

UNIVERSITY OF MISSOURI

COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

RESEARCH BULLETIN 62

NORMAL GROWTH OF DOMESTIC ANIMALS

(Publication authorized June 30, 1922.)



COLUMBIA, MISSOURI

NOVEMBER, 1923

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COLLEGE OF AGRICULTURE
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PREFACE

Conveniently arranged tables are among the most useful time-saving devices to those who have occasion to make use of numerical data. This is illustrated by the wide-spread use of engineering, mathematical, chemical and biological handbooks. The time is arriving for the compilation of handbooks of agricultural data.

This bulletin is a first cooperative attempt to put into convenient form scattered data on growth of farm animals. In addition to the numerical data, curves are presented to show the process of growth as a whole. These curves and tables will be useful to the growers of animals and to investigators in nutrition of farm animals, as norms, or standards of growth. They may also be of interest to the general student of growth.

A word concerning the persons who inspired the accumulation of data on growth in this Station: The former director of this station, H. J. Waters, and the present director, F. B. Mumford have taken much interest in, and made important contributions to, the subject of growth. The accumulation of data in this Station is due in a large measure to the stimulus of these two men. The undersigned were appointed by Director Mumford as a committee to arrange the available data on growth for publication in this bulletin, and to make additions to this compilation from time to time.

C. R. Moulton
H. L. Kempster
A. G. Hogan
Samuel Brody.

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Normal Growth of Domestic Animals

INTRODUCTION

F. B. MUMFORD

The physiological phenomenon of growth in the domestic animals is undoubtedly the most important single factor, not only in research but in the development of animals for economic and commercial purposes. It is important to determine if possible what is normal growth in the domestic animals and to establish standards of growth which may be used by investigators. Because of a lack of such standards, it is now difficult to coordinate the results of different investigators. Investigators are handicapped in growth studies of the domestic animals because there are no satisfactory standards of normal growth available.

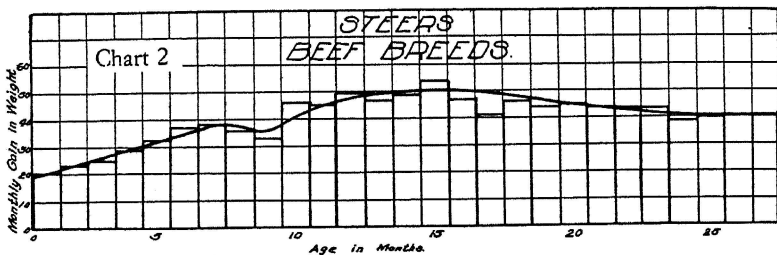
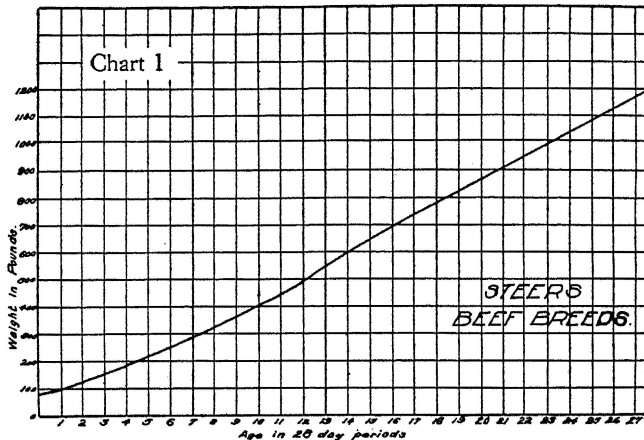
The Missouri Experiment Station has during a number of years conducted growth experiments in several departments and has assembled from other sources valuable data on the subject. This publication by various authors interested in growth studies is a first attempt on the part of these workers to establish normal growth standards. It is hoped that the publication of these results will suggest similar contributions by others, and that in the end we may have comparatively definite standard growth curves which will give greater definiteness to growth studies. The tables and charts submitted in this publication will be revised from time to time as further data accumulate.

GROWTH CURVES FOR BEEF STEERS

A. G. HOGAN, H. D. FOX

The data from which the first chart was drawn, were kindly sent us by Prof. T. L. Haecker, and are presented as unpublished data furnished by the Minnesota Agricultural Experiment Station.

The method of feeding these steers has been described in Bulletin 193 of the Minnesota Station, and will not be repeated here. Our interpretation of their statement, however, is that these steers were not fed to grow at the maximum rate, but were fed to grow as rapidly as practicable under ordinary conditions.



Charts 1 and 2.—(1) Weight-age curve of beef steers. (2) Gain in weight by months. (Numbers and legends for succeeding charts are for the most part included in the charts themselves)

An additional chart has also been prepared showing the monthly (28 day) gain in weight made by these steers. This chart gives some indication that the steers have grown in cycles. The

only comment we have to offer is that possibly the method of feeding may have obscured any tendency to cyclic growth.

TABLE 1.—AVERAGE WEIGHTS OF BEEF STEERS FROM WHICH CURVES WERE DRAWN.

Age in months (28 days)	Av. weight (in pounds)	Age in month (28 days)	Av. weight (in pounds)
Birth	80	Birth	
1	102	15	644
2	125	16	691
3	150	17	732
4	178	18	779
5	211	19	823
6	248	20	868
7	286	21	912
8	322	22	956
9	356	23	1000
10	402	24	1039
11	447	25	1079
12	496	26	1120
13	543	27	1170
14	592	28	1194

TABLE 2.—WEIGHTS AND MEASUREMENTS OF BEEF STEERS.
Group I.—Full Feed.

Age months	Number of Animals	Weight lbs.	Number of Animals	Height of Withers cms.	Length to ischium cms.	Width of hips cms.	Heart girth cms.
At birth		80	--	68	66	16	74
1	12	135	3	76	79	19.2	86
2	14	175	6	82.5	88.6	21.9	96.4
3	14	215	7	87.5	97	24.1	105
4	13	270	7	91.5	103.6	26.3	112
5	13	325	10	95	109.5	28.3	119.3
6	11	385	6	98.5	114.5	30.2	126.4
7	10	445	5	102	119.2	32.1	133.3
8	10	505	9	105.3	123.8	34	140.3
9	8	565	--	108.3	128.3	35.8	147.3
10	8	625	--	111.1	132.9	37.7	154.0
11	8	685	8	113.9	137.3	39.5	160.6
12	6	745	--	116.5	141.5	41	166.3
13	6	815	--	119	146	42.4	171.8
14	6	880	6	121	150.2	43.8	176.8
15	6	945	--	122.7	154.0	45.2	181.3
16	6	1000	5	124.3	156.7	46.5	185.3
17	6	1045	--	125.7	158.5	47.8	188.5
18	6	1090	6	126.6	160	49	191
19	5	1130	6	127.4	161	50	193.3
20	5	1165	--	128.2	162	51	196
21	5	1200	6	129	163	52	198.5
22	4	1240	4	129.7	164	52.5	201
23	4	1275	4	130.3	164.9	53.2	203.7
24	4	1315	4	131.1	165.9	53.8	206.3
25	4	1355	4	131.9	166.9	54.4	209.3
26	4	1395	4	132.6	167.8	55	212.0
27	4	1430	4	133.3	168.8	55.7	214.7
28	4	1465	4	134	169.7	56.2	217.3
29	4	1500	4	134.7	170.7	56.8	219.7
30	4	1535	4	135.5	171.7	57.4	222
31	4	1565	4	136.1	172.7	58	224
32	4	1595	4	136.7	173.7	58.5	226
33	4	1620	4	137.3	174.7	59.2	228
34	4	1645	4	137.9	175.4	59.7	230
35	3	1670	3	138.5	175.7	60	232
36	3	1695	3	139.1	175.9	60.5	233.8
37	3	1720	3	139.7	176	60.9	235.5
38	3	1745	3	140.3	176.2	61.3	237.3
39	3	1767	3	140.8	176.5	61.7	239
40	3	1788	2	141.3	177.3	62.2	240.7
41	2	1802	2	141.8	179.3	62.8	242.3
42	2	1815	2	142.3	181.9	63.3	244
43	2	1835	2	142.7	184.5	63.9	245.2
44	2	1875	2	142.9	186.9	64.5	246.4
45	2	1915	2	143	187.7	64.8	247.7
46	1	1940	1	143	188	65	248.8
47	1	1955	1	143	188.3	65	249.7
48	1	1965	1	143	188.6	65	250.2

