

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
RESEARCH BULLETIN 36

THE NORMAL GROWTH OF DAIRY CATTLE

(Publication Authorized December 19, 1918)



COLUMBIA, MISSOURI
APRIL, 1920

UNIVERSITY OF MISSOURI

COLLEGE OF AGRICULTURE

Agricultural Experiment Station

BOARD OF CONTROL

THE CURATORS OF THE UNIVERSITY OF MISSOURI

EXECUTIVE BOARD OF THE UNIVERSITY

SAM SPARROW, Chairman,
Kansas City

C. B. ROLLINS,
Columbia

JOHN H. BRADLEY,
Kennett

ADVISORY COUNCIL

THE MISSOURI STATE BOARD OF AGRICULTURE

OFFICERS OF THE STATION

A. ROSS HILL, PH. D., LL. D., PRESIDENT OF THE UNIVERSITY

F. B. MUMFORD, M. S., DIRECTOR

STATION STAFF

APRIL, 1920

AGRICULTURAL CHEMISTRY

C. R. MOULTON, Ph. D.
L. D. HAIGH, Ph. D.
W. S. RITCHIE, A. M.
E. E. VANATTA, A. M.
EMORY M. ROLLER

AGRICULTURAL ENGINEERING

E. H. LEHMANN, B. S. in A. E.
MACK M. JONES

ANIMAL HUSBANDRY

F. B. MUMFORD, M. S.
E. A. TROWBRIDGE, B. S. A.
L. A. WEAVER, B. S. in Agr.
RAY E. MILLER, B. S. in Agr.
D. W. CHITTENDEN, B. S. in Agr.
J. H. LONGWELL, B. S. in Agr.

BOTANY

W. E. MANEVAL, Ph. D.
W. J. ROBBINS, Ph. D.

DAIRY HUSBANDRY

A. C. RAGSDALE, B. S. in Agr.
A. C. DAHLBERG, M. S.
W. W. SWETT, A. M.
PERCY WERNER, JR., A. M.
W. H. E. REED, B. S. in Agr.
C. W. TURNER, B. S. in Agr.

ENTOMOLOGY

LEONARD HASEMAN, Ph. D.
K. C. SULLIVAN, A. M.

FIELD CROPS

W. C. ETHERIDGE, Ph. D.
E. M. McDONALD, B. S.
C. A. HELM, A. M.
L. J. STADLER, A. M.

RURAL LIFE

O. R. JOHNSON, A. M.
R. M. GREEN, B. S. in Agr.

FORESTRY

FREDERICK DUNLAP, F. E.

HORTICULTURE

V. R. GARDNER, M. S. A.
H. D. HOOKER, Ph. D.
H. F. MAJOR, B. S. A.
J. T. ROSA, JR., M. S. H.
H. G. SWARTWOUT, B. S. in Agr.

POULTRY HUSBANDRY

H. L. KEMPSTER, B. S.
G. W. HERVEY, B. S.

SOILS

M. F. MILLER, M. S. A.
R. R. HUDELSON, A. M.
W. A. ALBRECHT, Ph. D.
F. L. DULEY, A. M.
H. H. KRUSEKOPF, A. M.
Wm. DEYOUNG, B. S. in Agr.

VETERINARY SCIENCE

J. W. CONNOWAY, D. V. M., M. D.
L. S. BACKUS, D. V. M.
O. S. CRISLER, D. V. M.
A. J. DURANT, A. M.
H. G. NEWMAN, B. S. in Agr.

OTHER OFFICERS

R. B. PRICE, M. S., Treasurer
J. G. BABB, A. M., Secretary
E. H. HUGHES, A. M., Asst. to Dean
O. W. WEAVER, B. S., Agricultural Editor
GEORGE REEDER, Director Weather Bureau
MISS BERTHA HITE,¹ Seed Testing Laboratory
J. F. BARHAM, Photographer

¹In service of U. S. Department of Agriculture.

The Normal Growth of Dairy Cattle

C. H. ECKLES*

In the course of investigations¹ concerning the raising of dairy heifers the need was felt for some standard by which the results could be measured. In studying various factors influencing growth such as the liberality of the ration and the influence of age at first calving, the question arose constantly as to how the results secured would compare with those from animals raised under normal conditions. A search thru dairy literature did not reveal any data whatever regarding the normal rate of growth for cattle of any breed. Inquiries made of breeders of dairy cattle indicated that while experienced men can look at an animal of a certain age and judge reasonably well whether it is as large as it should be for its age, none of the breeders consulted could give any figures as to the normal size at various ages during the growing period for animals of the breed represented in his herd. Frequent inquiries from young breeders for information as to how large animals should be at certain ages, and the desire on the part of the author to use data of this character in teaching, showed that there is a real demand for such data for use in commercial work as well as in investigational fields. As a result of these needs the taking of data for the purpose of determining the normal growth rate was begun in 1912. The possibilities in regard to the use of normal growth curves by those interested in the growing of domestic animals is shown by the wide use made of the data giving the normal rate of growth for humans in connection with infant-welfare work.

Method of measuring growth.—The first question that arose concerned the best method of measuring growth. Should growth be measured entirely by increase in live weight, or by increase in the size of the body of the animal as shown by certain measurements, or by both? If body measurements are used, what ones

ACKNOWLEDGMENT.—The author desires to express his indebtedness to W. M. Regan, T. C. Reed, and W. W. Swett, who served as assistants in the Department of Dairy Husbandry for various intervals while the accumulation of the data was in progress, and who were responsible for the details in making the records. The careful study of the subject and the accumulation of data by L. S. Gillette and C. L. Burlingham, graduate students in Dairy Husbandry, also contributed materially to the completion of the project.

