	10.0	1,386.3	.152
4 11	15	13	1,376	1,338–1,415	142.0	10.3	1,391.2	.161
5 0	13	13	1,398	1,361–1,436	138.2	9.9	1,396.4	.169
5 1	14	15	1,408	1,369–1,448	145.9	10.4	1,401.7	.176
5 2	13	15	1,400	1,360–1,440	148.1	10.6	1,407.2	.181
5 3	15	11	1,411	1,369–1,472	152.7	10.8	1,412.9	.185
5 4	17	13	1,418	1,377–1,459	152.4	10.7	1,418.6	.187
5 5	15	13	1,413	1,380–1,446	123.8	8.8	1,424.3	.188
5 6	23	13	1,434	1,399–1,470	130.7	9.1	1,430.0	.188
5 7	22	16	1,444	1,405–1,483	146.0	10.1	1,435.7	.186
5 8	23	20	1,427	1,390–1,464	135.8	9.5	1,441.3	.184
5 9	19	22	1,434	1,394–1,474	147.1	10.3	1,446.7	.180
5 10	10	24	1,434	1,396–1,472	140.7	9.8	1,452.1	.176
5 11	15	29	1,439	1,405–1,473	125.7	8.7	1,457.3	.171
6 0	13	35	1,453	1,419–1,487	126.9	8.7	1,462.3	.164
6 1	11	36	1,450	1,417–1,483	123.6	8.5	1,467.1	.157
6 2	12	42	1,465	1,428–1,502	138.3	9.4	1,471.6	.150
6 3	8	51	1,464	1,424–1,504	148.0	10.1	1,476.0	.142
6 4	10	53	1,472	1,435–1,509	136.2	9.3	1,480.0	.133
6 5	13	51	1,491	1,453–1,529	139.8	9.4	1,483.8	.124
6 6	17	49	1,503	1,464–1,542	145.6	9.7	1,487.2	.114
6 7	19	45	1,521	1,481–1,561	148.6	9.8	1,490.4	.104
6 8	17	47	1,507	1,467–1,547	147.1	9.8	1,493.2	.094
6 9	18	53	1,507	1,467–1,547	149.0	9.9	1,495.8	.083
6 10	17	58	1,514	1,478–1,550	133.0	8.8	1,498.0	.072
6 11	14	60	1,510	1,473–1,546	134.2	8.9	1,499.8	.062
7 0	17	49	1,515	1,476–1,554	144.5	9.5	1,501.4	.051
7 1	15	55	1,520	1,480–1,560	147.9	9.7	1,502.6	.040
7 2	8	53	1,493	1,450–1,536	159.6	10.7	1,503.5	.029
7 3	10	45	1,502	1,459–1,544	157.5	10.5	1,504.1	.018
7 4	8	42	1,494	1,453–1,535	153.4	10.3	1,504.3	.009
7 5	7	44	1,489	1,444–1,534	166.0	11.2	1,504.3	−.001
7 6	10	42	1,500	1,456–1,545	164.5	11.0	1,504.0	−.010
7 7	13	44	1,507	1,464–1,551	161.9	10.7	1,503.4	−.020
7 8	13	38	1,500	1,455–1,545	166.3	11.1	1,502.5	−.028
7 9	16	38	1,503	1,457–1,549	169.1	11.3	1,501.4	−.036
7 10	21	29	1,517	1,471–1,562	169.0	11.1	1,500.1	−.043
7 11	17	26	1,503	1,458–1,548	166.1	11.0	1,498.6	−.050
8 0	21	29	1,516	1,467–1,564	178.8	11.8	1,496.9	−.055
8 1	12	27	1,475	1,429–1,520	168.1	11.4	1,495.1	−.060
8 2	13	25	1,475	1,428–1,522	178.2	12.1	1,493.1	−.064
8 3	12	25	1,487	1,442–1,532	166.6	11.2	1,491.1	−.067
8 4	12	25	1,476	1,433–1,518	157.0	10.6	1,489.0	−.069
8 5	11	25	1,479	1,434–1,524	166.5	11.3	1,486.8	−.070
8 6	13	25	1,483	1,437–1,529	170.2	11.5	1,484.7	−.070
8 7	12	25	1,482	1,434–1,530	177.2	12.0	1,482.7	−.068
8 8	8	24	1,469	1,421–1,516	177.2	12.1	1,480.7	−.065
8 9	9	20	1,478	1,430–1,526	178.3	12.1	1,478.8	−.061
8 10	11	18	1,489	1,441–1,538	179.1	12.0	1,477.2	−.055
8 11	12	16	1,492	1,443–1,542	182.4	12.2	1,475.7	−.048

The coefficients of variation increased considerably after 83 months of age. The standard deviations continued to increase while there was a gradual decrease in the average weights.

In this age-limit group, the highest estimated weights occurred at 88 months of age. The highest 7 consecutive average actual weights were from 79 to 85 months of age, but most of the average weights continued at 1,500 pounds or more until after 96 months of age. Both the estimated weights and the average actual weights continued to decline during all or nearly all of the remaining ages in this 107-month age-limit group.

For 124- and 142-Month Age-Limit Groups

The data for older Holstein cows were condensed and combined in table 11 for the purpose of studying the weight changes at more advanced ages. The data for average actual weight, pregnancy score, and relative number of cows on test are averages of the values for 3 consecutive months centering on the age in months indicated. The estimated weights were calculated by months in the same manner as those for other age-limit groups, but only the values for the specified months are shown in table 11. The estimated daily gains in weight are for the months indicated instead of an average for a 3-month interval. Measures of variation are not presented in this table.

The cows in the 124-month age-limit group were definitely lighter than those in previous age-limit groups from shortly after birth. Their average actual weights were below the 5-percent fiducial limits in table 1 for average weights at 90, 180, and 365 days of age, and below those in table 3 for average weights at 18 months of age. At other ages their weights were below the 5-percent fiducial limits for average weights shown in table 9.

The cows in the 142-month age-limit group were below the 5-percent fiducial limits for average weights in table 1 at birth, and at 90, 180, and 365 days of age, but they were above the average weights at 18 months in table 3. At older ages the average weights for this group were definitely above those in the 124-month age-limit group and some of the previous age-limit groups.

Neither the average nor the estimated weights in the 124-month age-limit group showed any indication of an end to the trend toward lower average weights with advance in age. The 142-month age-limit group showed slight gains in estimated weights after 132 months of age. The lowest average weights occurred from 120 to 124 months of age.

The coefficients of variation were a little high for cows in the 124-month age-limit group, especially after 85 months of age. On the other hand, the cows in the 142-month age-limit group had high coefficients of variation from 86 to 108 months of age, but they were no higher than any other group from then on.

TABLE 11.—*Growth in weight for two groups of older Holstein cows*

124-MONTH AGE-LIMIT GROUP (29 COWS)

Age	Pregnancy score	Cows on test	Average actual weight	Estimated standards	
				Weight	Daily gain
Year-Month		*Percent*	*Pounds*	*Pounds*	*Pounds*
5 0	13	10	1,368	1,368.0	
5 3	14	8	1,388	1,389.3	0.222
5 6	20	11	1,417	1,408.9	.211
5 9	23	24	1,423	1,427.3	.196
6 0	12	40	1,428	1,444.0	.177
6 3	9	48	1,451	1,458.8	.155
6 6	14	47	1,486	1,471.5	.130
6 9	17	46	1,494	1,481.8	.104
7 0	19	43	1,503	1,489.7	.077
7 3	5	54	1,469	1,495.0	.049
7 6	9	49	1,489	1,497.9	.022
7 9	16	44	1,504	1,498.3	−.004
8 0	20	37	1,514	1,496.3	−.029
8 3	14	29	1,490	1,492.3	−.052
8 6	12	29	1,475	1,486.4	−.071
8 9	12	24	1,474	1,478.9	−.087
9 0	17	22	1,479	1,472.0	−.098
9 3	16	17	1,451	1,460.8	−.105
9 6	17	15	1,457	1,451.2	−.105
9 9	14	13	1,447	1,441.8	−.100
10 0	14	8	1,432	1,433.4	−.087
10 3	13	6	1,423	1,426.9	−.067

142-MONTH AGE-LIMIT GROUP (18 COWS)

5 0	13	11	1,412	1,398.7	
5 3	16	9	1,422	1,420.3	.230
5 6	17	16	1,436	1,439.9	.207
5 9	18	27	1,449	1,457.5	.184
6 0	13	49	1,457	1,472.9	.161
6 3	13	56	1,485	1,486.2	.138
6 6	16	53	1,507	1,497.3	.114
6 9	14	56	1,502	1,506.3	.091
7 0	16	42	1,519	1,513.2	.068
7 3	5	51	1,490	1,518.1	.046
7 6	12	42	1,531	1,521.1	.026
7 9	14	42	1,534	1,522.2	.006
8 0	21	38	1,557	1,521.7	−.011
8 3	14	27	1,528	1,519.7	−.027
8 6	11	27	1,493	1,516.4	−.041
8 9	12	16	1,508	1,512.0	−.052
9 0	12	13	1,503	1,506.7	−.061
9 3	14	18	1,479	1,500.8	−.066
9 6	20	13	1,512	1,494.6	−.068
9 9	16	11	1,496	1,488.4	−.067
10 0	8	9	1,458	1,482.5	−.062
10 3	4	7	1,442	1,477.3	−.053
10 6	14	7	1,474	1,473.2	−.040
10 9	17	2	1,501	1,470.6	−.022
11 0	15	7	1,496	1,469.9	.000
11 3	11	7	1,479	1,471.6	.028
11 6	12	13	1,475	1,476.1	.061
11 9	12	13	1,471	1,483.9	.096

Information From All Age-Limit Groups

Although a continuous growth standard from birth to old age would be desirable, differences in the average actual weights at the same age for animals in different age-limit groups prevent the joining of the several curves of estimated weights.

However, a summarization of the average actual weights of Holstein females in the Beltsville herd is given in table 12. These average weights include data previously omitted because of age-limit group requirements and a considerable amount of data obtained since the standards were calculated. Twins and inbred animals were not included for comparison.