TABLE 3.—WEIGHTS AND MEASUREMENTS OF BEEF STEERS.
Group II.—Maximum Growth Without Fattening.

Age months	Number of Animals	Weight lbs.	Number of Animals	Height at Withers cms.	Length shoulder to ischium cms.	Width of hips cms.	Heart girth cms.
At birth		80	--	68	66	16	74
1	19	125	4	76	79	18.7	86
2	19	155	9	81.5	87.7	21.1	93.2
3	19	185	7	84.5	92.5	22.7	98
4	18	215	5	87.5	96	24.3	103.4
5	17	255	9	90.5	99.2	25.8	109
6	16	295	8	93	102.4	27.3	114.8
7	13	335	6	95.5	105.4	29	120.5
8	11	375	5	98	108.2	30.4	126.9
9	11	410	--	100.5	111	32	132.5
10	10	450	--	103	113.7	33.6	138.2
11	10	490	5	105.5	116.5	35.2	143.4
12	9	525	4	108	119.3	36.2	148.5
13	8	560	--	110.5	122.3	37.2	152.2
14	8	595	5	113	125.4	38.3	154.6
15	8	625	--	115	128.5	39.3	156.7
16	8	655	--	117	131.5	40	159
17	8	685	--	118.7	135.7	40.8	161.3
18	8	710	8	120.6	138.6	41.7	163.7
19	7	735	5	122.9	140.3	42.4	165.8
20	7	760	6	124.9	142.5	43.3	168
21	7	785	--	126.7	144.3	44	170
22	6	810	5	128.4	146.2	44.7	172
23	6	835	--	130	148	45.3	174
24	6	855	5	131.1	149.8	45.8	175.6
25	6	875	5	131.9	151.6	46.2	177
26	6	895	--	132.6	153.4	46.4	178.4
27	5	910	6	133.3	155.3	46.7	180
28	5	925	5	134	157	47	181.4
29	5	940	4	134.7	158.8	47.3	183
30	5	950	5	135.5	160.7	47.7	184.5
31	5	957	--	136.1	162.6	48.3	186.3
32	5	962	--	136.7	164.5	48.8	188
33	5	967	4	137.3	165.8	49.3	189.5
34	5	972	4	137.9	165.9	49.7	191
35	5	977	3	138.5	166	50.1	192.6
36	4	987	3	139.1	166	50.4	193.5
37	4	1000	3	139.7	166.1	50.8	194.3
38	4	1015	3	140.3	166.3	51.2	195.2
39	4	1025	3	140.8	166.7	51.5	196.2
40	4	1060	3	141.3	167.1	52	197.1
41	2	1100	2	141.8	167.7	52.3	198
42	2	1135	2	142.3	168.3	52.7	199.2
43	2	1165	2	142.7	169.2	53.2	201
44	2	1190	2	142.9	170	53.7	203
45	2	1208	2	143	170.7	54.3	205
46	1	1225	1	143	171	54.8	206.9
47	1	1240	1	143	171.3	55.3	208.7
48	1	1255	1	143	171.5	55.8	210.4

TABLE 4.—WEIGHTS AND MEASUREMENTS OF BEEF STEERS.
Group III.—Poor Growth.

Age months	Number of Animals	Weight lbs.	Number of Animals	Height at Withers cms.	Length shoulder to ischium cms.	Width of hips cms.	Heart girth cms.
At birth		80	--	68	66	16	74
1	15	125	4	76	79	18.7	86
2	17	155	13	81.5	87.7	21.1	93.2
3	18	180	8	84.5	92.5	22.7	98
4	17	205	8	87.5	96	24	102.2
5	16	230	7	90.5	99.2	25.3	106.1
6	14	253	7	93	102.4	26.3	109.7
7	11	275	5	95.5	105.1	27.2	113.3
8	10	295	--	98	107	28.1	117.2
9	10	315	6	100.5	109	29	121.3
10	9	336	--	103	110.7	29.9	125.2
11	9	357	4	105.5	113	30.8	129.1
12	9	378	6	108	115	31.7	132.8
13	7	400	4	110.5	117.3	32.6	136.5
14	7	420	--	113	119.8	33.5	140.1
15	7	440	4	115	122.6	34.4	143.3
16	7	461	--	117	125.5	35.3	146
17	7	482	--	118.7	128.5	36.3	148.8
18	7	503	--	120.3	131.5	37.3	151
19	7	523	5	121.7	134.5	38.2	153
20	6	543	4	123	137.3	39	154.7
21	6	563	4	124.2	139.3	39.9	156.7
22	6	582	4	125.2	141	40.7	158.5
23	6	600	4	126.1	142.8	41.3	160.3
24	6	615	4	127	144.5	41.5	161.3
25	6	630	4	127.9	146.3	41.8	162.7
26	6	645	4	128.8	148	42.2	164.8
27	5	655	3	129.7	149.3	42.5	167
28	5	665	3	130.6	150.7	43	169.1
29	5	675	3	131.5	151.9	43.5	170.7
30	5	685	3	132.4	153.2	44	172.6
31	5	695	3	133.4	154.5	44.5	174.3
32	5	707	3	134.3	155.8	45	175.7
33	5	717	3	135.2	157	45.3	176.8
34	5	727	3	135.5	158.4	45.6	177
35	5	736	3	135.9	159.7	45.8	177.2
36	5	746	3	136.3	160.4	46	177.4
37	5	756	3	136.9	160.5	46.2	177.7
38	5	766	3	137.2	160.6	46.4	178.1
39	5	776	3	137.7	160.7	46.6	178.8
40	5	790	3	138.2	160.8	47	179.9
41	5	817	3	138.7	161.3	47.9	181.2
42	3	843	2	139.2	162.2	48.5	182.8
43	3	870	2	139.6	163	49.3	184.7
44	3	886	2	140.1	164	50	186.7
45	3	900	2	140.7	164.8	50.6	189.1
46	3	912	1	141.3	165.7	51.2	191.5
47	2	920	1	141.9	166.6	51.7	194
48	1	928	1	142.5	167.5	52.4	196

GROWTH OF THE HEREFORD-SHORTHORN STEER

C. ROBERT MOULTON

The data on which the following work is based are from the Use of Food experiment carried on for some years at the Missouri Agricultural Experiment Station. The data appear in Research Bulletin 43 and this must be consulted for acknowledgments and details. The data as averaged and used in this bulletin are shown in Tables 2 to 4. The number of animals which were averaged to give the data for any month are shown together with the average weight and measurement. The number of individuals is not sufficient to permit of an accurate statement being made or a law derived.