¹ (a) Eckles, C. H. The Ration and Age of Calving as Factors Influencing the Growth and Dairy Qualities of Cows. Mo. Exp. Station Bul. 135, pp. 1-91 (1915).

(b) Winter Rations for Dairy Heifers. Mo. Exp. Station Bul. 158, pp. 1-54 (1918).

(c) Eckles, C. H., and Swett, W. W. Some Factors Influencing the Rate of Growth and the Size of Dairy Heifers at Maturity. Mo. Exp. Station Research Bul. 31, pp. 1-56 (1918)

*Resigned, March, 1919.

are the most desirable, and how should they be taken? These questions are discussed and data concerning them presented in a previous publication.² As a result of this study it was concluded that the growth of an animal cannot be properly represented either by live weight or any bodily measurement alone. The rate of skeletal growth does not necessarily parallel the increase in live weight and is much less easily influenced by the conditions to which the animal is subjected. So far no satisfactory method has been devised properly to represent growth in any one term. It was decided that the most satisfactory plan is to use both the live weight and some body measurement which represents the skeletal growth; and for the latter, it was concluded height at withers is the most satisfactory.

There are obviously two ways of getting data concerning the normal growth of animals. One involves taking single measurements of heights and weights from a very large number of animals, and from these data to construct a mean that would fairly represent the group. The advantages of this plan are that a greater variety of conditions of feeding and management would be represented by the animals used. There are, however, some serious practical difficulties in the way of getting such data and the figures must necessarily include a very large number of animals. The second plan, and the one followed, was to gather a large amount of data from a smaller number of animals by taking the weights and measurements at monthly intervals from birth to maturity.

Source of data.—The data used were taken from purebred animals in the herd owned by the University of Missouri. In addition, single measurements were made of about 350 animals on exhibition at certain shows. Data from this source are not included in the results reported except in so far as they are considered in the discussion.

The original plans called for measurements to be taken, of height at withers and the weight of all dairy heifers in the University herd not used for special experimental purposes which might influence the results. When the taking of the data was begun all heifers under eighteen months of age at the time were included. Additions to the list were made of all heifers as dropped when not used in some other experimental manner. One exception

² Eckles, C. H., and Swett, W. W. Some Factors Influencing the Rate of Growth and the Size of Dairy Heifers at Maturity. Mo. Exp. Station Research Bul. 31, pp. 10-17 (1918).

was that certain heifers used in wintering experiments covering periods of five months with conditions of feeding which were not at all extreme, were continued on the list of normal animals. A portion of the data included in that given for weights of cows after the first parturition, represents animals not included in the data regarding growth in the earlier months of life. This is done for the purpose of completing the data without undue prolongation of time.

Manner of taking height measurements.—Height measurements at withers were taken with an ordinary measuring standard graduated in centimeters. The animal to be measured was stood on a level floor and care taken that it assumed a position as near normal as possible. For reasons discussed in a previous publication,³ each animal was measured three times with the precaution of moving it to a new position after each reading. The figure used was the average of the three measurements.

Method of taking weights.—The weight of each calf was taken within a few hours after birth. Thereafter, weights were taken three days in succession at monthly intervals. In all cases the weights were taken in the morning after the animals had been away from water during the night. This plan was followed up to the time of first calving after which the weights used were an average of weights taken the first three days following parturition and the average of those taken three days in succession, six months after calving. This method of taking the weight of cows after coming in milk was the result of much experience in taking weights under various plans. Data are available for a large number of cows showing their weights by months from birth to after several calves were dropped. However, the plan of using only the weights following calving and again six months later was found the most satisfactory. This plan gives a series of weights from year to year under conditions as comparable as it is possible to get them in a herd managed under normal conditions.

Extent of the data.—The number of animals used was unfortunately more limited than was desirable, but the gathering of such data, covering as it does a period of several years, is necessarily limited in any one herd. Furthermore, no data are at hand for Guernseys or Brown Swiss as neither of those breeds are in-

³ Eckles, C. H., and Swett, W. W. Some Factors Influencing the Rate of Growth and the Size of Dairy Heifers at Maturity. Mo. Exp. Station Research Bul. 31, p. 9 (1918).

cluded in the University herd. The total number of animals supplying the data is shown by Table 1.

Not all of these animals, however, furnished complete data from birth to maturity since some were several months old before the gathering of the data was begun and others had not reached maturity when the data given were assembled.

TABLE 1.—NUMBER OF ANIMALS REPRESENTED

Breed	Birth weight	Birth to first calving	First to fifth calving
Jerseys	94	21	29
Holsteins	83	23	26
Ayrshires	26	12	10
Shorthorns	17	8	..

WHAT IS "NORMAL GROWTH"?

The purpose of gathering the data given in the tables which follow was to determine the average height at withers, and the average weight of females of the dairy breeds at intervals from birth to maturity with the purpose in view of establishing the normal rate of growth. The question arises at once as to what is meant by normal growth, and what conditions of feeding and management does it represent. The data given really represent the rate of growth of females of the breeds used under conditions as maintained in the dairy herd of the University of Missouri.