Table 12.—*Average weights of Holstein cows and heifers in the Beltsville herd without regard to age-limit groups*

Age	Holstein females	Average actual weight	Estimated standard weight	Age	Holstein females	Average actual weight	Estimated standard weight
	Number	*Pounds*	*Pounds*		*Years*	*Number*	*Pounds*	*Pounds*
At birth	488	95	92.6	1	488	713	711.5
				1½	461	912	909.8
Days				2	399	1,120	1,114.7
30	488	117	118.1	2½	390	1,194	1,193.1
60	488	159	159.5	3	360	1,294	1,305.0
90	488	212	212.0	4	295	1,385	1,386.0
180	488	395	393.1	5	248	1,436	1,428.2
270	488	559	557.6	6	194	1,476	1,463.4
				7	148	1,502	1,503.9
				8	92	1,493	1,496.9

At most ages the average actual weights shown in table 12 are in close agreement with the estimated standard weights. However, the average weights are higher at 2 years of age, when a greater proportion of the animals were in advanced pregnancy. At 5 and 6 years of age, the average weights in table 12 are higher than either the estimated standards or the average weights from which the standards were calculated.

Analysis of variance was used on the data from 372 Holstein heifers at successive ages (in months) in order to estimate the earliest age at which there were significant differences between the average weights for different stages of pregnancy and lactation. The variance ratios for 15, 16, 17, 18, 19, 20, 21, 22, and 23 months of age were 0.89, 9.14, 5.45, 9.69, 13.51, 13.79, 18.45, 21.40, and 20.05, respectively. All but the first were highly significant. Thus, there appeared to be significant differences at 16 months of age between the weights of 54 Holstein heifers that were pregnant more than 45 days and 318 heifers that were not. However, these differences may have been partly due to a tendency for smaller heifers to conceive at a later age. Another study on the weights of most of these same heifers showed that the average calving age of 47 heifers whose weights at 15 months of age would have been graded 1 or 2, was about 2 months later than the average for 53 heifers whose weights would have been graded 9 or 10. A significant difference in the weights of Jersey heifers at Beltsville (7) was not found until 18 months of age.

Similar tests with analysis of variance were made on the differences between the average weights of cows and heifers at different ages (in months) during various 18-month periods from birth. In the 35-month age-limit group, the variance ratio for the effect of age was 8,957.15 for the period from birth to 17 months of age and 314.06 for the period from 18 to 35 months of age. In the 53-month age-limit group, the variance ratios were 235.15 for ages from 18 to 35 months and 14.07 for ages from 36 to 53 months. In the 71-month age-limit group, the variance ratios were 9.44 for ages from 36 to 53 months and 1.66 for ages from 54 to 71 months. This last variance ratio was significant, but not highly significant.

In the 89-month age-limit group, the variance ratios for differences between monthly average weights during 18-month periods ending at 53, 71, and 89 months of age were 6.28, 2.01, and 2.58, respectively. All were highly significant. However, these results may include the effect of other conditions, such as differences in the number of cows on test. In the 107-month age-limit group, the variance ratios between average weights at successive months during 18-month periods ending at 53, 71, 89, and 107 months of age were 2.12, 1.30, 1.38, and 0.41, respectively. The variance ratio for the period ending at 53 months of age is the only one that is significant.

STANDARD FOR ASSIGNING GRADES TO THE WEIGHTS OF HOLSTEIN COWS

A standard for assigning grades to the weights of Holstein cows was produced by combining the results of a number of different tabulations and computations. The estimated standard weights in tables 5 to 10 were not used. They provided no way of estimating the effects of different stages of pregnancy and lactation on the weights of individual cows, nor the effect at different ages on the standard itself of different numbers of cows on test or in various stages of pregnancy and lactation. Therefore, the data were tabulated on an entirely different basis. The results of various steps in these tabulations are shown in table 13.

The first step was to adopt the average of the first 10 monthly weights in a lactation as the basic measure of a cow's weight. This provided a control of the effects of lactation and, to a large extent, a control of the effects of pregnancy. However, differences in the intervals from one calving to the next may have resulted in a varying pregnancy effect on the weights for the 9th or 10th month after calving. The averages of 1,039 such basic 10-month weights from cows calving at different ages are listed in table 13. The age of a cow at the time of the first of 10 monthly weights was used as the basis for expressing the cow's age. In general, the ages used in table 13 may be about 15 days older than the average calving age.

The irregular changes between average weights for successive ages, and the realization that a larger percentage of the cows were on official test at some ages than at others, demonstrated the need for finding some other method of measuring the effect of age. Therefore, the effects of age were measured by difference between the basic 10-month

TABLE 13.—*Data used in calculating estimated standards for average weight of Holstein cows during the first 10 months of a lactation*

Age at time of first monthly weight	Average of first 10 monthly weights after calving		Weight changes between lactations				Estimated values	
			Cows represented in—		Gain per month	Cumulative gains	Cumulative gains	Standard weights
	Cows	Weight	Successive lactations	Alternate lactations				
Year-Month	*Number*	*Pounds*	*Number*	*Number*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1 11	7	1,170					−4.3	1,127.8
2 0	65	1,164	5		10.4	10.4	9.4	1,140.9
2 1	61	1,160	35	2	12.6	23.0	22.7	1,154.2
2 2	40	1,183	59	7	12.2	35.1	35.7	1,167.2
2 3	28	1,226	76	7	12.1	47.2	48.3	1,179.8
2 4	29	1,194	89	9	11.7	58.9	60.5	1,192.0
2 5	27	1,193	98	9	11.5	70.4	72.4	1,204.0
2 6	9	1,249	106	10	11.5	81.9	84.0	1,215.5
2 7	12	1,254	107	11	11.4	93.4	95.2	1,226.8
2 8	6	1,255	108	14	11.3	104.7	106.1	1,237.6
2 9	7	1,301	110	14	11.3	116.0	116.7	1,248.2
2 10	7	1,340	112	14	11.2	127.2	126.9	1,258.5
2 11	5	1,323	114	15	11.1	138.3	136.9	1,268.4
3 0	7	1,238	116	15	11.0	149.4	146.5	1,278.0
3 1	9	1,335	116	17	10.8	160.2	155.8	1,287.3
3 2	23	1,313	115	18	10.7	170.9	164.8	1,296.4
3 3	26	1,362	104	18	10.2	181.2	173.6	1,305.1
3 4	25	1,368	95	18	9.4	190.6	182.0	1,313.5
3 5	20	1,220	94	20	8.3	199.0	190.1	1,321.7
3 6	26	1,361	88	23	7.8	206.8	198.0	1,329.5
3 7	20	1,319	89	25	7.0	213.8	205.6	1,337.1
3 8	17	1,311	90	26	6.2	220.0	213.0	1,344.5
3 9	17	1,317	92	28	5.7	225.7	220.0	1,351.5
3 10	15	1,382	94	31	5.4	231.1	226.8	1,358.4
3 11	15	1,383	95	32	5.1	236.3	233.4	1,364.9
4 0	7	1,415	89	34	4.8	241.1	239.7	1,371.2
4 1	6	1,372	91	34	4.6	245.6	245.8	1,377.3
4 2	9	1,336	93	34	4.5	250.1	251.6	1,383.1
4 3	10	1,382	91	34	4.5	254.7	257.2	1,388.7
4 4	17	1,397	87	35	4.5	259.2	262.5	1,394.1
4 5	12	1,389	87	35	4.2	263.4	267.7	1,399.2
4 6	21	1,376	88	37	4.1	267.5	272.6	1,404.1
4 7	14	1,382	88	35	4.3	271.8	277.3	1,408.8
4 8	18	1,361	86	34	4.3	276.1	281.8	1,413.3
4 9	14	1,419	82	35	4.2	280.3	286.1	1,417.6
4 10	14	1,409	80	36	4.3	284.7	290.2	1,421.7
4 11	14	1,385	72	40	4.3	289.0	294.1	1,425.6
5 0	11	1,369	68	41	4.1	293.1	297.8	1,429.3
5 1	6	1,409	66	41	3.9	297.0	301.3	1,432.8
5 2	13	1,399	64	41	3.9	300.9	304.6	1,436.2
5 3	12	1,414	63	44	3.5	304.4	307.8	1,439.3
5 4	12	1,436	56	46	3.4	307.8	310.8	1,442.3
5 5	9	1,510	51	47	3.4	311.2	313.6	1,445.1
5 6	9	1,411	46	44	3.1	314.4	316.3	1,447.8
5 7	12	1,412	45	41	3.0	317.4	318.8	1,450.3
5 8	17	1,419	37	42	3.2	320.6	321.1	1,452.6
5 9	12	1,444	38	44	2.5	323.1	323.3	1,454.8
5 10	9	1,453	37	44	1.8	324.8	325.3	1,456.9
5 11	13	1,473	37	43	1.7	326.6	327.2	1,458.8
6 0	8	1,399	38	43	1.6	328.2	329.0	1,460.5
6 1	9	1,465	40	42	1.6	329.8	330.6	1,462.1
6 2	7	1,502	40	41	1.5	331.3	332.1	1,463.6
6 3	8	1,466	39	40	1.2	332.4	333.5	1,465.0
6 4	7	1,506	39	38	1.1	333.5	334.8	1,466.3
6 5	4	1,370	38	37	1.0	334.5	335.9	1,467.4
6 6	5	1,535	36	37	1.0	335.5	336.9	1,468.5
6 7	6	1,453	36	37	1.1	336.6	337.9	1,469.4
6 8	9	1,459	36	35	1.4	338.0	338.7	1,470.2
6 9	12	1,520	37	35	1.6	339.6	339.4	1,470.9
6 10	11	1,466	35	34	1.6	341.2	340.1	1,471.6
6 11	9	1,480	31	33	1.5	342.7	340.6	1,472.1
7 0	2	1,465	29	29	1.3	343.9	341.1	1,472.6
7 1	8	1,407	27	29	1.1	345.0	341.4	1,473.0
7 2	10	1,410	25	29	1.1	346.1	341.7	1,473.3
7 3	2	1,535	26	25	.3	346.4	342.0	1,473.5
7 4	5	1,482	27	25	.2	346.6	342.1	1,473.7

TABLE 13.—*Data used in calculating estimated standards for average weight of Holstein cows during the first 10 months of a lactation*—Continued