However, since the general results are in accord, in the main, with the observations of Robertson¹ and growth is shown to occur in cycles which agree in point of time in practically all the groups, the data are presented with the belief that they will be useful. The curves for Group I (Full Fed) show the maximum growth that should be expected of the Hereford-Shorthorn beef steer. The curves for Group II (Maximum Growth Without Fattening) show the growth to be expected when the same beef steer is fed such a quantity of feed that it will grow without appreciable fattening. The animals averaged about one pound a day gain for the first two years. The curves for Group III (Poor Growth) show the growth of the same steer when fed such a ration that it is growing poorly and averaging for the first two years but 0.69 of a pound daily.

The curves show growth cycles with maxima near 10 months and again later at 40 to 45 months. These are in contrast to the maxima for the dairy cow which occur at 5 months and at 20 months.

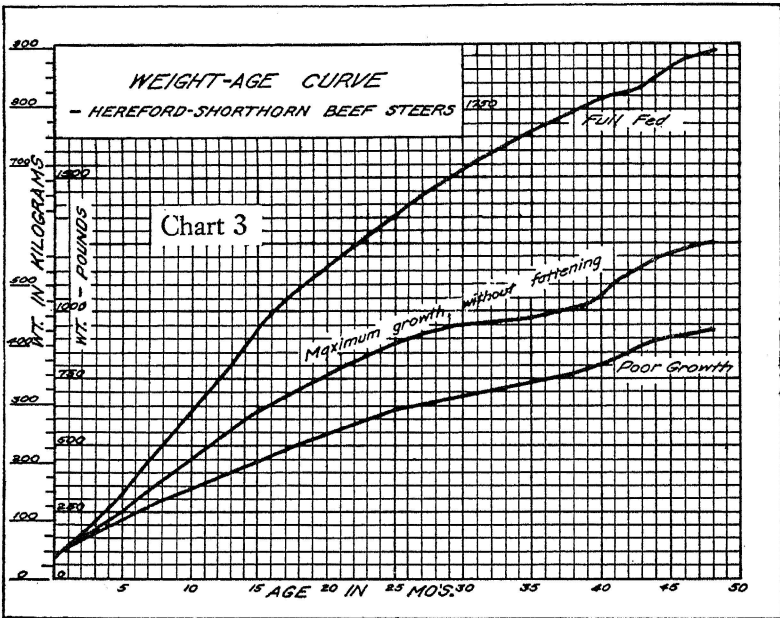
The height at withers fails to show cycles but the weight, length of body, width of hips, and heart girth have fairly well defined cycles with maxima at the ages shown just above. Height at withers is essentially a leg-length measurement. Length of body, width of hips, and heart girth are measurements indicating volume of the body. It is therefore not surprising to see that the latter exhibit growth cycles while the former does not.

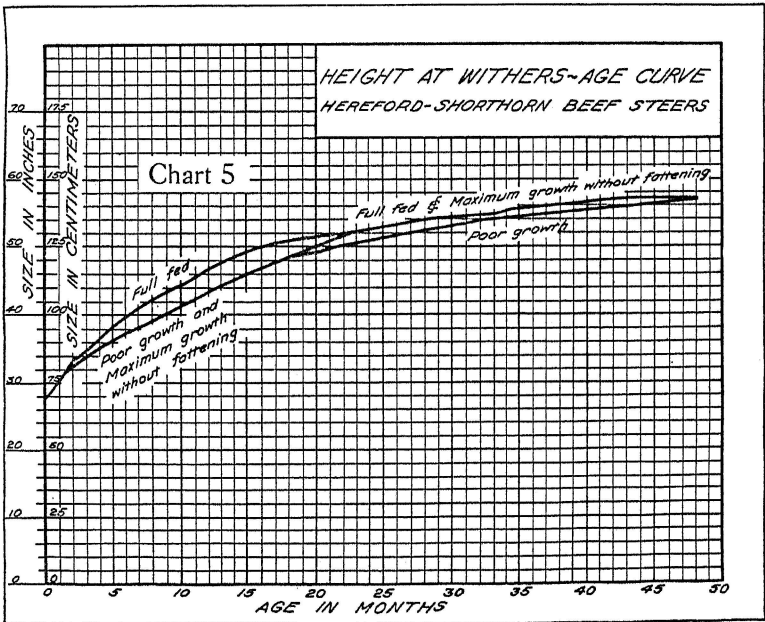
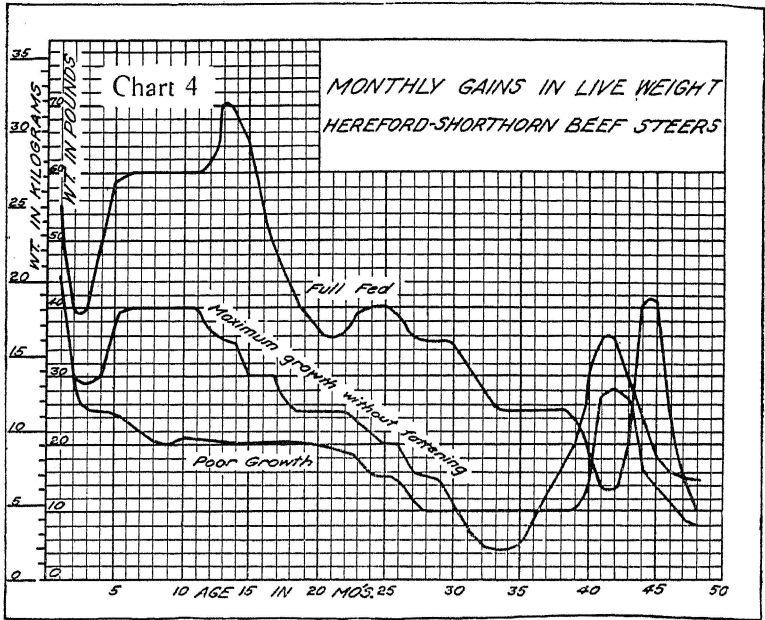
It may be that unsexing is responsible for the retardation