In the management of this herd the attempt is made to keep within what is considered the limits of correct dairy practice. The calves receive a portion of the milk from their mothers from birth to about two weeks of age. At this point they are gradually changed to skim milk supplemented by hay, usually alfalfa, or pasture, and a small amount of grain which is mostly cornmeal. From the time when the feeding of milk is discontinued, which is about six months of age, until within a few weeks of the date of first parturition, the heifers are placed on pasture during the summer, while the winter ration is corn silage, some legume hay, and generally from one to two pounds of grain daily. The object is to keep them in good growing condition without allowing them at any time to become unnecessarily fat. These conditions, while better than maintained on many farms, do not result in the maximum rate of growth as brought about by the very liberal feeding of grain practiced by some breeders of purebred cattle.

On the whole, it seems safe to say that the conditions under which these animals were raised were about the average of those existing in purebred herds and somewhat better than the average of those herds which are kept primarily for producing dairy products for the market. It is believed that the results so far as the growth of the animals is concerned may be safely called normal. The age at first calving was higher than in many herds, averaging thirty months for the Holsteins, twenty-nine for the Jerseys, and twenty-eight for the Ayrshires.

Types represented.—Another factor of importance in connection with the question of normal growth is the hereditary characteristics of the animals used, or in other words, the type. This is especially important with the Jersey breed on account of the wide variation in size between animals of the so-called "Island Type," and those descended from animals bred for a longer time in this country and commonly known as the "American Type." The Jerseys supplying the data were of the American type or with one quarter Island-type blood. The average age at first calving was 29 months, which is from three to five months older than the average in many herds. Delaying the beginning of lactation gives a better opportunity for the animals to reach their maximum size and is a factor, altho of less importance than that of type, in the large size of the Jerseys as shown by the data given. That the Jerseys used were above the average for the breed as found in general use is shown by the fact that the mature cows in the group used averaged 125.2 centimeters in height at withers, while data available for 96 Jerseys owned by members of a cow test association in Ohio⁴ averaged 120.6 centimeters in height.

The Ayrshires used represent lines of breeding found in some of the leading herds in this country and were close descendants of animals imported from Scotland. The Holsteins were, unquestionably, entirely normal for the breed and represent strains of breeding used in herds recognized among the best.

Conditions influencing the rate of growth.—It is well known that in addition to hereditary characteristics other factors, especially the liberality of the ration and age at first calving, may exert considerable influence upon the rate of growth and even upon the size of the animal when mature. Discussion of these questions based upon extensive data is found in a previous publication.

⁴ Wylie, Robt. The Relation of Type and Conformation to Production in Dairy Cattle. Thesis for A. M. degree University of Missouri (1916).

Under conditions as ordinarily found in dairy herds many, if not nearly all the young animals, are subjected at some time during the growing period to one or more of these factors. Since no attempt was made to keep the animals supplying the data presented under especially controlled conditions further than to make sure that the conditions were such as would be recognized as good practice, it is certain the rate of growth of many was influenced

TABLE 2.—NORMAL HEIGHT OF JERSEY AND HOLSTEIN FEMALES DURING THE GROWING PERIOD

Age	HOLSTEINS Height at Withers			JERSEYS Height at Withers		
	Normal	Highest	Lowest	Normal	Highest	Lowest
<i>Months</i>	<i>Centimeters</i>	<i>Centimeters</i>	<i>Centimeters</i>	<i>Centimeters</i>	<i>Centimeters</i>	<i>Centimeters</i>
Birth	71.8	....	....	66.1	....	....
1	76.8	81.0	73.0	70.3	75.8	68.5
2	82.0	85.5	79.0	74.7	79.8	71.0
3	86.8	90.5	84.5	79.3	83.7	74.5
4	92.0	95.8	88.8	83.9	89.0	77.0
5	96.5	99.5	91.2	89.3	93.5	83.8
6	100.9	105.3	95.2	93.7	97.0	88.3
7	104.0	109.3	97.5	96.8	101.5	92.5
8	107.1	113.0	99.7	99.8	103.5	93.6
9	109.1	116.3	103.0	102.8	107.0	96.7
10	111.2	117.5	105.3	105.0	110.0	99.0
11	112.6	118.8	107.7	106.5	110.0	101.7
12	114.0	119.3	108.8	108.3	111.2	102.7
13	115.7	120.3	111.0	110.1	113.5	105.0
14	117.4	122.3	114.0	111.4	115.7	106.0
15	118.8	123.0	115.5	112.7	117.7	108.8
16	120.3	124.3	116.5	113.4	117.7	107.8
17	121.3	124.2	117.8	114.6	119.2	109.0
18	121.8	126.0	118.0	115.6	120.3	110.0
19	122.7	128.0	119.5	116.8	121.2	111.8
20	123.8	128.7	121.0	117.5	121.7	111.8
21	124.3	130.0	121.0	118.1	121.0	112.2
22	124.9	130.3	122.0	118.9	122.3	113.2
23	125.7	131.3	123.0	119.8	122.8	113.7
24	126.5	133.0	123.0	120.4	124.5	114.1
25	127.6	132.5	123.5	....	....	....
26	128.2	132.7	124.0	....	....	....
27	129.3	134.7	125.5	121.9	124.8	115.0
28	129.8	134.8	125.0	....	....	....
29	130.4	134.7	126.5	....	....	....
30	130.7	136.3	126.5	122.6	126.7	115.8
33	132.0	137.3	126.8	123.2	127.3	117.0
36	132.8	137.3	128.1	124.2	127.3	116.5
42	133.7	139.5	129.5	124.5	127.5	117.0
48	134.9	139.5	131.5	125.6	130.0	117.5
54	135.5	139.0	131.5	125.2	....	....
60	136.2	138.0	131.8	....	....	....
72	137.2	140.3	132.0	....	....	....