Age at time of first monthly weight	Average of first 10 monthly weights after calving		Weight changes between lactations			Estimated values	
			Cows represented in—		Gain per month	Cumulative gains	Cumulative gains	Standard weights
	Cows	Weight	Successive lactations	Alternate lactations				
Year-Month	*Number*	*Pounds*	*Number*	*Number*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
7 5	3	1,384	24	23	.1	346.7	342.2	1,473.7
7 6	2	1,168	25	21	.0	346.7	342.3	1,473.8
7 7	3	1,436	25	19	.1	346.8	342.2	1,473.8
7 8	4	1,512	25	18	−.2	346.6	342.1	1,473.7
7 9	2	1,513	25	18	−.3	346.3	342.0	1,473.5
7 10	1	1,493	24	17	−.5	345.8	341.8	1,473.4
7 11	7	1,427	24	16	−.5	345.3	341.6	1,473.2
8 0	3	1,554	22	12	−.6	344.6	341.4	1,472.9
8 1	9	1,438	20	12	−.7	344.0	341.1	1,472.6
8 2	4	1,460	23	9	−.8	343.2	340.8	1,472.3
8 3	3	1,440	23	7	−1.2	342.0	340.4	1,471.9
8 4	5	1,411	23	6	−1.1	340.9	340.0	1,471.6
8 5	2	1,342	23	5	−1.0	339.9	339.7	1,471.2
8 6	1	1,539	23	5	−.8	339.0	339.2	1,470.8
8 7	4	1,365	22	5	−1.0	338.0	338.8	1,470.4
8 8	5	1,448	20	5	−.9	337.1	338.4	1,469.9
8 9	2	1,358	19	5	−1.2	335.9	338.0	1,469.5
8 10	1	1,315	19	4	−1.1	334.8	337.5	1,469.1
8 11	1	1,521	19	4	−1.1	333.7	337.1	1,468.6
9 0	2	1,635	18	4	−1.1	332.7	336.7	1,468.2
9 1	4	1,368	19	4	−.8	331.8	336.2	1,467.8
9 2	3	1,315	21	2	−.1	331.7	335.8	1,467.4
9 3	1	1,565	21	2	.0	331.7	335.4	1,467.0
9 4	1	1,507	21	2	.7	332.4	335.1	1,466.6
9 5	3	1,339	20	2	.9	333.3	334.7	1,466.2
9 6	1	1,511	18	2	.8	334.0	334.4	1,465.9
9 7	3	1,394	17	2	.3	334.3	334.1	1,465.6
9 8	2	1,380	16	2	−.6	333.7	333.8	1,465.3
9 9	4	1,351	15	2	−.9	332.8	333.6	1,465.1
9 10	3	1,412	13	2	−.9	331.9	333.4	1,464.9
9 11			12	2	−.0	331.9	333.2	1,464.8
10 0	2	1,398	12	2	−.0	331.9	333.1	1,464.7
10 1	2	1,270	13	1	.1	332.0	333.1	1,464.6
10 2	1	1,628	11	1	.6	332.6	333.1	1,464.6
10 3			10	1	−.2	332.3	333.1	1,464.6
10 4	2	1,376	10	1	−.2	332.1	333.2	1,464.7
10 5			8	1	−.4	331.7	333.4	1,464.9
10 6	2	1,356	8	1	.5	332.1	333.6	1,465.1
10 7	1	1,327	8	1	.5	332.6	333.9	1,465.4
10 8	1	1,532	8	1	1.2	333.8	334.2	1,465.8
10 9			7	1	2.0	335.8	334.7	1,466.2
10 10			7	1	2.0	337.7	335.2	1,466.7
10 11	3	1,423	7	1	2.0	339.7	335.8	1,467.3
11 0			8	1	2.0	341.7	336.4	1,467.9

weights of individual cows for two consecutive lactations, when the cows were on test in both lactations or not on test in both lactations. When cows were alternately on test and not on test in consecutive lactations, the effect of age was measured by differences in the basic 10-month weights of the first and third, or the second and fourth lactations, and so on, provided the cows were on test in both lactations or were not on test in both lactations. Weights from 375 pairs of consecutive lactations and 70 pairs of alternate lactations were available for studies of the effect of age.

The gain or loss in weight for each cow was divided by the number of months between the lactations, and these monthly gains or losses were tabulated for each of the intervening months. The numbers of cows represented at each age by these tabulations are shown in two

columns in table 13. In calculating the average gains from both consecutive and alternate lactations, the tabulated total weights and number of cows for alternate lactations were divided by 2 in order to compensate for the range of 2 lactations and give preference to data from consecutive lactations.

The series of average cumulative gains had irregularities that were smoothed out by using a fourth-degree orthogonal polynomial to produce the estimated cumulative gains shown in table 13. As an illustration of the effect of age on the rate of gain in weight, it may be stated that the estimated daily gains at 2, 3, 4, 5, 6, 7, 8, 9, and 10 years of age, respectively, were 0.450, 0.316, 0.207, 0.122, 0.058, −0.008, −0.014, and −0.005 pounds.

The average of the 1,039 basic 10-month weights for all ages in table 13 was 1,340.34 pounds. The average of the estimated cumulative gains weighted by the same number of observations at each age was 208.82 pounds. The difference, 1,131.52 pounds, was added to each of the estimated cumulative gains to give estimated or standard basic 10-month lactation weights for Holstein cows. These estimated standard weights are shown in the last column of table 13.

By these procedures a growth curve, little affected by changes in the relative number of cows on official test or by the relative number of light or heavy cows from which weight data were obtained, was fitted on basic 10-month lactation weight data that were little affected by differences in the stages of lactation or pregnancy.

Variation in these data was calculated from the sum of the squares for the deviations of the 1,039 basic 10-month weights from the estimated standard weights for the same ages. The result was a mean square of 13,671.632 and a standard deviation from the estimated values of 116.926 pounds.

Average deviations at different ages, particularly at older ages, were of little use in determining the normal effect of age on the deviations from the estimated values. The effects of age were mixed with the results of wider differences associated with the relative numbers of cows on official test and the relative numbers of light or heavy cows in the various groups. Data in tables 5 to 10 showed some variation with age in the coefficients of variation, but the lower coefficients tended to occur at ages when a higher percentage of the cows were on test. Thus, there seemed to be little reason for not using the same coefficient of variation for all ages for the deviations from the estimated standard weights. The average coefficient of variation for the deviations from the estimated standard weights for Holstein cows was 8.72 percent. The corresponding figure for Jersey cows at Beltsville was 9.65 percent. A similar difference was the lower coefficients of variation at most ages for Holstein cows in the age-limit groups than for Jersey cows.

Since the coefficient of variation was assumed to be the same at all ages, the factors 0.25335, 0.52440, 0.84162, and 1.28155, from a table by Fisher (*4*), that were used in calculating boundary weights for Holstein heifers, could be used with the coefficient of variation in calculating constants to apply directly to the basic 10-month weights in order to determine the boundary weights between 10 grades for Holstein cow weights. These constants for calculating the boundaries between grades 1 and 2, 2 and 3, and so on, are 0.88820, 0.92658, 0.95425,

0.97790, 1.00000, 1.02210, 1.04575, 1.07342, and 1.11180, respectively. Table 14 shows the boundary weights that were calculated in this manner.

The constants used in calculating the boundary weights may also be considered as percentages if it is desired to use them in interpreting comparisons between individual weights and weights presented in other standards. For example, weights less than 88.82 percent of the standard being used would be equivalent to a grade of 1, and weights more than 111.18 percent of the same standard would be equivalent to a grade of 10.

The standard basic 10-month weights show a gain in weight for Holstein cows to 7 years 7 months of age, but there is less than 10 pounds difference between the standard weights for any ages over 6 years 2 months of age. This difference of 10 pounds is less than one-third of the range in weight for any grade at these ages shown in table 14.

Variations in Weight Due to Stages of Pregnancy and Lactation

It might be desirable at times to estimate the relative size of a cow before all 10 monthly weights are available. In such cases it would be convenient to know the normal relationship between the basic 10-month weight and whatever single weights or group of weights may be available. Table 15 was prepared to furnish such information and also to show the normal changes in weight throughout the months of pregnancy and the following lactation. Stages of pregnancy are represented in reverse order by stating the number of months before calving. Data involving abortions were not used. On the average, the first monthly weight before calving would be equivalent to 264 days of pregnancy, the second to 234 days of pregnancy, and so on; but wide deviations are possible. The data were grouped according to the ages of the cows at the first monthly weight after calving in order to demonstrate the additional effect of age at the younger ages. Two groups were included for a comparison between lactations when cows were on test and lactations when cows were not on test.

The average lactation weights, on which the deviations in table 15 were based, were 1,195, 1,342, 1,385, 1,430, 1,479, and 1,425 pounds, respectively, for the 6 age groups, 1,445 pounds for cows on test, and 1,363 pounds for cows not on test.

The data from the 10th to the last month before calving show average 9-month gains of 371 pounds for the 23- to 35-month group, 242 pounds for the 36- to 47-month group, 200 pounds for the 48- to 59-month group, 227 pounds for the 60- to 71-month group, and 216 pounds for the 72- to 83-month group. Gains in weight from the 2d month after calving, which was usually the lowest month, to the 10th month for the same groups in the same order were 160, 128, 121, 110, and 89 pounds, respectively.

Holstein weights reported in a similar manner by Morgan and Davis (*8*) were generally higher than those observed in this study, by differences for the months immediately preceding and after calving that did not exceed 100 pounds. Differences at older ages were considerably less. Gains in weight during the months of pregnancy were very similar.