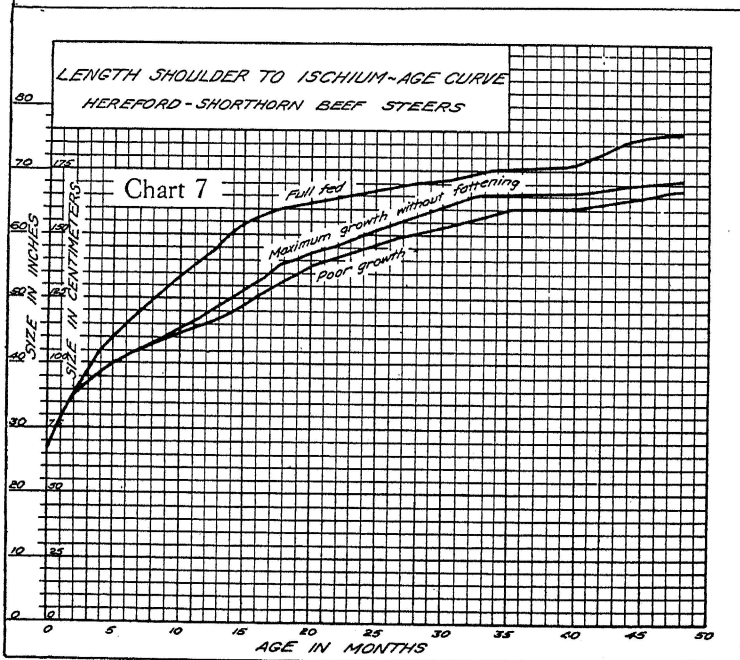
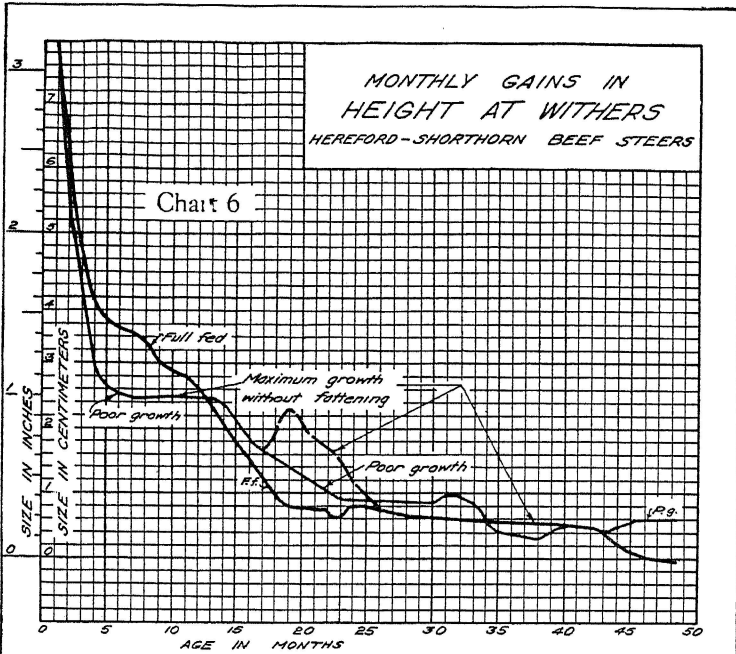
¹Robertson, T. B., 1920. Principles of Biochemistry.

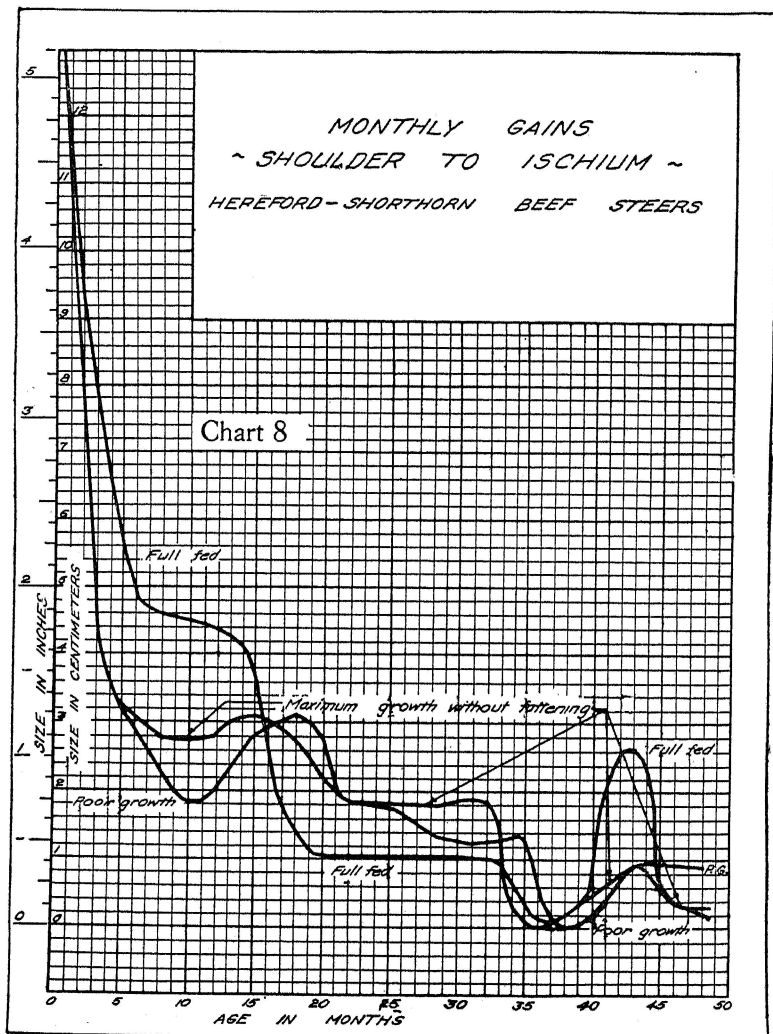
of the growth cycles in the beef steer as compared to the dairy cow. However, since Stotsenberg² has shown that the presence or absence of testicular matter has no effect on the growth of the rat, it may simply be that these later occurring growth cycles are normal for the beef animal.

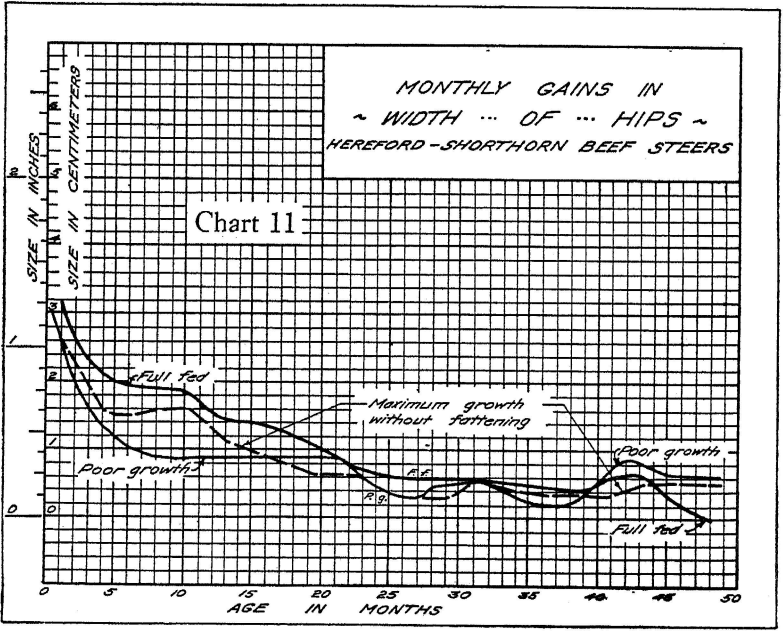
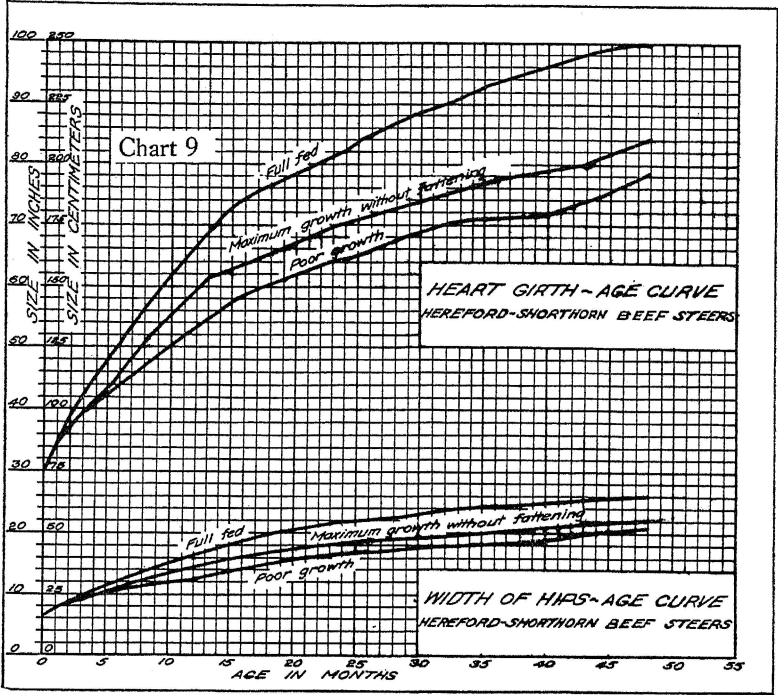
²Stotsenberg, J. M., Anat. Record 3, 233.