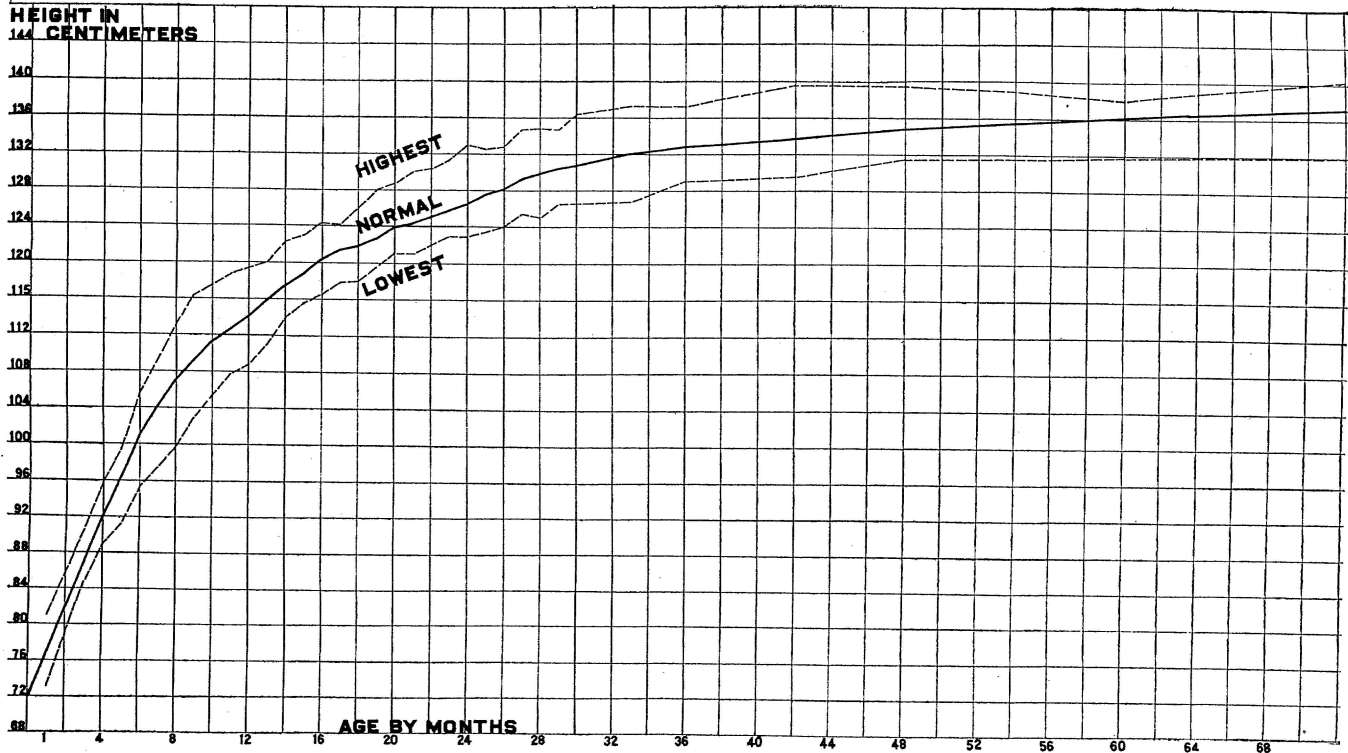


FIG. 1.—Curve of growth in height at withers for Holstein females from birth to maturity. The curve marked normal represents the average measurement, the curves labeled highest and lowest indicate the extreme figures for individuals included in the data used

at times by the conditions, especially of pasture, to which they were subject. Had all the animals used been of the same age so that the possible influence of poor feed for short periods came at the same point the error in the final results would have been a serious one. The fact that the dates of birth of the animals used are found in every month of the year and distributed thru four years, reduces the possibility of an error of the kind under consideration, to a minimum.