TABLE 14.—*Boundary weights between grades for the average weights of Holstein cows during the first 10 months of a lactation*

Age at time of first monthly weight		Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9	Grade 10
Year	*Month*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1	11	1,001.7	1,045.0	1,076.2	1,102.9	1,127.8	1,152.7	1,179.4	1,210.6	1,253.9	
2	0	1,013.4	1,057.1	1,088.7	1,115.7	1,140.9	1,166.1	1,193.1	1,224.6	1,268.4	
2	1	1,025.2	1,069.5	1,101.4	1,128.7	1,154.2	1,179.7	1,207.0	1,238.9	1,283.2	
2	2	1,036.7	1,081.5	1,113.8	1,141.4	1,167.2	1,193.0	1,220.6	1,252.9	1,297.7	
2	3	1,047.9	1,093.2	1,125.8	1,153.7	1,179.8	1,205.9	1,233.8	1,266.4	1,311.7	
2	4	1,058.8	1,104.5	1,137.5	1,165.7	1,192.0	1,218.4	1,246.6	1,279.6	1,325.3	
2	5	1,069.4	1,115.6	1,148.9	1,178.3	1,204.0	1,230.6	1,259.0	1,293.4	1,338.5	
2	6	1,079.6	1,126.3	1,159.9	1,188.7	1,215.5	1,242.4	1,271.1	1,304.8	1,351.4	
2	7	1,089.6	1,136.7	1,170.6	1,199.6	1,226.8	1,253.9	1,282.9	1,316.8	1,363.9	
2	8	1,099.3	1,146.8	1,181.0	1,210.3	1,237.6	1,265.0	1,294.3	1,328.5	1,376.0	
2	9	1,108.7	1,156.6	1,191.1	1,221.6	1,248.2	1,275.8	1,305.3	1,339.9	1,387.8	
2	10	1,117.8	1,166.1	1,200.9	1,230.6	1,258.5	1,286.3	1,316.0	1,350.9	1,399.2	
2	11	1,126.6	1,175.3	1,210.4	1,240.4	1,268.4	1,296.4	1,326.4	1,361.5	1,410.2	
3	0	1,135.1	1,184.2	1,219.6	1,249.8	1,278.0	1,306.3	1,336.5	1,371.9	1,420.9	
3	1	1,143.4	1,192.8	1,228.4	1,258.9	1,287.3	1,315.8	1,346.2	1,381.9	1,431.3	
3	2	1,151.4	1,201.2	1,237.1	1,267.7	1,296.4	1,325.0	1,355.7	1,391.5	1,441.3	
3	3	1,159.2	1,209.3	1,245.4	1,276.2	1,305.1	1,333.9	1,364.8	1,400.9	1,451.0	
3	4	1,166.7	1,217.1	1,253.4	1,284.5	1,313.5	1,342.6	1,373.6	1,409.9	1,460.4	
3	5	1,173.9	1,224.6	1,261.2	1,292.5	1,321.7	1,350.9	1,382.1	1,418.7	1,469.4	
3	6	1,180.9	1,231.9	1,268.7	1,300.2	1,329.5	1,358.9	1,390.4	1,427.2	1,478.2	
3	7	1,187.7	1,239.0	1,276.0	1,307.6	1,337.1	1,366.7	1,398.3	1,435.3	1,486.6	
3	8	1,194.2	1,245.8	1,283.0	1,314.8	1,344.5	1,374.1	1,406.0	1,443.2	1,494.8	
3	9	1,200.4	1,252.3	1,289.7	1,321.7	1,351.5	1,381.4	1,413.4	1,450.8	1,502.6	
3	10	1,206.5	1,258.6	1,292.4	1,328.3	1,358.4	1,388.4	1,420.5	1,458.1	1,510.2	
3	11	1,212.3	1,264.7	1,302.5	1,334.7	1,364.9	1,395.1	1,427.3	1,465.1	1,517.5	
4	0	1,217.9	1,270.5	1,308.5	1,340.9	1,371.2	1,401.5	1,433.9	1,471.9	1,524.5	
4	1	1,223.3	1,276.2	1,314.3	1,346.8	1,377.3	1,407.7	1,440.3	1,478.4	1,531.2	
4	2	1,228.5	1,281.6	1,319.8	1,352.5	1,383.1	1,413.7	1,446.4	1,484.6	1,537.7	
4	3	1,233.4	1,286.7	1,325.2	1,358.0	1,388.7	1,419.4	1,452.2	1,490.6	1,543.9	
4	4	1,238.2	1,291.7	1,330.3	1,363.2	1,394.1	1,424.9	1,457.8	1,496.4	1,549.9	
4	5	1,242.8	1,296.5	1,335.2	1,368.3	1,399.2	1,430.1	1,463.2	1,501.9	1,555.6	
4	6	1,247.1	1,301.0	1,339.9	1,373.1	1,404.1	1,435.1	1,468.3	1,507.2	1,561.1	
4	7	1,251.3	1,305.4	1,344.4	1,377.7	1,408.8	1,440.0	1,473.3	1,512.3	1,566.3	
4	8	1,255.3	1,309.5	1,348.7	1,382.1	1,413.3	1,444.5	1,478.0	1,517.1	1,571.3	
4	9	1,259.1	1,313.5	1,352.8	1,386.3	1,417.6	1,448.9	1,482.4	1,521.7	1,576.1	
4	10	1,262.8	1,317.3	1,356.7	1,390.3	1,421.7	1,453.1	1,486.7	1,526.1	1,580.6	
4	11	1,266.2	1,320.9	1,360.4	1,394.1	1,425.6	1,457.1	1,490.8	1,530.3	1,585.0	

5	0	1,269.5	1,324.4	1,363.9	1,397.7	1,429.3	1,460.0	1,494.7	1,534.2	1,589.1
5	1	1,272.6	1,327.6	1,367.3	1,401.2	1,432.8	1,464.5	1,498.4	1,538.0	1,593.0
5	2	1,275.6	1,330.7	1,370.5	1,404.4	1,436.2	1,467.9	1,501.9	1,541.6	1,596.7
5	3	1,278.4	1,333.7	1,373.5	1,407.5	1,439.3	1,471.1	1,505.2	1,545.0	1,600.2
5	4	1,281.1	1,336.4	1,376.3	1,410.4	1,442.3	1,474.2	1,508.3	1,548.2	1,603.6
5	5	1,283.6	1,339.0	1,379.0	1,413.2	1,445.1	1,477.1	1,511.2	1,551.2	1,606.7
5	6	1,285.9	1,341.5	1,381.6	1,415.8	1,447.8	1,479.8	1,514.0	1,554.1	1,609.7
5	7	1,288.2	1,343.8	1,384.0	1,418.3	1,450.3	1,482.4	1,516.7	1,556.8	1,612.4
5	8	1,290.2	1,346.0	1,386.2	1,420.5	1,452.6	1,484.7	1,519.1	1,559.3	1,615.0
5	9	1,292.2	1,348.0	1,388.2	1,422.7	1,454.8	1,487.0	1,521.4	1,561.6	1,617.5
5	10	1,294.0	1,349.9	1,390.2	1,424.7	1,456.9	1,489.1	1,523.5	1,563.8	1,619.7
5	11	1,295.7	1,351.7	1,392.0	1,426.5	1,458.8	1,491.0	1,525.5	1,565.8	1,621.8
6	0	1,297.2	1,353.3	1,393.7	1,428.2	1,460.5	1,492.8	1,527.3	1,567.7	1,623.8
6	1	1,298.7	1,354.8	1,395.3	1,429.8	1,462.1	1,494.5	1,529.0	1,569.5	1,625.6
6	2	1,300.0	1,356.2	1,396.7	1,431.3	1,463.6	1,496.0	1,530.6	1,571.1	1,627.3
6	3	1,301.2	1,357.5	1,398.0	1,432.6	1,465.0	1,497.4	1,532.0	1,572.6	1,628.8
6	4	1,302.4	1,358.6	1,399.2	1,433.9	1,466.3	1,498.7	1,533.4	1,573.9	1,630.2
6	5	1,303.4	1,359.7	1,400.3	1,435.0	1,467.4	1,499.9	1,534.5	1,575.2	1,631.5
6	6	1,304.3	1,360.6	1,401.3	1,436.0	1,468.5	1,500.9	1,535.6	1,576.3	1,632.6
6	7	1,305.1	1,361.5	1,402.2	1,436.9	1,469.4	1,501.9	1,536.6	1,577.3	1,633.7
6	8	1,305.8	1,362.3	1,402.9	1,437.7	1,470.2	1,502.7	1,537.5	1,578.2	1,634.6
6	9	1,306.5	1,362.9	1,403.7	1,438.4	1,470.9	1,503.4	1,538.2	1,578.9	1,635.4
6	10	1,307.1	1,363.5	1,404.3	1,439.0	1,471.6	1,504.1	1,538.9	1,579.6	1,636.1
6	11	1,307.5	1,364.0	1,404.8	1,439.6	1,472.1	1,504.7	1,539.5	1,580.2	1,636.7
7	0	1,308.0	1,364.5	1,405.2	1,440.0	1,472.6	1,505.1	1,539.9	1,580.7	1,637.2
7	3	1,308.8	1,365.3	1,406.1	1,440.9	1,473.5	1,506.1	1,540.9	1,581.7	1,638.2
7	6	1,309.0	1,365.6	1,406.4	1,441.2	1,473.8	1,506.3	1,541.2	1,582.0	1,638.5
7	9	1,308.8	1,365.4	1,406.1	1,441.0	1,473.5	1,506.1	1,540.9	1,581.7	1,638.3
8	0	1,308.2	1,364.8	1,405.5	1,440.3	1,472.9	1,505.4	1,540.3	1,581.0	1,637.6
8	3	1,307.4	1,363.9	1,404.6	1,439.4	1,471.9	1,504.5	1,539.3	1,580.0	1,636.5
8	6	1,306.3	1,362.8	1,403.5	1,438.3	1,470.8	1,503.3	1,538.1	1,578.8	1,635.2
8	9	1,305.2	1,361.6	1,402.3	1,437.0	1,469.5	1,502.0	1,536.7	1,577.4	1,633.8
9	0	1,304.1	1,360.4	1,401.0	1,435.7	1,468.2	1,500.6	1,535.4	1,576.0	1,632.3
9	3	1,303.0	1,359.3	1,399.9	1,434.5	1,467.0	1,499.4	1,534.1	1,574.7	1,631.0
9	6	1,302.0	1,358.3	1,398.9	1,433.5	1,465.9	1,498.3	1,533.0	1,573.5	1,629.8
9	9	1,301.3	1,357.5	1,398.1	1,432.7	1,465.1	1,497.5	1,532.1	1,572.7	1,628.9
10	0	1,300.9	1,357.1	1,397.6	1,432.3	1,464.7	1,497.0	1,531.7	1,572.2	1,628.4
10	3	1,300.9	1,357.1	1,397.6	1,432.3	1,464.6	1,497.0	1,531.6	1,572.2	1,628.4
10	6	1,301.3	1,357.5	1,398.1	1,432.7	1,465.1	1,497.5	1,532.1	1,572.7	1,628.9
10	9	1,302.3	1,358.5	1,399.1	1,433.8	1,466.2	1,498.6	1,533.3	1,573.8	1,630.1
11	0	1,303.8	1,360.2	1,400.8	1,435.5	1,467.9	1,500.4	1,535.1	1,575.7	1,632.0