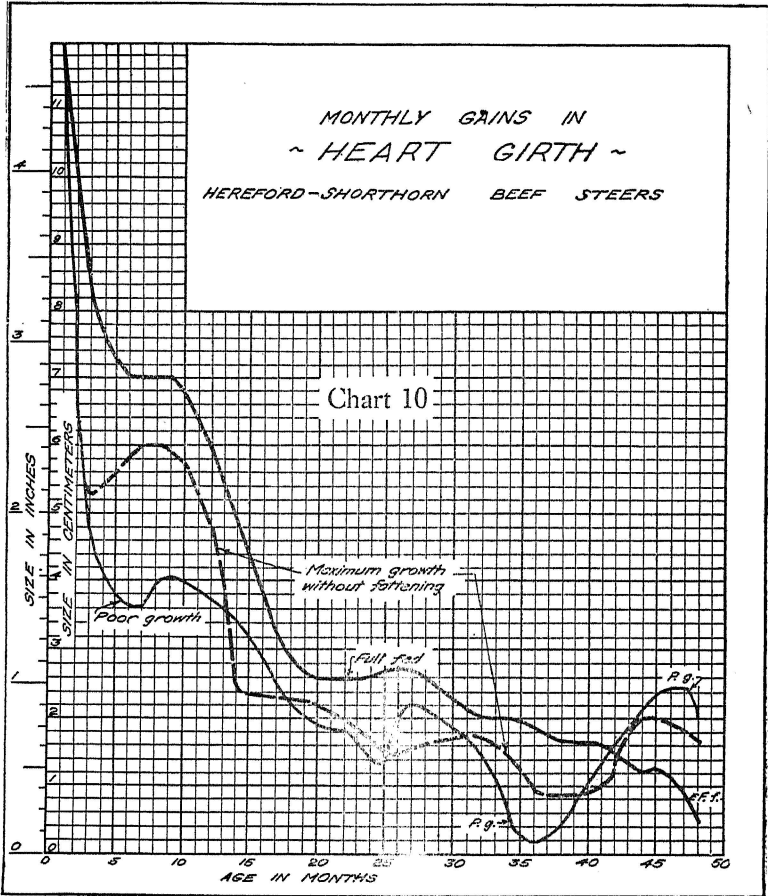












GROWTH OF THE DAIRY COW

SAMUEL BRODY, ARTHUR C. RAGSDALE

The data were obtained by Eckles and his co-workers in this Station. Eckles³ describes these animals as follows: "On the whole, it seems safe to say that the conditions under which they 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 market. It is believed that the results so far as the growth of the animals is concerned, may be safely called normal".

To eliminate variations in the growth curves due to pregnancy and lactation, the curves were drawn through the points representing the weight of the animals after parturition. The weights six months after parturition are also indicated.

Chart 12, showing the relation between age and weight, and age and height at withers, brings out the following points of interest: (1) about 50 per cent of growth in height at withers, takes place *in utero*. Only about 7 per cent of growth in weight takes place *in utero*. (2) Increase in height at withers practically ceases at the age of 30 months. Increase in weight continues for a much longer period.

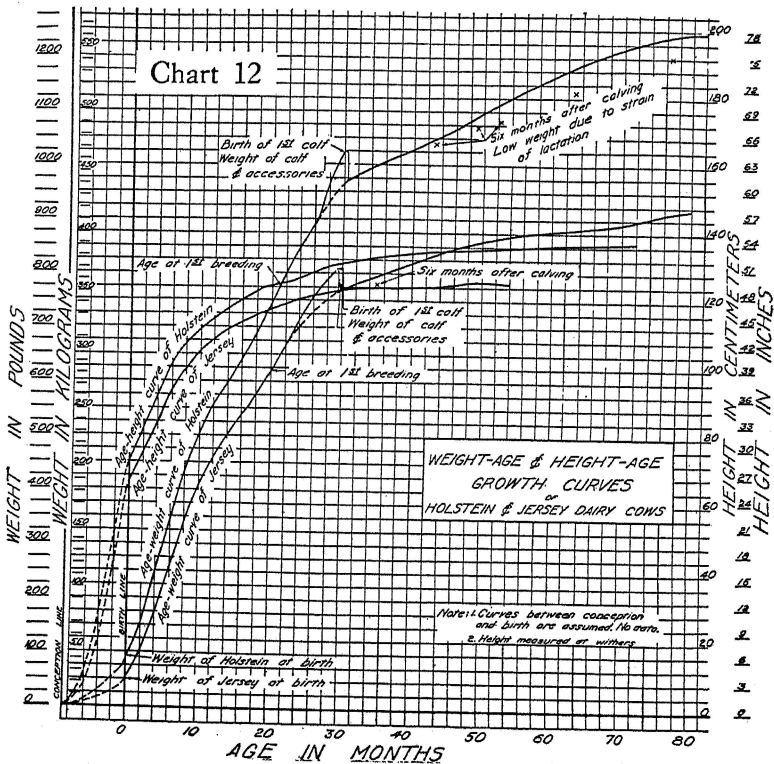
Chart 13 showing the variation of monthly gains with age, brings out the following points of interest: Growth is most rapid at about 5 and 20 months of age. The cow may be said to have two extra-uterine growth cycles⁴ with maxima at about 5 and 20 months of age. It can be shown from Chart 14, the change in weight of a gestating Jersey cow, that there is at least one intra-uterine growth cycle, with a maximum at about 5 months after conception when the curve is steepest, and ending at about 7 months after conception when the curve becomes flat. The rise following the flat part is the beginning of the first extra-uterine cycle with a maximum at 5 months of age.

Chart 15 showing the relation between age, weight, and height at withers, represents an attempt to condense the four curves of the first figure into one curve, and in addition to present a new method of measuring the condition, or state of nutrition of the cow. It is of course clear that any given individual cow weighs a little less or a little more than the "average cow" because

³Eckles, C. H. 1920. University Missouri Agr. Exp. Sta. Research Bul. 36.

⁴Cf. Robertson, T. B. 1920 Principles of Biochemistry, p. 471.

of an inherent tendency of living organisms to vary. In our herd 10-month-old Holstein heifers vary on the average by 50 pounds from the average of the herd; that is, about half of the heifers weigh on the average 50 pounds less, and the other half weigh 50 pounds more than the average of the herd. Some differ by less than 50 pounds, but others make up for it by differing by much more than 50 pounds. The difference between the heaviest and lightest 10-month-old Holstein heifers in our herd is 270 pounds. Now in experimental work where only a few animals are used, a difference of 50 pounds, or even in some cases 135 pounds, due to the individuality of the animal, may be greater than that due to the effect of experimental conditions. An animal may be 150 pounds below the average due to its individuality and be in perfect condition, but the investigator may be led to the conclusion, because it is below the average in weight, that the feed he used or other experimental conditions are responsible for it. This weight-height curve will eliminate this error due to the individuality of the cows as will become evident on the following considerations.