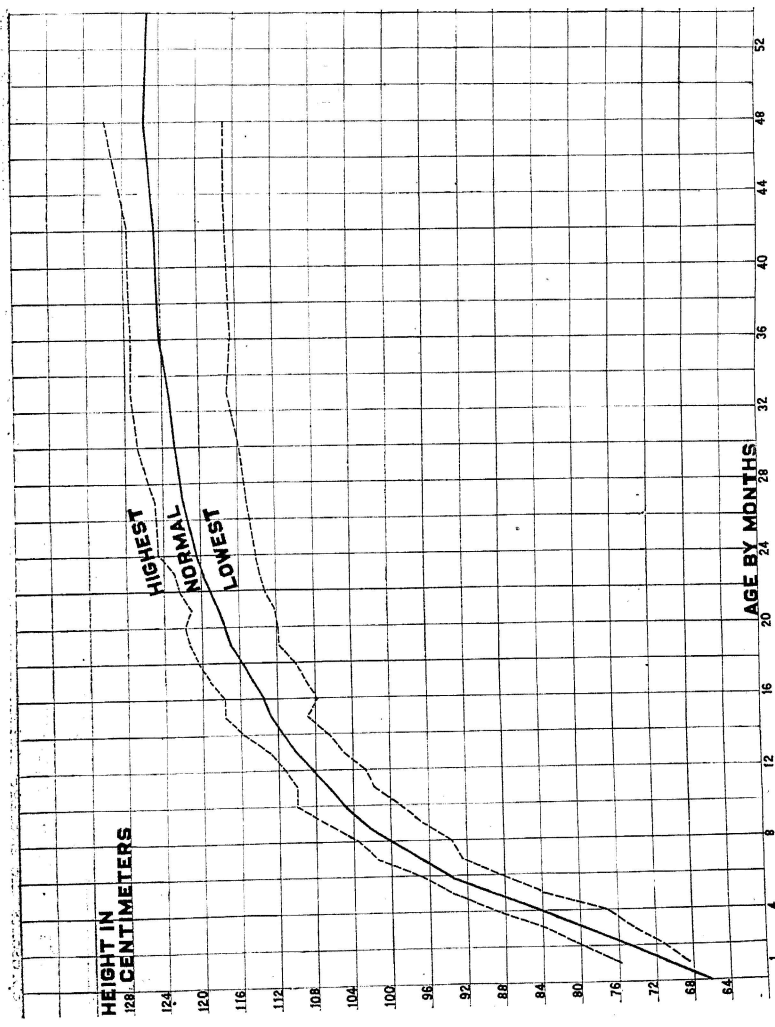


FIG. 2.—Curve of growth in height at withers for females of the Jersey breed from birth to maturity. The curve marked normal represents the average height at withers, the curves marked highest and lowest represent extreme figures for individuals included in the data used

EXPERIMENTAL DATA

Table 2 gives the data for height measurements at withers for Holsteins and Jerseys. The figures under the headings "normal" are the average of the data available for the Jersey and Holstein breeds and are assumed to represent the height at withers of females of these breeds under normal conditions of development. The data given under the headings "highest" and "lowest" represent the extremes for the ages indicated and are therefore individual measurements. Since the "normal heights" figures are a mean, the height of individual animals will necessarily vary on both sides of this mean even under what might be called normal

TABLE 3.—NORMAL WEIGHTS OF JERSEY AND HOLSTEIN FEMALES DURING THE GROWING PERIOD TO TIME OF FIRST CALVING

Age	HOLSTEINS			JERSEYS		
	Normal weight	Highest weight	Lowest weight	Normal weight	Highest weight	Lowest weight
<i>Months</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Birth	90	112	55	55	67	32
1	121	137	114	76	94	63
2	157	164	142	105	119	85
3	200	221	173	140	161	107
4	249	269	203	174	206	133
5	302	330	233	222	251	168
6	349	392	263	260	298	197
7	389	454	285	302	342	235
8	425	503	286	340	385	251
9	466	554	303	376	415	263
10	501	600	332	407	470	324
11	529	659	368	432	480	346
12	558	675	399	456	500	376
13	574	662	425	480	523	405
14	596	696	453	503	547	420
15	612	707	521	520	557	443
16	643	725	561	533	581	494
17	660	737	563	553	599	504
18	686	773	611	572	631	553
19	715	806	623	598	679	553
20	746	803	680	621	684	554
21	774	877	661	649	727	576
22	796	909	686	668	729	621
23	824	885	708	689	774	595
24	841	910	759	716	788	655
25	869	955	767	737	785	638
26	893	995	761	758	858	670
27	925	1066	805	770	896	684
28	966	1108	855	784	790	698
29	994	1149	894	804	...	...
30	1021	...	...	...	...	...

conditions. As would be expected these individual measurements do not show the uniformity of increase that is found in the average figures which are designated as normal.

The data in Table 2 are shown in Figures 1 and 2 in which the solid line represents the mean of normal height and the dotted lines are the highest and lowest measurements for each age. These extremes show the limitations within which were included the heights of all animals used. Under conditions reasonably close to normal, it is safe to assume that nearly all the animals of the breeds represented will fall within these limits. It will be noted that the data are given by months up to twenty-four months of age for the Jerseys, and thirty months of age for the Holsteins, and at