TABLE 15.—*Average weights and deviations from the average of the first 10 monthly weights after calving for Holstein cows at various months before and after calving*

Period weighed	Age groups [1]															
	23 to 35 months		36 to 47 months		48 to 59 months		60 to 71 months		72 to 83 months		48 to 132 months		36 to 132 months			
													On test		Not on test	
	Weight	Deviation	Weight	Deviation	Weight	Deviation	Weight	Deviation	Weight	Deviation	Weight	Deviation	Weight	Deviation	Weight	Deviation
Months before calving:	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
10	873	−322	1,203	−139	1,334	−51	1,363	−67	1,413	−66	1,387	−38	1,329	−116	1,336	−27
9	907	−288	1,224	−118	1,344	−41	1,366	−64	1,424	−55	1,393	−32	1,345	−100	1,342	−21
8	938	−257	1,239	−103	1,356	−29	1,371	−59	1,428	−51	1,398	−27	1,352	−93	1,351	−12
7	969	−226	1,253	−89	1,365	−20	1,378	−52	1,425	−54	1,405	−20	1,360	−85	1,361	−2
6	1,006	−189	1,275	−67	1,376	−9	1,397	−33	1,447	−32	1,422	−3	1,380	−65	1,377	14
5	1,056	−139	1,304	−38	1,407	22	1,432	2	1,457	−22	1,445	20	1,401	−44	1,406	43
4	1,100	−95	1,340	−2	1,435	50	1,461	31	1,503	24	1,477	52	1,441	−4	1,433	70
3	1,152	−43	1,375	33	1,465	80	1,497	67	1,542	63	1,512	87	1,476	31	1,468	105
2	1,197	2	1,407	65	1,499	114	1,536	106	1,586	107	1,550	125	1,519	74	1,499	136
1	1,244	49	1,445	103	1,534	149	1,566	160	1,629	150	1,592	167	1,559	114	1,540	177
Months after calving:																
1	1,118	−77	1,292	−50	1,354	−31	1,406	−24	1,460	−19	1,409	−16	1,403	−42	1,352	−11
2	1,126	−69	1,292	−50	1,347	−38	1,392	−38	1,448	−31	1,393	−32	1,400	−45	1,333	−30
3	1,145	−50	1,306	−35	1,352	−33	1,397	−33	1,452	−27	1,396	−29	1,413	−32	1,333	−30
4	1,168	−27	1,319	−23	1,361	−24	1,405	−25	1,456	−23	1,402	−23	1,427	−18	1,337	−26
5	1,187	−8	1,326	−16	1,365	−20	1,413	−17	1,466	−13	1,409	−16	1,439	−6	1,339	−24
6	1,205	10	1,340	−2	1,374	−11	1,420	−10	1,471	−8	1,416	−9	1,449	4	1,346	−17
7	1,221	26	1,355	13	1,390	5	1,435	5	1,485	6	1,427	2	1,461	16	1,360	−3
8	1,237	42	1,374	32	1,406	21	1,449	19	1,499	20	1,442	17	1,472	27	1,380	17
9	1,258	63	1,396	54	1,435	50	1,477	47	1,517	38	1,465	40	1,486	41	1,410	47
10	1,286	91	1,420	78	1,468	83	1,502	72	1,537	58	1,492	67	1,506	61	1,441	78
1 to 5	1,149	−46	1,307	−35	1,356	−29	1,402	−28	1,457	−22	1,402	−23	1,416	−29	1,339	−24
3 to 5	1,167	−28	1,317	−25	1,359	−26	1,405	−25	1,459	−20	1,402	−23	1,426	−19	1,336	−27
6 to 10	1,241	46	1,377	35	1,414	29	1,457	27	1,502	23	1,448	23	1,475	30	1,388	25
1 to 10	1,195	0	1,342	0	1,385	0	1,430	0	1,479	0	1,425	0	1,445	0	1,363	0
Number of records	302		214		157		135		95		517		335		396	

[1] Cows are arranged in groups according to their ages at first weighing after calving.

In the comparison between cows on test and cows not on test, those not on test averaged about 6 months older than those on test. The average interval from the previous calving was between 14.5 and 15.0 months for both groups. There was practically no difference in the average weights of the 2 groups from 10 to 5 months before calving, and the cows going on test were only 19 or 20 pounds heavier than the others for the last 2 months before calving. At the first monthly weight after calving, the cows on test were 51 pounds heavier than those not on test; and the difference gradually increased to 103 pounds at 6 months after calving. The cows on test lost very little weight after the first month, whereas the average weight for cows not on test did not equal the first month's weight until after the sixth month.

The average deviations from the basic 10-month weights shown in table 15 may be used to provide a means of adjusting single weights, or a certain series of weights, to the equivalent basic 10-month weight necessary for using the boundary weights in table 13. In using the deviations in table 15, minus deviations are added to the cow's weight at a certain month or group of months, and plus deviations are subtracted from a cow's weight to give an adjusted weight comparable to the boundary weights listed in table 14. These adjustments, however, provide no way of accounting for differences between individual cows in the relationship between single weights and the basic 10-month weights.

There is an age difference in the relationship that makes it advisable to use the deviations for the 23- to 35-month group and the 36- to 47-month group at these younger ages. The deviations for cows 48 to 132 months of age might be used for all other ages. For an example, a cow may have calved less than a month before she was 5 years of age, and weighed 1,380 pounds about 4 months after calving. Add the deviation (−23 pounds) shown in table 15, to give her an adjusted weight of 1,403 pounds. According to the boundary weights in table 14, this weight at 5 years of age would receive a grade of 5.

In determining what month after calving to use in making an adjustment, it should be remembered that, in assembling the data for table 15, weights taken within 30 days after calving were tabulated for the first month, weights taken from 31 to 60 days after calving were tabulated for the second month, and so on. Any fraction of a month after calving is represented in table 15 as part of the next month.

Grades were assigned to the 1,039 basic 10-month lactation weights that were used in preparing this standard, in order to test the actual distribution of these grades in the Holstein herd at Beltsville. Theoretically, there should have been about 104 weights for each grade. Actually, the number of weights for each grade from 1 to 10 was 96, 104, 86, 116, 107, 110, 118, 109, 88, and 106, respectively. The lower coefficient of variation for the Holstein data than for the Jersey data did not result in a distribution with greater numbers in the grades or groups at either end of the array.

There were distinct differences in the distribution of grades for cows on test and cows not on test. The percentages of the 618 lactations for cows on test receiving grades 1 to 10 were 3.9, 6.0, 7.3, 9.5,

9.4, 10.8, 12.9, 12.8, 11.5, and 15.9 percent, respectively. Similar percentages for 421 lactations for cows not on test were 17.1, 15.9, 9.7, 13.5, 11.6, 10.2, 9.0, 7.1, 4.0, and 1.9 percent.

TIME TRENDS IN THE AVERAGE WEIGHT OF HOLSTEIN FEMALES AT BELTSVILLE

Occasional observations indicated the possibility of a time trend in the weights of Holstein females in the Beltsville herd over a period of more than 30 years. Weight data obtained in this herd have the advantage that they are based on adequate numbers of females in a herd that was maintained (1) under uniform environment over a considerable number of years and (2) without culling for size or production or adding purchased females.

The weights at certain ages of Holstein females in the Beltsville herd were tabulated according to the year of birth. Data for these tabulations included many weights obtained since the weight standards were calculated. The average weights from such tabulations are shown in table 16. The average weights for each year are for the same group of females, minus those that left the herd. Weights of twins and inbred animals were not used.

The environmental year, as distinguished from the year of birth, of the animals, can be determined for some of the average weights by adding the age to the year of birth. For example, the environmental years for females born in 1940 were from January 1940 through December 1940 for weights at birth, from July 1940 to June 1941 for weights at 180 days of age, from January 1941 through December 1941 for weights at 12 months of age, from July 1941 through June 1942 for weights at 18 months of age, and from January 1944 through December 1944 for weights at 4 years of age.

For the same group of females born in 1940, the environmental period for most of the first-lactation weights, each of which was an average of 10 monthly weights after calving, would have been from January 1942 through April 1944. The environmental period for mature-lactation weights would have been spread over a greater number of years, because weights for lactations beginning at any age between 4 and 8 years were used, in order to base these values as far as possible on weights obtained during lactations on test. Nevertheless, for all years in this study, 20.5 percent of the mature-lactation weights were not obtained from cows on test. All but 4.2 percent of the first-lactation weights were obtained from cows on test.

All first-lactation weights were adjusted to a calving age of 26 months. This was done by multiplying the standard lactation weight for 26 months of age by the ratio of the cow's lactation weight divided by the standard lactation weight for cows of her age. All mature-lactation weights were adjusted to a calving age of 7 years in the same manner. The adjusted values at 7 years of age are a good representation of each cow's maximum weight while milking.

It is possible that some of the differences in the average weights, from the sorting according to the year of birth, may have been due to inherited differences from the sires that were used. Therefore, letter symbols are used in table 16 to indicate the bulls siring one-sixth

or more of the heifers whose weights are tabulated from birth to 12 months of age. This may or may not indicate the proportion of the females born in the same year that remained in the herd to older ages.

It may be noticed that average birth weights were high when bull *a* was the predominant sire. Many average weights for the same groups at older ages were relatively low. Weights at birth and at some older ages were low for females born in 1926, when bull *b* was the predominant sire. Although 40 percent of these calves were the first offspring of their dams, it so happened that sire *b* had three definitely undersized daughters, all of which were born in 1926. As another illustration, many of the average weights were high for animals born in 1933, 1934, 1935, and 1936, when bull *e* was the predominant sire.

The significance of differences between the average weights of animals born in different years was tested by analysis of variance. The mean squares for the variance between years and the variance within years are shown in table 16. In nearly all instances, except birth weights from 1928 through 1951, differences in the average weights for different years were highly significant. These results, however, do not distinguish between the relative effects of inheritance, environment, or a general trend.