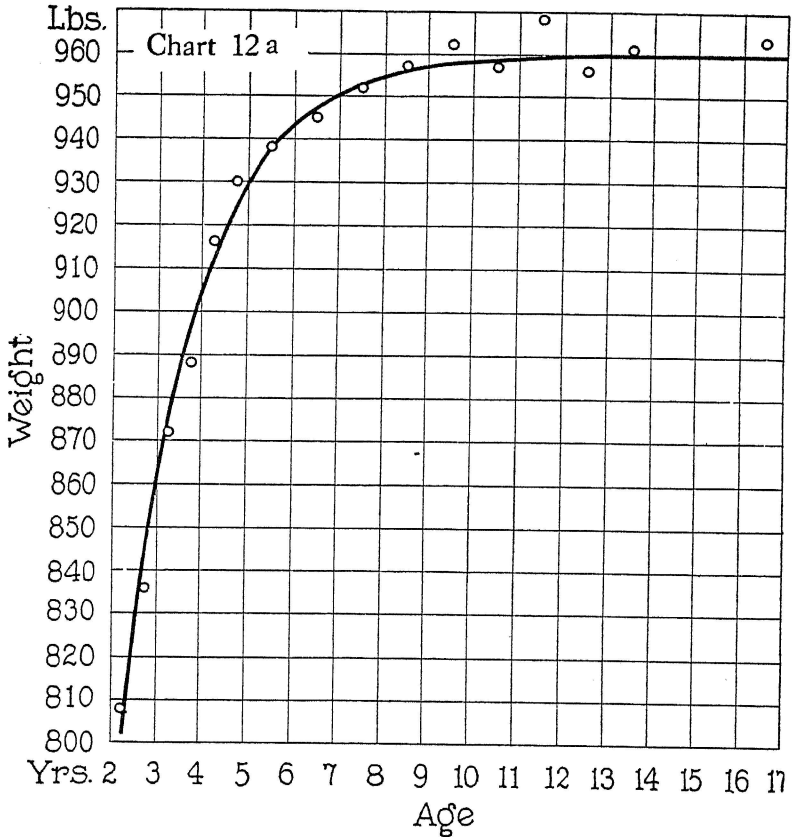
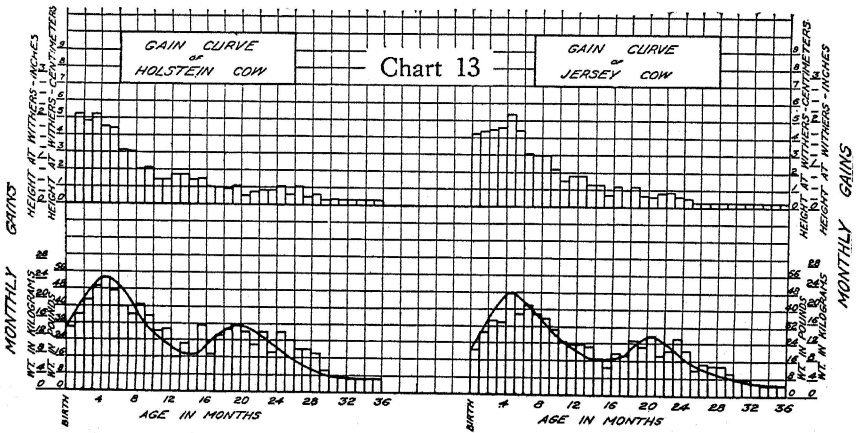
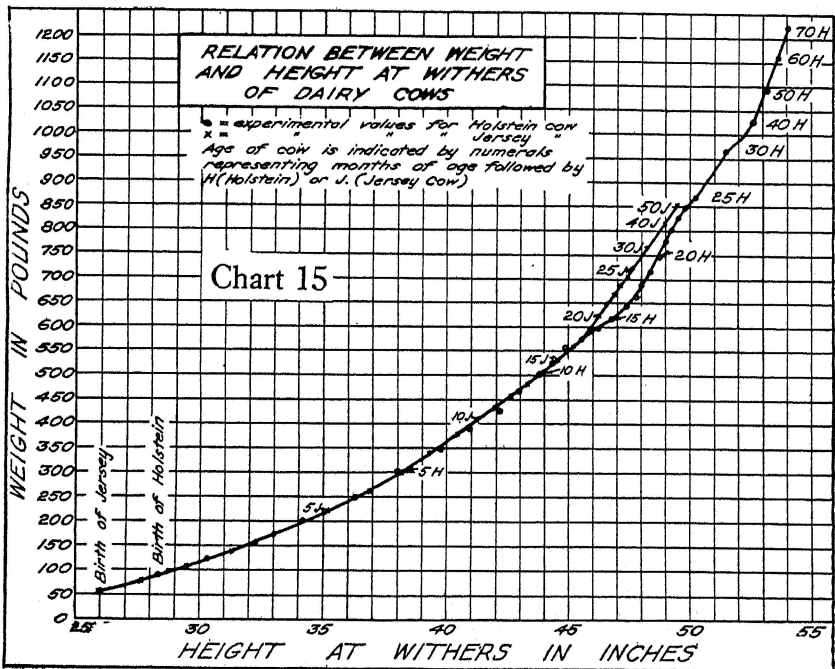
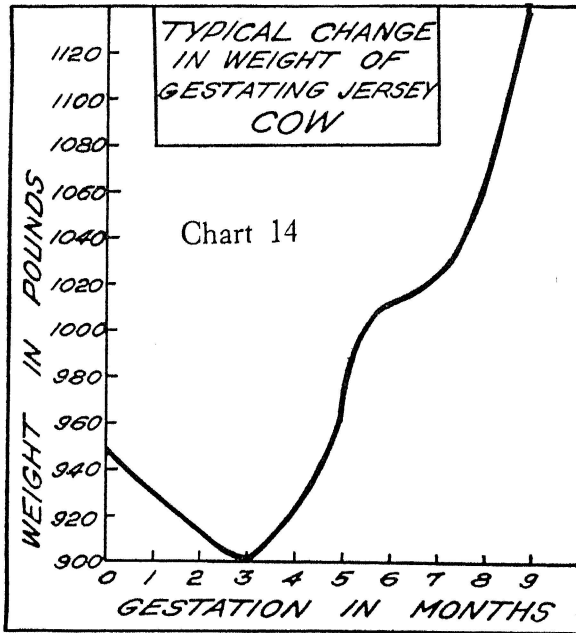


Chart 12a.—Weight-age curve of Register of Merit Jersey Cows.





The height at withers has been shown by Waters, Mumford and their associates in this Station, to be very slightly affected even under great extremes of experimental conditions. This is strikingly illustrated by the relative effect of food supply on weight and height at withers of three groups of steers shown by Dr. Moulton in another section of this bulletin. While the effect on the weight of the animals is profound, the height at withers is very little affected even under these extreme conditions. Under ordinary variations of food supply and other experimental conditions, the effect on the height at withers may be considered as negligible.