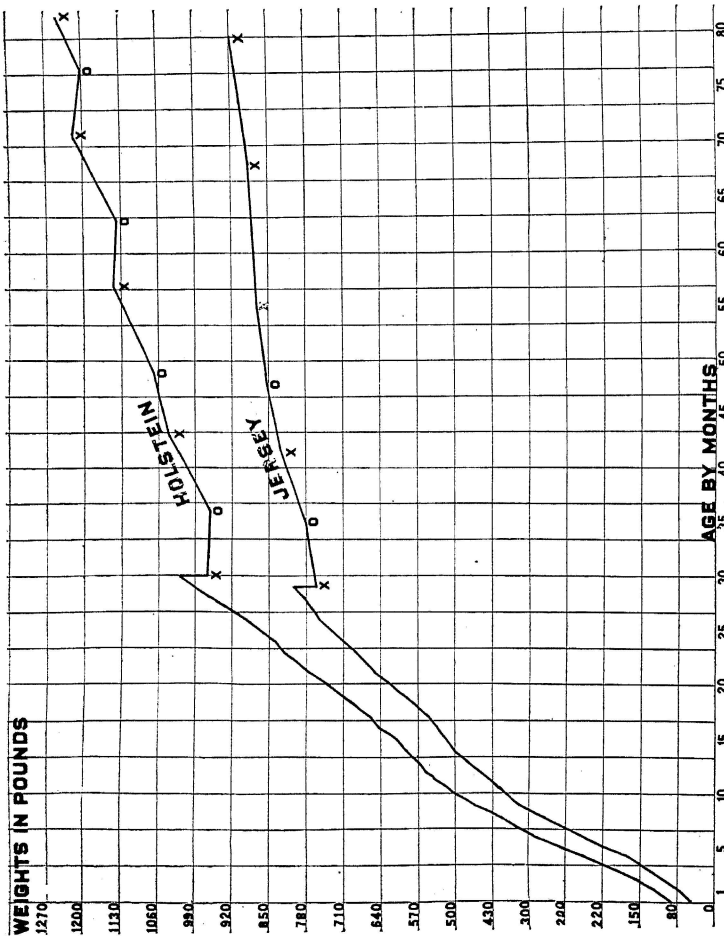


FIG. 3.—Curves representing average or normal weight of Holstein and Jersey females from birth to maturity. The letter X marks the weights after parturitions, and the letter O the weights six months after calf birth. Note that the gain in weight by the two breeds is nearly parallel at first but difference gradually increases to maturity

longer intervals after this age is passed. The reason for lengthening the interval between measurements with the older animals is the small monthly increment in height after the age of thirty months which makes it unsatisfactory and unnecessary to attempt to take the measurements at intervals closer than those used.

Table 3 gives the average, or normal, the highest, and the lowest weights of the groups of Holsteins and Jerseys from which the data were taken. These data are included up to the date of

TABLE 4.—NORMAL WEIGHTS AND HEIGHT AT WITHERS OF SHORTHORN AND AYRSHIRE FEMALES

Age	SHORTHORNS		AYRSHIRES	
	Normal weight	Normal height	Normal weight	Normal height
<i>Months</i>	<i>Pounds</i>	<i>Centimeters</i>	<i>Pounds</i>	<i>Centimeters</i>
Birth	73	....	69	....
1	118	79.0	90	70.0
2	133	81.5	128	75.0
3	174	86.2	170	79.3
4	225	90.9	218	84.2
5	268	94.1	254	89.2
6	316	97.7	286	92.6
7	348	101.5	304	94.8
8	419	104.5	336	97.8
9	461	106.5	366	99.1
10	538	109.9	406	100.8
11	576	111.2	427	101.9
12	547	112.8	456	103.5
13	564	114.6	485	105.0
14	579	115.4	533	106.8
15	617	116.7	547	107.8
16	627	119.4	560	108.5
17	642	120.0	579	109.5
18	668	121.2	604	111.2
19	695	122.6	627	112.3
20	728	123.3	651	113.4
21	745	124.0	679	114.1
22	741	124.8	707	115.3
23	821	125.7	733	115.9
24	845	126.6	759	116.5
25	845	127.5	798	118.3
26	877	128.0	807	118.7
27	885	128.4	859	119.0
28	922	128.9	...	119.3
29	928	128.9	...	119.5
30	998	130.2	...	119.8
33	...	131.3	...	121.2
36	...	132.2	...	121.7
42	...	134.6	...	122.7
48	...	136.0	...	123.2
54	...	136.6	...	124.6
60	...	137.5	...	124.7

average age at first calving, which was thirty months for the Holsteins and twenty-nine months for the Jerseys. The data giving the weights following each of the first five parturitions, and at points six months following each calving, are found in Table 5. The data for the weights of Jerseys and Holsteins as given in Tables 3 and 5 are shown in Figure 3. For reasons previously given, it was not found satisfactory to use weights taken monthly after lactation began. The strong influence of lactation upon growth and the slight effect of gestation is shown by data already published.

TABLE 5.—AVERAGE WEIGHT OF JERSEY, HOLSTEIN, AND AYRSHIRE COWS FROM FIRST TO FIFTH PARTURITION

	HOLSTEINS		JERSEYS		AYRSHIRES	
	Age	Average weight	Age	Average weight	Age	Average weight
	<i>Months</i>	<i>Pounds</i>	<i>Months</i>	<i>Pounds</i>	<i>Months</i>	<i>Pounds</i>
After first calving	30	965	29	764	28	868
Six months after first calving	36	962	35	779	34	840
After second calving	43	1040	42	827	37	874
Six months after second calving	49	1071	48	854	43	892
After third calving	57	1143	55	872	55	960
Six months after third calving	63	1136	..	..	61	952
After fourth calving	71	1219	68	887	74	1022
Six months after fourth calving	77	1200	..	..	80	980
After fifth calving	82	1247	80	919	92	1045
Six months after fifth calving . . . . .	..	..	..	..	98	1023

It will be noted that increase in weight continued with the Holsteins to the time of the fifth parturition at the average age of eighty-two months. Beyond this the data available are not sufficient to justify a definite conclusion but indicate no further gain in weight. The data for the Jerseys show the same general facts. Cows of this breed may be expected to attain their maximum weight at about six years but may gain slightly beyond this age. The number of animals supplying this data is shown in Table 1.