Aside from numerous up-and-down changes from one year to the next, there appears to be a trend toward higher weights during the first 10 or 12 years and then a leveling off for the remaining 20 years. Tests on the average weights at 12 months of age were made by orthogonal polynomial regression. The use of the second-degree term, which produces a parabolic curve, showed a highly significant reduction ($F=9.58$) in the sum of squares. Reductions in the sums of squares were not significant for a linear regression, nor the third- and fourth-degree terms that produce more complicated curves. On the basis of these results it was decided to use the weights from animals born from 1919 through 1930 for a study of the period of increasing average weights, and to use the weights for animals born from 1928 through 1951 for a study of the period of little change in average weights.

The average weights for each of these periods are shown in table 16. The average weights at all ages except at birth were definitely higher for the period 1928–51 than for the period 1919–30.

Linear regression coefficients were calculated to determine the trends in weights during each of these periods. The results are shown in table 16. During the entire period 1919–51, there were small yearly increases in weight at all ages except at birth. These trends were highly significant when tested by the reduction in the sums of squares by regression. There was a significant trend for lower weights at birth during this period.

Regression coefficients for the period 1919–30 showed much larger yearly increases in average weights. In spite of the fewer numbers, most of the regressions caused highly significant reductions in the sums of squares. There was a nonsignificant trend in the opposite direction for weights at birth.

Regression coefficients for the period 1928–51 show trends for increasing weights at some ages and decreasing weights at others. Only the trend for decreasing weights at 18 months of age was significant.

TABLE 16.—*Yearly trends in the average weights of Holstein females sorted according to year of birth* [1]

Year of birth	Sires of various percentages of the heifers, from birth to 12 months of age [2]			Number of females, and average weights from birth to 12 months of age—						Number of females, and average weights, from 18 months through mature lactation—							
	50 percent	33.3 to 49.9 percent	16.7 to 33.2 percent	At birth		At 180 days		At 12 months		At 18 months		At 4 years		At first lactation		At mature lactation	
				Number	*Pounds*	*Number*	*Pounds*	*Number*	*Pounds*	*Number*	*Pounds*	*Number*	*Pounds*	*Number*	*Pounds*	*Number*	*Pounds*
1919	*A, D*					2	378	2	606	2	861	5	1,304	3	1,159	5	1,288
1920		*a*	*B, C, D*	5	103.6	5	379	5	632	5	833	4	1,293	4	1,166	2	1,344
1921	*a*			5	101.0	5	342	5	584	5	862	5	1,151	5	1,058	5	1,374
1922	*a*			7	101.4	7	369	7	659	7	845	6	1,248	6	1,115	5	1,429
1923	*a*	*E*		9	98.1	9	359	9	642	7	852	6	1,271	6	1,142	5	1,419
1924	*a*	*F*		8	103.0	8	358	8	624	8	834	6	1,404	6	1,138	4	1,544
1925	*a*			5	98.2	5	367	5	630	5	904	5	1,283	5	1,104	5	1,468
1926	*b*		*a*	10	79.5	10	340	10	613	10	824	9	1,246	10	1,072	7	1,431
1927	*b*		*a*	9	98.9	9	392	9	684	9	872	9	1,293	9	1,158	6	1,473
1928		*b*	*a, c, l*	11	98.1	11	391	11	700	11	912	11	1,407	11	1,217	10	1,470
1929		*b, l*	*c*	9	97.7	9	397	9	739	9	968	7	1,371	8	1,243	7	1,480
1930		*l*	*b, c*	13	94.7	13	398	13	719	13	906	10	1,333	11	1,169	8	1,463
1931	*l*	*b*		8	98.3	8	390	8	745	8	950	8	1,403	8	1,192	3	1,468
1932		*d, l*	*m*	11	89.6	11	374	11	705	11	869	9	1,434	11	1,182	6	1,485
1933	*e*		*l, m*	18	93.3	18	395	18	715	18	908	6	1,466	9	1,260	4	1,618
1934	*e*		*m*	10	89.0	10	375	10	715	10	937	7	1,427	8	1,236	6	1,563
1935	*e*		*m*	9	101.1	9	427	9	768	9	1,005	8	1,526	9	1,294	8	1,637
1936		*e, m*	*n*	11	103.0	11	412	11	769	11	968	9	1,434	11	1,237	4	1,692
1937	*e*			8	94.5	8	391	8	708	8	934	7	1,362	8	1,155	5	1,417
1938			*e, f, m, o*	16	90.0	16	376	16	715	16	936	12	1,380	15	1,192	6	1,433
1939		*e*	*g, m*	12	102.3	12	409	12	729	12	941	11	1,393	11	1,234	11	1,549
1940		*e, g*		21	92.3	21	399	21	718	20	916	17	1,348	20	1,175	16	1,520
1941		*g*	*e, p*	14	96.1	14	411	14	736	14	958	11	1,487	13	1,201	11	1,504
1942	*g*		*p*	23	93.7	23	399	23	715	23	910	16	1,416	19	1,200	13	1,501
1943	*g*		*q*	17	96.4	17	407	17	739	17	951	16	1,433	16	1,232	12	1,454
1944		*g*	*r*	15	97.6	15	412	15	735	14	918	11	1,429	13	1,197	8	1,504
1945	*h*			24	93.8	24	415	24	748	24	929	19	1,395	21	1,209	16	1,541

1946	*h*			33	97.2	33	416	33	744	33	901	20	1,431	25	1,106	11	1,546
1947	*h*			30	98.1	30	408	30	713	30	900	20	1,395	26	1,187	17	1,586
1948		*t*	*s*	27	93.0	27	374	27	677	25	879	5	1,380	13	1,124	3	1,464
1949			*h, i, p*	40	93.5	40	384	40	697	34	889			22	1,244		
1950		*i*	*j*	28	91.3	28	401	28	729	27	946			21	1,261		
1951	*j*		*k*	20	89.2	20	423	20	758	8	949						
Averages:																	
1919–51				486	95.0	488	395	488	713	463	912	295	1,385	383	1,194	229	1,502
1919–30				91	96.6	93	375	93	665	91	878	83	1,309	84	1,150	69	1,440
1928–51				428	94.7	428	400	428	724	405	921	240	1,410	329	1,207	185	1,521
Mean squares between years:																	
1919–51					313.8**		5,715**		21,184**		18,952**		47,807**		28,225**		40,124**
1919–30					662.5**		3,651**		18,222**		15,291**		35,431*		22,532**		21,550
1928–51					130.6		4,181**		9,581**		14,389**		20,289*		20,333**		31,158**
Mean squares within years:																	
1919–51					122.1		1,208		3,149		4,595		13,497		7,977		13,283
1919–30					228.9		1,280		2,255		5,161		16,414		8,576		12,257
1928–51					103.1		1,196		3,221		4,319		12,956		7,078		12,980
Regression of weight on years:																	
1919–51					−.122*		1.17**		2.23**		1.27**		4.94**		2.32**		4.74**
1919–30					−.086		4.08**		11.63**		9.10**		10.55*		8.73*		12.55**
1928–51					−.117		.42		−.21		−1.14*		.47		−.33		2.11

[1] 1 asterisk indicates significance at the 5-percent level; 2 asterisks indicate significance at the 1-percent level.

[2] Letters *A* through *F* represent sires of foundation cows. Letters *a* through *k* represent the proved sires that were brought in from outside for use in the breeding experiment. Letters *l* through *t* represent sires raised at Beltsville, which for the most part had some relationship to their mates.

The fact that the regressions for weights at 12 and 18 months of age and during the first lactation were negative, whereas all others except weights at birth were positive, suggests the possibility of an environmental difference in the care of older heifers. Also, in view of the number of animals available and the general absence of significant reductions in the sums of squares, there is no indication of a trend in the size of Holstein females during the periods represented by animals born from 1928 through 1951.

Similar results were shown in a study of the weights of Jersey females at Beltsville (7). The results from both breeds support the theory that in a breeding program of outcrossing to sires proved for high production, the average weights in an assembled herd will increase for 2 or 3 generations, and then remain at a fairly constant level as long as proved sires from outside the herd are used. However, for the last 12 or more years, only Beltsville-raised bulls with some degree of relationship to most of their mates were used in the Jersey herd. In the Jersey herd, there was a significant downward trend in most average weights during the period from 1928 through 1951. The explanation of this difference in the results from the 2 breeds may be in the fact that, for the last 12 or 14 years, most Jersey cows were mated to Beltsville-raised bulls that had some degree of relationship to the cows.

RELATIONSHIPS BETWEEN EARLY AND MATURE WEIGHTS

Because of the efforts made to maintain uniform environmental conditions and provide a liberal plane of feeding for growth and milk production at Beltsville, the weight data from the Holstein herd provide an excellent opportunity to study the relationships between early weights and mature weights. By using a number of weights obtained since the weight standards were calculated, data were made available from birth to near maturity on 197 Holstein cows. The weights of inbred cows and twins were not used.

The preferred measure of a cow's mature weight was the average of the first 10 monthly weights during a lactation on test beginning at 7 years of age. Such weights would be close to the maximum weights of cows in milking condition, when on careful feeding. However, few lactations on test began at exactly 7 years of age. Although table 13 shows only slight changes in the standard weights between 6.5 and 9 years of age, many cows were started on official test at earlier ages, but under mature-test conditions. Therefore, all lactation weights were converted to a 7-year-old equivalent, by using the ratio of each cow's lactation weight divided by the standard for cows of her age.

Adjusting the lactation weights for age made it possible to include data from a number of cows calving after 4 years of age but without later lactations on test. Every effort was made to use weights from cows on test, but more than 11 percent of the mature-lactation weights in this study were obtained from cows not on test.

First-lactation weights were adjusted to equivalent values at 26 months of age, in the manner previously described. All but 2 percent of these weights were obtained from cows on test.

The results of these studies of the relationships of mature-lactation weights to weights at earlier ages are shown in table 17. Additional

studies were made on data from the same 197 cows, of the relationships between weights at birth and at 6 months of age, and between weights at 12 months of age and during the first lactation.