If height at withers is practically independent of experimental conditions, it may be taken as the unvarying measure of hereditary size of the animal at any age. If the relation between height and weight under "normal" conditions is established, it is easy to determine from this established relation, knowing the height, what should be the corresponding weight. This is easiest accomplished by a weight-height curve as shown in this weight-height figure. For every height there is under a given set of conditions, a corresponding definite weight. Knowing the height of the animal under experimental conditions the weight corresponding to this height is found from this curve for "normal" animals and compared to the actual weight. The difference between the two is a measure of the effect of the experimental conditions on the animal.

That there is a definite weight for a given height under "normal" conditions, regardless of the hereditary growth capacity, is shown by this figure. The height and weight of the relatively small Jersey fall on the same line as the weight and height of the much larger Holstein, and this is probably true for all dairy breeds. The same relation of symmetry probably holds for all breeds of the same type. The only difference between the different breeds of different hereditary sizes consists in the difference between the age-height relationship and age. Thus from the figure a 15-month-old Jersey has the weight-height relation of a 10-month-old Holstein; a 50-month-old Jersey has the weight-height relation of a 24-month-old Holstein. But for a given height, for example 45 inches, there is always the same corresponding weight of 550 pounds, regardless of the breed.

This curve therefore eliminates errors due to individuality of the animal, taking the "ideal hereditary" size of the given individual as the standard unit for its measure.

This curve may also be used as pointed out for determining weight or height at any age for the Holstein or Jersey cow.

In addition to the foregoing data obtained by Eckles and co-workers on animals owned by this Station, we also present data (Table 5a and Chart 12a) on lactating Jersey cattle from 2 to 17 years compiled by us in cooperation with C. W. Turner from the Register of Merit of Jersey Cattle. Certain theoretical⁵ and practical⁶ aspects of these data have been discussed elsewhere.

TABLE 5A.—DATA ON THE GROWTH OF THE DAIRY COW.
(Register of Merit Jersey Cattle)

Age Yrs.	No. Animals Represented	Average Weight (lbs.)
2.25	3,155	808
2.75	1,449	836
3.25	1,523	872
3.75	1,122	888
4.25	1,171	916
4.75	916	930
5.5	1,692	938
6.5	1,235	945
7.5	965	952
8.5	621	957
9.5	364	962
10.5	208	957
11.5	108	968
12.5	64	956
13.5	32	961
14.5	14	1,036
15.5	9	975
16.5	4	963

⁵Brody, Ragsdale, A. C., and Turner, C. W., *J. Gen. Physiol.* 1923. V. 445.

⁶Turner, C. W., Ragsdale, A. C., and Brody, S., *J. Dairy Science* Vol. VI. No. 5. Sep. 1923.

TABLE 5.—DATA ON THE GROWTH OF THE DAIRY COW

Age mos.	Holstein Cows			Jersey Cows		Ayrshire Cows			Shorthorn Cows			
	No. animals represented.	Average weight	Average height at withers	No. animals represented.	Average weight	Average height at withers	No. animals represented.	Average weight	Average height at withers	No. animals represented.	Average weight	Average height at withers
		(lbs.)	(cms.)		(lbs.)	(cms.)		(lbs.)	(cms.)		(lbs.)	(cms.)
Birth	83	90	71.8	94	55	66.1	26	69	....	17	73	
1	9	121	76.8	6	76	70.3	3	90	70.0	1	118	79.0
2	9	157	82.0	7	105	74.7	4	123	75.0	2	133	81.5
3	9	200	86.8	7	140	79.3	6	170	79.3	2	174	86.2
4	9	249	92.0	8	174	83.9	8	218	84.2	4	225	90.9
5	9	302	96.5	9	222	89.3	8	254	89.2	4	268	94.1
6	9	349	100.9	10	260	93.7	10	286	92.6	3	316	97.7
7	11	389	104.0	10	302	96.8	11	304	94.8	3	348	101.5
8	11	425	107.1	10	340	99.8	11	336	97.8	3	419	104.5
9	11	466	109.1	11	376	102.8	10	366	99.1	3	461	106.5
10	11	501	111.2	11	407	105.0	10	406	100.8	3	538	109.9
11	11	529	112.6	11	432	106.6	10	427	101.9	3	576	111.2
12	11	558	114.0	11	456	108.3	10	456	103.5	4	547	112.8
13	11	574	115.7	11	480	110.1	10	485	105.0	4	564	114.6
14	11	596	117.4	11	503	111.4	9	533	106.8	4	579	115.4
15	12	612	118.8	11	520	112.7	8	547	107.8	4	617	116.7
16	13	643	120.3	11	533	113.4	8	560	108.5	4	627	119.4
17	14	660	121.3	12	553	114.6	8	579	109.5	4	642	120.0
18	14	686	121.8	13	572	115.6	8	604	111.2	4	668	121.2
19	14	715	122.7	13	598	116.8	8	627	112.3	4	695	122.6
20	14	746	123.8	13	621	117.5	8	651	113.4	4	728	123.5
21	14	774	124.3	13	649	118.1	8	679	114.1	4	745	124.0
22	14	796	124.9	13	668	118.9	8	707	115.3	3	741	124.8
23	14	824	125.7	12	689	119.8	8	733	115.9	3	821	125.7
24	14	841	126.5	12	716	120.4	8	759	116.5	5	845	126.6
25	14	869	127.6	..	737	....	7	798	118.3	4	845	127.5
26	14	893	128.2	..	758	....	6	807	118.7	3	877	128.0
27	14	925	129.3	..	770	121.9	5	859	119.0	4	883	128.4
28	14	966	129.8	..	784	....	..	868*1	119.3	4	922	128.9
29	13	994	130.4	..	804†	....	..	..	119.5	3	928	128.9
30	26	1021†	130.7	12	764*1	122.6	..	..	119.8	4	998	130.2
33	..	965*1	132.0	..	..	123.2	..	..	121.2	4	..	131.3
34	..	..	..	..	..	..	..	840	..	..	..	..
35	..	..	..	..	779	..	..	..	..	..	..	..

36	26	962	132.8	11	...	124.2	7	...	121.7	4	...	132.2
37	..	...	....	..	...	....	..	874*2	....	.	...	....
42	..	...	133.7	..	827*2	124.5	7	...	122.7	4	...	134.6
43	22	1040	...	..	...	....	..	892	....	.	...	....
48	..	...	134.9	..	854	126.6	7	...	123.2	4	...	136.0
49	20	1071	...	..	...	....	..	...	....	.	...	....
54	..	...	135.5	..	...	....	..	...	124.6	2	...	136.6
55	..	...	....	..	872*3	....	..	...	....	.	...	....
57	17	1143*3	....	..	...	....	..	960*3	....	.	...	....
60	..	...	136.2	..	...	....	..	...	....	.	...	....
61	..	...	....	..	...	....	..	...	....	.	...	....
63	13	1136	....	..	...	....	6	...	124.7	1	...	137.5
68	..	...	....	..	...	....	..	952	....	.	...	....
71	8	1219*4	....	..	887*4	....	..	...	....	.	...	....
72	..	...	137.2	..	...	....	..	...	....	.	...	....
74	..	...	....	..	...	....	..	1022*4	....	.	...	....
77	3	1200	....	..	...	....	..	...	....	.	...	....
80	..	...	....	..	919*5	....	..	...	....	.	...	....
82	4	1247*3	....	..	...	....	..	980	....	.	...	....
98	..	...	....	..	...	....	..	1045*5	....	.	...	....
	..	...	....	..	...	....	..	1023	....	.	...	....

*1, *2, etc., indicate weight after first, second, third, fourth or fifth calving.
 † Indicates weight before calving.