Table 4 gives the normal weight and height at withers for females of the Dairy Shorthorn and Ayrshire breeds. The data upon which these normals are based are less extensive than that available for the Jerseys and the Holsteins. It will be noted that

the normal for the Shorthorns follows very closely that given for the Holsteins while the normal for the Ayrshires is not far different from that for the Jerseys as found in Tables 2 and 3. Some surprise may be experienced that the Ayrshire height figures are not

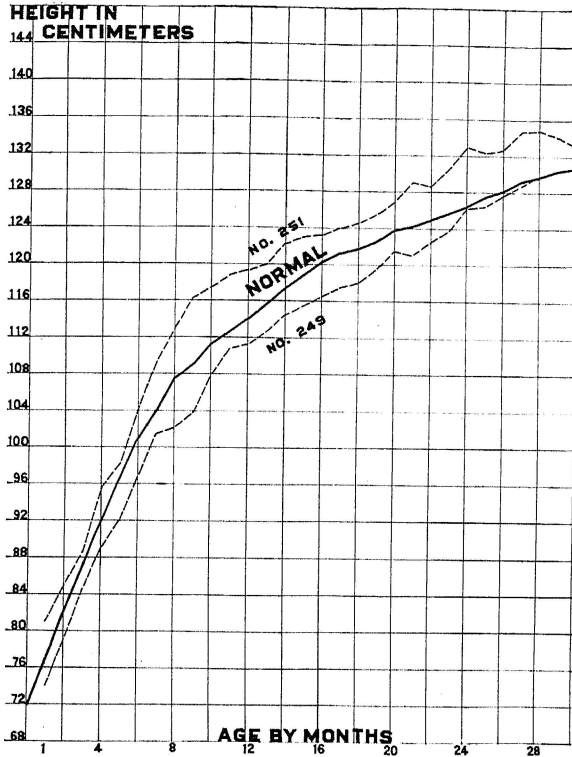


FIG. 4.—These curves compare the growth in height at withers of two individuals with the normal. The unavoidable variations in taking measurements of animals is shown by the irregularities in the individual curves. Individuals either above or below the normal, tend to follow in the same relative position to the normal for long periods

greater than the Jersey, since the Ayrshire breed on the average exceeds the Jersey in weight. It is possible that the data given are somewhat low for the Ayrshire breed altho the animals from which the data were taken represent lines of breeding found in some of the best known herds of that breed in this country. The main reason for the Ayrshires not exceeding the Jerseys in height is

due to the type of Jerseys used rather than to abnormally small Ayrshires.

Figure 4 gives the normal curve of growth in height at withers for Holsteins and the same data for two individuals, No. 251 and No. 249. The purpose of presenting this figure is to illustrate some of the individual variations that occur and the fact that the curve of normal growth is followed rather closely by individuals. No. 251 was one of the most rapid growing and one of the largest animals for her age included in our records. No. 249 was among those furthest below the normal in size in the group supplying the data used. The irregularities in the individual curves are due presumably to inaccuracies in taking measurements, which are unavoidable.

A comparison of these and other data not given in detail, shows that as a rule, an animal follows the normal curve of growth surprisingly close. If an animal is below the normal at a certain age it tends to remain about the same distance below normal for a long period, often until near the age when growth ordinarily ceases. The animal in question may continue growing longer than usual and by this means reach the normal for the breed. If an animal is above normal in height at any point during the growing period the tendency is likewise to follow the curve but to remain above the normal. In this case growth usually ceases at an earlier age than normal and the animal may be no more than normal in height at maturity.

The curve of normal growth in research work.—The data and curves of normal growth serve a useful purpose in any investigations that concern growing animals. Constant use has been made of these data in the research work of the Missouri Agricultural Experiment Station from a time when they were only partly complete. For example, in investigations concerning the minimum protein requirements of dairy animals at this experiment station, curves are plotted representing the normal growth in height and weight. Curves representing the growth of individual animals are then placed on the same sheet for comparison and are extended month by month. It is possible by this means to determine within a short time, to what extent the animal tends to vary from normal under the conditions to which it is subject. Without the normal-growth curve it would be necessary to have check animals in every case for comparison. The normal-growth curves not only eliminate the necessity for these check animals but furnish a basis for comparison which is much better than a check animal or even

several check animals as it is the average of a group large enough to furnish a fair mean.

Value of normal growth figures to practical breeders.—It is believed that the normal growth figures will be of great value to breeders of dairy cattle. The inexperienced breeder especially, is often more or less uncertain as to how liberally the young animals in his herd should be fed and especially as to how large they should be at various ages. Experience alone has been the only guide in this respect in the past. By occasional comparisons with the normal figures it will be possible for any breeder to determine if his young stock is being developed normally. A few breeders learning of the gathering of this data have asked for advanced copies with the intention of using it in a practical way in connection with the development of their herds. The herdsman of the University of Missouri herd has found it advantageous to weigh the calves and young heifers occasionally and compare the weights with the normal figures for animals of the breed and age represented. A company having a large number of dairy cattle has asked for a copy of the normal weights and expressed the intention of having the weights of all their young animals checked with the normal figures at frequent intervals.

Size of exhibition animals.—In connection with the taking of data in the University herd, single measurements of height at withers were made under the supervision of the writer, of 204 animals of the Jersey, Holstein and Ayrshire breeds⁵ at exhibitions which bring together the best specimens of these breeds. It was not practicable to get weights on these animals. The majority of the animals were in good condition and carried more flesh than usual with heifers raised under ordinary conditions. For this reason it is probable that weights should have shown even a wider margin above normal growth than did the height measurements. While the number of animals measured seems large the individual measurements vary widely. It was noted that the animals of certain herds were uniformly larger in proportion to the normal than others.