TABLE 17.—*Relationships between weights at different ages in the same Holstein females*

Earlier weights			Later weights			Correlation coefficient[1]	Reduction in Sy^2 due to regression	Regression coefficient	Standard deviation from regression
Age	Average weight	Standard deviation	Age	Average weight	Standard deviation				
	Pounds	*Pounds*		*Pounds*	*Pounds*		*Percent*	*Pounds*	*Pounds*
At birth	97	12.4	Mature lactation	1,521	126.5	0.2149	4.6	2.19	123.8
90 days	216	23.4	do	1,521	126.5	.3418	11.7	1.85	119.1
180 days	405	38.6	do	1,521	126.5	.4067	16.5	1.33	115.8
12 months	719	64.6	do	1,521	126.5	.5118	26.2	1.00	108.9
18 months	926	75.3	do	1,521	126.5	.5930	35.2	1.00	102.1
First lactation	1,201	99.3	do	1,521	126.5	.7250	52.6	.92	87.3
At birth	97	12.4	180 days	405	38.6	.3679	13.5	1.15	36.0
12 months	719	64.6	First lactation	1,201	99.3	.6798	46.2	1.05	73.0

[1] All correlation coefficients are highly significant.

All correlation coefficients were highly significant, showing a definite relationship between early weights and later weights. The successive increases in the correlation coefficients, from 0.2149 for birth weights and mature-lactation weights to 0.7250 for first- and mature-lactation weights, demonstrate the greater reliability of each older age in predicting mature-lactation weights. It is also interesting to observe that there was a higher correlation between weights at 6 months of age and mature-lactation weights than between weights at birth and weights at 6 months of age.

Another demonstration of the relative values of early weights in predicting mature-lactation weights is the proportion of the sum of squares for mature-lactation weights (Sy^2) that was attributable to regression. These percentage values were calculated as $r^2(100)$. A low correlation of 0.2149 for the relationship between birth weights and mature-lactation weights accounted for only 4.6 percent of the sum of squares for mature-lactation weights, whereas the correlation of 0.7250 between first- and mature-lactation weights accounted for 52.6 percent. These values are also shown in table 17.

The standard deviations from regression, or standard errors of estimate, for mature-lactation weights were successively lower at each older estimating age. The standard error of estimate from the regression of mature-lactation weights on weights at birth was only 2.7 pounds less than the standard deviation for mature-lactation weights. The error of estimate from regression of mature-lactation weights on first-lactation weights was 39.2 pounds less.

The values in table 17 also show that using weights at 12 months of age produced considerably more reliable estimates of first-lactation weights than of mature-lactation weights. In parallel studies on weight data from the Jersey herd at Beltsville (7), this difference between first- and mature-lactation estimates was not as great. In all other respects the results on Jersey weight data were almost identical with the results from the Holstein weight data.

GROWTH STANDARDS FOR BULL CALVES

Weights from birth were available on a number of bull calves born in the Holstein herd at Beltsville, although many bulls were transferred to another herd soon after birth and many others were loaned to cooperating dairymen before they were a year old. Nevertheless, weights were obtained regularly from birth to 270 days of age on 256 bulls, from birth to 12 months of age on 148 bulls, from birth to 15 months of age on 54 bulls, and from birth to 18 months of age on 27 bulls.

Feeding and management of the Holstein bulls was much like that described for Holstein heifers, except that the bulls were moved out of the calf barn at an earlier age. For example, of the 148 bulls that reached 12 months of age in the Beltsville herd, 26 percent were out of the calf barn at 240 days of age, 61 percent at 270 days, 86 percent at 300 days, 95 percent at 330 days, and 98 percent at 360 days. No silage was fed to the bulls, but pasture was available for young bulls some of the time.

The average weights for four groups of Holstein bulls are shown in table 18. Standard deviations are shown for two groups that reached 270 days and 15 months of age, respectively. Averages of the coefficients of variation for the 256 bulls that reached 270 days of age were 12.02, 10.41, and 9.37 percent during the first, second, and third 3-month period after birth, respectively. These values were not greatly different from those for Holstein heifers at the same age. They were, however, definitely lower than the coefficients of variation for Jersey bull calves at Beltsville (7). The coefficients of variation for the 54 Holstein bull calves in the 15-month age-limit group were slightly lower than for those in the 270-day age-limit group. For bulls between 9 and 15 months of age, the average coefficient of variation was 8.68 percent.

At most ages there were only slight differences between the average weights for the 4 age-limit groups shown in table 18, but at 240 and 270 days of age the average weights in the 18-month age-limit group were as much as 12 and 14 pounds greater than those in other groups.

Estimated weights for 10-day periods were calculated, by fourth-degree orthogonal polynomial regression, from the average weights in the 270-day age-limit group and from the average weights at 10, 11, and 12 months of age from the 12-month age-limit group, with linear interpolations for the weights at intervening 10-day periods. Thus, a curve of estimated weights by 10-day periods was calculated in a manner comparable to that for Holstein heifer calves. However, estimated weights by 10-day periods are not presented beyond 300 days of age because of the environmental changes involved in the transfer of a large percentage of the calves to the bull barn.

Estimated weights of Holstein bulls by months, like the estimated weights for heifers, were calculated by fifth-degree orthogonal polynomial regression from the average weights of the 54 bulls that reached 15 months of age, from the adjusted weights of 27 bulls that reached 18 months of age, and from the average gains in weight for 13 bulls that reached 21 months of age in the herd. The average weights for 30-day periods were adjusted to a calendar month basis in the manner described for heifers. Calculations for estimated weights were made

to 21 months of age in order to have a growth curve comparable to that for heifers; but because of the limited number of animals involved at the older ages, no estimated weights beyond 18 months of age are presented in table 18.

According to the estimated weights by 10-day periods, Holstein bulls exceeded Holstein heifers in weight at birth and at 90, 180, and 270 days of age by 8.8, 17.4, 51.1, and 81.6 pounds, respectively, or in another measure by 9.4, 8.2, 13.0, and 14.6 percent. According to the estimated weights by months, the bulls exceeded the heifers at 6, 9, 12, 15, and 18 months of age by 47.8, 78.2, 117.6, 175.0, and 243.3 pounds, respectively, or by 12.0, 13.7, 16.7, 21.6, and 26.7 percent. Thus, it appears that bulls become proportionally larger than heifers as they grow older. The differences between Holstein bulls and heifers, however, are not as great as those between Jersey bulls and heifers at the same station (*7*).

Differences in the growth rates of Holstein bulls and heifers are shown also in the estimated daily gains. During the 1st, 3d, 6th, 9th, 12th, 15th, and 18th month of age, respectively, the estimated daily gains in weight were 1.2, 14.4, 15.6, 23.7, 36.1, 62.7, and 64.0 percent higher for the bulls than for the heifers.

The boundary weights for assigning grades to the weights of Holstein bull calves are shown by 10-day periods in table 19 and by calendar months in table 20. The boundary weights by 10-day periods were calculated in the same manner as those for heifer calves, by using the standard deviations from the 270-day age-limit group plus those from the 12-month age-limit group for ages beyond 270 days. The boundary weights by calendar months were calculated from the standard deviations for the 15-month age-limit group. Adjustments of the considerably different standard deviations for the older age-limit groups appeared to be impractical for ages after 15 months. Instead, standard deviations for the 6 oldest ages were estimated by assuming that the average coefficients of variation for the ages from 12 to 15 months in the 15-month age-limit group would have continued with little change for the next few months. The standard deviations for successive ages were smoothed by the use of fourth-degree orthogonal polynomials.

This standard for weights of Holstein bull calves is definitely higher at some ages than the Ragsdale standard (*10*). If, for example, the weights in the Ragsdale standard were graded according to the data in table 17, the grades for the Ragsdale weights would drop from a grade of 3 at 2 and 3 months of age to a grade of 1 at 7 to 10 months of age, but would gradually increase to a grade of 5 at 15 months of age and to a grade of 6 at 18 months of age.

Not enough weights were available for a study of growth in weight by older bulls. However, some indication of the size of mature Holstein bulls in the Beltsville herd may be obtained by calculating for each bull the average of 10 consecutive monthly weights for each year of age beginning at 4 years, and designating the highest of these average weights as the bull's maximum weight. Calculated in this manner, the average of the maximum weights of 7 Holstein sires brought in from outside of the herd was 2,095 pounds at an average age of 115 months for the first of the 10 monthly weights. A similar

TABLE 18.—*Average weights and standard deviations, and estimated weights and gains, for Holstein bull calves*

Age	256 calves to 9 months of age		Weights of 148 calves to 12 months	54 calves to 15 months of age		Weights of 27 calves to 18 months	Estimated values			
							By 10-day periods		By months [1]	
	Weight	Standard deviation		Weight	Standard deviation		Weight	Daily gain	Weight	Daily gain
Days	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
At birth	101	12.2	102	103	11.4	102	102.4		101.6	
10	104	12.1	106				106.2	0.38		
20	113	13.4	114				113.3	.72		
30	125	14.7	125	127	13.4	127	123.5	1.02	127.8	0.86
40	139	17.1	139				136.3	1.28		
50	155	19.0	156				151.5	1.51		
60	171	21.2	172	173	19.7	175	168.6	1.72	174.8	1.54
70	189	23.3	190				187.5	1.89		
80	208	24.4	210				207.8	2.03		
90	229	26.7	230	228	25.8	230	229.4	2.15	235.4	1.99
100	250	27.9	251				251.9	2.25		
110	273	29.2	274				275.1	2.33		
120	296	31.6	297	297	32.1	301	298.9	2.38	303.7	2.25
130	320	33.3	321				323.1	2.42		
140	344	35.5	346				347.5	2.44		
150	371	40.0	373	371	36.5	374	371.9	2.44	375.5	2.36
160	395	39.3	397				396.2	2.43		
170	420	42.0	422				420.3	2.41		
180	445	43.3	446	445	43.5	451	444.2	2.39	447.6	2.37
190	470	45.1	472				467.7	2.35		
200	495	47.2	498				490.8	2.31		
210	517	48.7	519	518	48.0	523	513.4	2.26	517.8	2.31
220	541	51.9	547				535.5	2.21		
230	564	53.3	570				557.1	2.16		
240	580	53.7	581	584	52.2	592	578.3	2.12	584.9	2.21
250	605	54.4	611				599.0	2.07		
260	628	56.1	631				619.3	2.03		
270	637	60.6	637	642	60.4	651	639.2	2.00	648.5	2.09

Months										
10			696	698	61.5	712	698.1	1.95	708.6	1.98
11			758	760	65.6	763			765.9	1.88
12			824	823	75.7	825			821.1	1.81
13				881	76.2	885			875.3	1.78
14				927	73.4	924			920.2	1.77
15				982	86.7	990			983.8	1.70
16						1,048			1,039.5	1.82
17						1,107			1,096.2	1.86
18						1,160			1,153.1	1.87

[1] These values are for calendar months instead of 30-day periods.