The Holsteins measured, seventy-one in all, averaged 105 per cent of the normal. They were almost uniformly above the normal figures. It is evident that the exhibitor of Holstein cattle considers it to his advantage to have his animals developed considerably

⁵ Burlingham, C. L., and Gillette, L. S. *The Normal Growth of Dairy Heifers*. Thesis for A. M. degree University of Missouri (1914).

above normal for their ages. While weights of these animals were not taken it was certain from observations that the weights were even more above the normal than the skeleton development as shown by the height measurements. What has been said concerning the Holsteins applies in all particulars to the Ayrshires. Altho the number measured, twenty-three, was comparatively small, the Ayrshire group averaged 107 per cent of the normal in weight measurements.

With the Jerseys the results were the reverse, as would be anticipated from the fact that exhibition animals are almost exclusively of the Island Type while the animals supplying the data used were of the American Type, or at most with one quarter Island Type. The one hundred exhibition Jerseys measured, aver-

TABLE 6.—AVERAGE HEIGHT AND WEIGHT OF MATURE DAIRY COWS

Breeds	Height at withers		Weight	
	Number of animals	Height at maturity	Number of animals	Weight at maturity
		<i>Centimeters</i>		<i>Pounds</i>
Jerseys—				
American Type	48	123.7	64	902
All Types	160	121.6	..	...
Holsteins	54	134.8	49	1245
Ayrshires	16	123.6	24	997

aged 97 per cent of the normal figures as given. It is probable that the difference would be even more marked but for the liberal feeding exhibition animals are certain to receive.

Measurements were also made of a number of young animals in a grade herd kept under reasonably good conditions and the figures received compared reasonably well with the normal growth figures as given.

Height and weight of cows at maturity.—The data available concerning the height at withers and the weight of mature cows of the Jersey, Holstein and Ayrshire breeds are found in Table 6.

The greater part of the data for all breeds were taken from the University of Missouri herd. A portion however, taken by Jensen,⁶ represents animals owned by the agricultural colleges of Kansas, Nebraska, and South Dakota. Height measurements of

⁶ Jensen, R. C. The Relation of Conformation to Production of Dairy Cattle. Thesis for A. M. degree University of Missouri (1913).

ninety-six Jerseys taken by Wylie,⁷ of cows owned by a cow test association in Ohio, are also included in the average of that breed. The data for the Jersey breed are divided on account of the marked influence of type upon the data taken from this breed. Unfortunately, data concerning the weights and heights of typical groups of animals exclusively of the Island Type are not available. The effect of type upon the breed is shown in a striking way by the data for the Jerseys of the 160 registered animals measured at withers; forty-eight in the University of Missouri herd averaged 123.7 centimeters in height; sixteen in other college herds 121.6 centimeters, and ninety-six in commercial herds 120.6 centimeters.

TABLE 7.—HEIGHT AT WITHERS OF MATURE JERSEY COWS

Number of animals...	1	3	14	38	49	37	12	5	1
Height in Centimeters	108-111	111-114	114-117	117-120	120-123	123-126	126-129	129-132	132-134

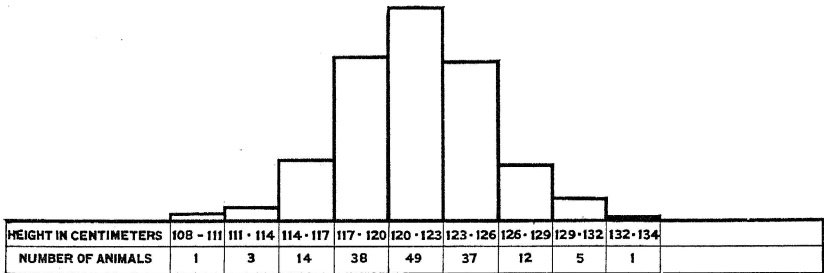


FIG. 5.—Frequency distribution of the height of Jersey cows at maturity. The average height was 121.6 centimeters

The Holstein and Ayrshire animals supplying the data given were all in college herds. The data available for the Guernsey breed are too scant to allow of safe averages being made.

All weights used from the University of Missouri herd, and this includes more than two-thirds of the total, represent the weight as taken as an average of three days, immediately after calving. Care also was taken to include only mature animals. The distribution of the weights of the Jerseys is found in Table 7, and is shown in Figure 5. It will be noted that a normal fre-

⁷ Wylie, Robt. The Relation of Type and Conformation to Production in Dairy Cattle.

quency curve results, as would be expected. Presumably, if a sufficient number of measurements or weights were available for the other breeds, the same type of curve would be found. During the ten-year period beginning in 1887, the Holstein-Friesian Association published measurements of height at withers of a large number of cows of the Holstein breed. These figures average slightly lower than the data given for this breed in Table 6.

SUMMARY AND CONCLUSIONS.

The curve of normal growth from birth to maturity, as represented by weight and height at withers, is given for females of the Jersey, Holstein, Ayrshire, and the dairy type of the Shorthorn breeds.

The data upon which this curve is based were taken at monthly intervals from birth to maturity from animals in the University of Missouri herd.

Curves of this character are useful in research work as a basis of comparison for the growth of experimental animals. By their use, the necessity for check animals is eliminated.

The figures of normal growth may be of considerable assistance to breeders of dairy cattle, giving them a means of determining whether their methods of feeding growing animals are such as to allow growth to continue at a normal rate and to judge if an individual animal is of normal size for its age.

A compilation of data is also given showing the average height at withers and weight of mature Jersey, Holstein and Ayrshire cows.