TABLE 19.—*Boundary weights by 10-day periods between grades for the weights of Holstein bull calves*

Age	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9	Grade 10
Days	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
At birth [1]	85.1	90.4	94.3	97.6	100.7	103.8	107.1	111.1	116.4	
At birth	87.9	92.9	96.5	99.5	102.4	105.2	108.3	111.9	116.8	
10	89.9	95.6	99.6	102.9	106.2	109.4	112.8	116.8	122.4	
20	95.3	101.5	105.9	109.8	113.3	116.9	120.7	125.2	131.4	
30	103.5	110.4	115.3	119.5	123.5	127.5	131.7	136.7	143.5	
40	114.2	121.8	127.3	131.9	136.3	140.7	145.4	150.8	158.4	
50	127.2	135.5	141.5	146.7	151.5	156.2	161.4	167.4	175.7	
60	142.2	151.2	157.8	163.4	168.6	173.8	179.4	185.9	195.1	
70	158.8	168.6	175.7	181.8	187.5	193.2	199.3	206.4	216.2	
80	176.8	187.4	195.1	201.7	207.8	213.9	220.6	228.3	238.9	
90	195.9	207.4	215.7	222.8	229.4	235.9	243.1	251.4	262.9	
100	215.9	228.3	237.2	244.8	251.9	258.9	266.6	275.5	287.8	
110	236.8	249.9	259.4	267.5	275.1	282.7	290.8	300.3	313.5	
120	258.1	272.1	282.2	290.9	298.9	307.1	315.7	325.8	339.8	
130	279.7	294.6	305.4	314.5	323.1	331.7	340.9	351.6	366.5	
140	301.6	317.3	328.7	338.4	347.5	356.5	366.2	377.6	393.4	
150	323.5	340.1	352.1	362.3	371.9	381.4	391.7	403.7	420.3	
160	345.3	362.8	375.4	386.1	396.2	406.3	417.1	429.6	447.1	
170	366.9	385.3	398.5	409.8	420.3	430.9	442.2	455.4	473.8	
180	388.3	407.5	421.3	433.1	444.2	455.2	467.1	480.9	500.1	
190	409.4	429.4	443.8	456.2	467.7	479.2	491.6	505.9	525.9	
200	430.1	450.9	465.9	478.8	490.8	502.8	515.6	530.6	551.5	
210	450.3	471.9	487.6	500.9	513.4	525.8	539.2	554.8	576.4	
220	470.1	492.5	508.7	522.6	535.5	548.4	562.2	578.4	600.9	
230	489.5	512.7	529.4	543.7	557.1	570.5	584.8	601.5	624.7	
240	508.4	532.4	549.7	564.5	578.3	592.1	606.8	624.1	648.1	
250	527.1	551.7	569.5	584.8	598.9	613.2	628.4	646.2	670.9	
260	545.3	570.7	588.9	604.6	619.3	633.9	649.6	667.9	693.3	
270	563.3	589.4	608.2	624.2	639.2	654.3	670.3	689.1	715.2	
280	581.1	607.8	627.1	643.6	658.9	674.3	690.5	710.1	736.8	
290	598.9	626.3	645.9	662.8	678.5	694.3	711.1	730.8	758.1	
300	616.8	644.7	664.8	681.9	698.1	714.1	731.3	751.4	779.3	

[1] Based on the observed mean and standard deviation.

TABLE 20.—*Boundary weights by calendar months between grades for the weights of Holstein bull calves*

Age	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9	Grade 10
Months	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
At birth [1]	88.7	93.7	97.3	100.4	103.3	106.2	109.3	112.9	117.9	
At birth	89.3	93.5	96.6	99.2	101.6	104.1	106.7	109.7	113.9	
1	108.5	115.1	119.9	123.9	127.8	131.7	135.7	140.5	147.2	
2	148.4	157.5	164.1	169.6	174.8	180.1	185.6	192.2	201.2	
3	201.9	213.4	221.6	228.7	235.4	241.9	249.1	257.4	268.9	
4	263.2	277.1	287.1	295.7	303.7	311.7	320.3	330.3	344.3	
5	327.9	344.3	356.1	366.1	375.5	384.9	394.9	406.7	423.1	
6	393.2	411.9	425.3	436.8	447.6	458.3	469.8	483.3	501.9	
7	456.7	477.7	492.8	505.7	517.8	529.8	542.8	557.9	578.8	
8	517.3	540.5	557.3	571.6	584.9	598.3	612.6	629.3	652.5	
9	574.6	599.9	618.2	633.9	648.5	663.1	678.8	697.1	722.5	
10	628.5	656.1	675.9	692.8	708.6	724.5	741.5	761.3	788.8	
11	679.8	709.3	730.7	748.9	765.9	782.9	801.2	822.5	852.1	
12	729.1	760.7	783.5	802.9	821.1	839.3	858.8	881.6	913.2	
13	777.5	811.1	835.2	855.9	875.3	894.6	915.3	939.5	973.1	
14	825.7	861.3	886.9	908.8	929.2	949.7	971.6	997.2	1,032.7	
15	874.7	912.1	939.2	962.3	983.8	1,005.4	1,028.5	1,055.5	1,093.1	
16	924.7	964.1	992.5	1,016.8	1,039.5	1,062.2	1,086.5	1,114.9	1,154.4	
17	975.5	1,016.9	1,046.8	1,072.3	1,096.2	1,120.1	1,145.5	1,175.4	1,216.8	
18	1,026.6	1,069.9	1,101.3	1,128.1	1,153.1	1,178.2	1,204.9	1,236.3	1,279.7	

[1] Based on the observed mean and standard deviation.

average of the maximum weights of 10 Holstein bulls, exclusive of inbred bulls, born at Beltsville was 2,155 pounds at an average age of 74 months.

SUMMARY

Studies of growth by Holstein cattle, as measured by changes in weight from birth to maturity, have been made by the Dairy Husbandry Research Branch from the weights of cows, heifers, and bull calves that were born and raised in the experimental breeding herd of Holsteins at Beltsville, Md., during the past 30 years. Twins and inbred animals were not included in these studies.

Because certain conditions have been maintained rather constant from the beginning, the Beltsville weight data are well suited for use as standards of normal growth. For example, good, practical methods of feeding and management have been used and an effort has been made to keep them as uniform as possible throughout the years of the experimental work. These conditions are described in detail and their effects represent a part of the normal included in these standards.

Tabulations of the weight data for Holstein females were made by dividing the data into nine age-limit groups, so that measures of the rates of growth covering a certain range in age would be based on successive weights from the same animals.

The average weight of 400 heifer calves was 96 pounds at birth, 394 pounds at 180 days of age, and 710 pounds at 12 months of age. Other average weights were 1,193 pounds for 307 cows at 30 months of age, 1,381 pounds for 233 cows at 4 years of age, and 1,514 pounds for 110 cows at 7 years of age.

The portions of the growth curves represented by the data on heifers from birth to 365 days of age and from birth to 21 months of age, and by the data for the last 2 to 5 years of age for cows in the several age-limit groups, were smoothed by calculating a fourth- or fifth-degree orthogonal polynomial regression for a series of average weights. The differences between successive estimated weights calculated in this way gave rates of gain that were relatively free from month-to-month variations, but that still showed long range trends due to age and some environmental conditions. These estimated weights and gains are presented as the Beltsville standards for normal growth.

A system of grades from 1 to 10 for the weights of heifers, by 10-day periods from birth to 365 days of age or by months to 21 months of age, was produced from the smoothed curves of the estimated weights and from similarly smoothed curves of the standard deviations. The purpose was to have some method of interpreting the importance of the difference between the weight of an individual heifer and the estimated standard weight. Theoretically, each grade from 1 to 10 would represent 10 percent of all weights for a given age. Checks at certain ages showed this to be approximately the distribution in the Beltsville herd.

Tabulations of weights during the ages covering the first pregnancy and the beginning of lactation showed that at each age the average

weights of heifers pregnant more than 165 days were definitely higher than those for heifers not pregnant, or for those in the early stages of pregnancy, or for those recently fresh.

The average weights of cows tended to be higher at ages when a greater proportion of them were on official test with higher levels of feeding and when the greater number were in advanced stages of pregnancy, as at 21 to 26 months of age.

Tests by analysis of variance showed significant differences between the average weights of heifers that were pregnant less than 45 days and heifers that were in more advanced stages of pregnancy—at 16 months of age and older. However, the difference at 16 months of age may have been affected by a tendency for heavier heifers to conceive at an earlier age than lighter ones.

Tests, by analysis of variance between the average weights at different ages during periods covering a range of 18 months in age, showed that the influence of age on weight was much greater at younger ages and of doubtful significance after 5 years of age.

Special tabulations and calculations were made to prepare a standard, which would not be complicated by differences in the stages of pregnancy or lactation, for assigning grades to the weights of individual cows. The basic weight for this standard was the average of the first 10 monthly weights after calving, and age was expressed as the cow's age at the time of the first monthly weight after calving. Changes in weight with age were calculated on a monthly basis from the difference between the basic weights of a cow in two successive lactations, when the cow was on test or not on test in both lactations. A fourth-degree orthogonal polynomial was used to produce a smooth curve of estimated standard weights. Deviations of observed weights from the standard weights were used as the measure of variation needed for establishing boundary weights between grades, from 1 to 10.

Another table was prepared to show the relationships between the standard for the average of 10 monthly weights after calving and the weights obtained at various times during the lactation or in the preceding gestation period. These data could be used to make adjustments when weights for 10 consecutive months are not available.

There were time trends in yearly average weights of Holstein females in the Beltsville herd. The trends were characterized by rapid increases in average weights during the first 10 or 12 years to a level that was maintained with little change for the remaining 20 years.

Correlation studies showed that mature-lactation weights were definitely related to weights at all earlier ages, but the correlations were progressively higher for each age nearer to the mature lactation.

Standards similar to those for heifers were prepared for measuring the growth of Holstein bulls by 10-day periods from birth to 300 days of age and by months from birth to 18 months of age. These data showed that the percentage differences between the weights of bulls and heifers increased with age, and that differences between the daily gains of bulls and heifers also increased with age.

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