GROWTH CURVES OF COLTS

D. W. CHITTENDEN, E. A. TROWBRIDGE, A. G. HOGAN

Unfortunately our data on horses are extremely scanty. We have complete records on only one colt up until weaning time, and for seven from weaning time on. Four of these are fillies and three are geldings. The latter were castrated when a little over a year old.

The colt, a filly, weighed before weaning, was foaled in 1921, the other seven in the spring of 1919. In 10 to 14 days after foaling the dams were worked regularly on the University Farm. The colts did not run with the mares while the latter were at work, and during working hours they suckled only at noon. A month after foaling the colts were given access to grain, and by the time they were weaned they were eating a small grain allowance regularly.

During their first winter the colts were kept in box stalls at night, and during the day also if the weather was bad. On pleasant days they had the run of small, dry lots. The ration consisted of corn, oats, bran, and alfalfa hay. The amount was sufficient to keep the colts in good growing condition, but not fat.

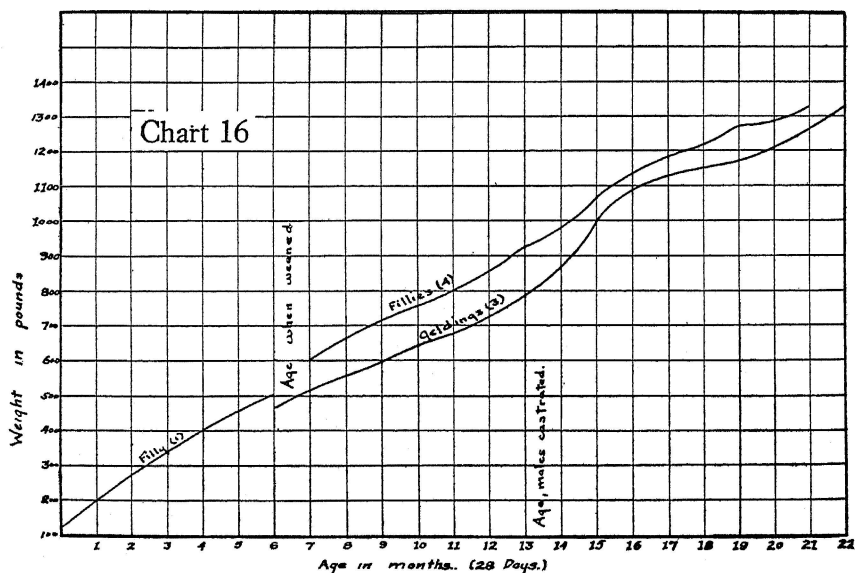


Chart 16—Weight-age curve of draft colts. Age in months (28-day periods).

During the second summer the colts were on bluegrass pasture, with a small grain allowance once a day.

During the second winter the colts were kept in tie stalls, but on pleasant days they were turned out on a bluegrass pasture. The ration was the same as during the first winter.

In the weight-age chart of the colts it is seen that after castration the geldings began to gain somewhat more rapidly. Probably because of the very small number of individuals represented, the curves are very irregular.

TABLE 6.—AVERAGE WEIGHTS OF PERCHERON COLTS FROM WHICH CURVES WERE DRAWN.

Age in months (28 days)	Average weight (in pounds)		
	Before weaning	After weaning	
	Filly (1)	Fillies (4)	Geldings (3)
Birth	110		
1	200		
2	270		
3	342		
4	405		
5	450		
6	500		468
7		604	517
8		663	557
9		713	597
10		758	645
11		797	677
12		855	720
13		925	783
14		975	870
15		1074	1005
16		1135	1090
17		1187	1127
18		1218	1153
19		1278	1167
20		1283	1219
21		1331	1263
22			1327

GROWTH CURVES OF SHEEP

H. D. FOX, E. A. TROWBRIDGE, A. G. HOGAN

The data presented in the following charts were secured chiefly from the records of the department of animal husbandry of this Station. The ewes represent two breeds, Hampshire and Shropshire, and as they were to go into the breeding flock they were kept in a thrifty condition, but were never fattened. They were bred near the close of the period shown on the charts, about a month or six weeks before the last weights were recorded. Our growth curves, therefore, are not affected by pregnancy. Sheep will begin to breed when 7 to 8 months old.

The rams, including Shropshires and Hampshires, were maintained in the condition suitable for breeding males, that is, not excessively fat.

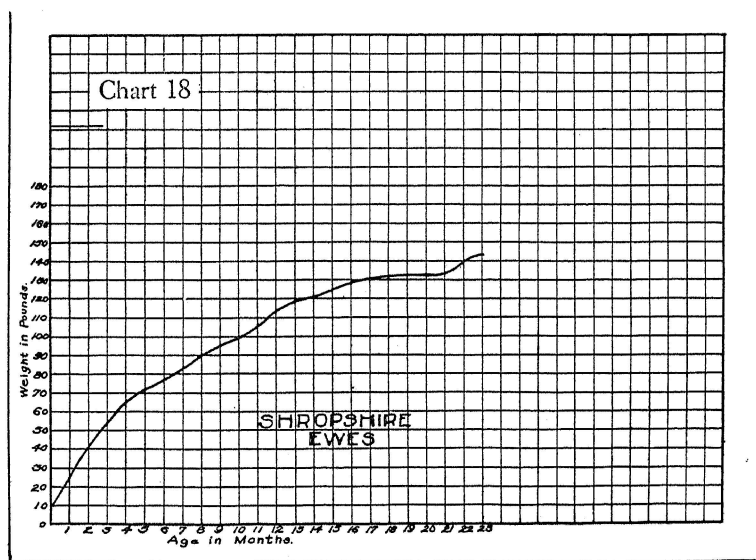
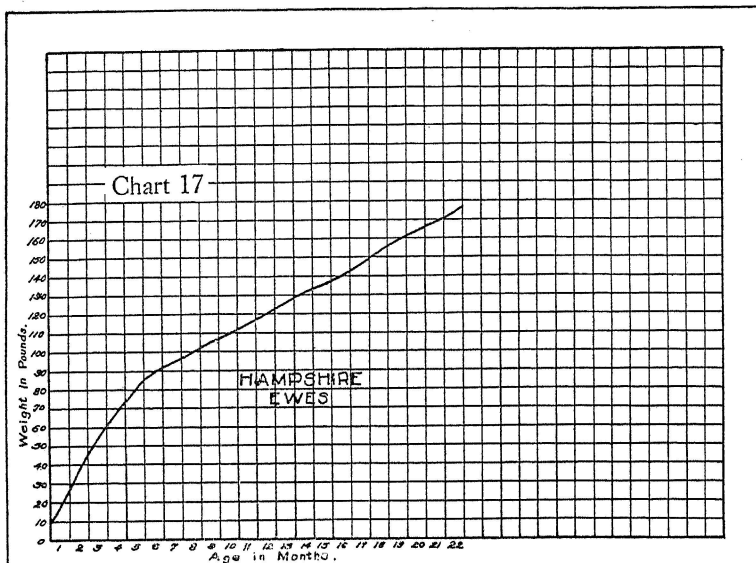
The wethers, of the Southdown breed, were fitted for exhibition and presumably were fed more heavily than the ewes or rams. They were castrated before they were a month old.

All the available data we have are included, and comprise the records of 14 Shropshire ewes, 10 Hampshire ewes, 8 Shropshire rams, 6 Hampshire rams, and 14 Southdown wethers.

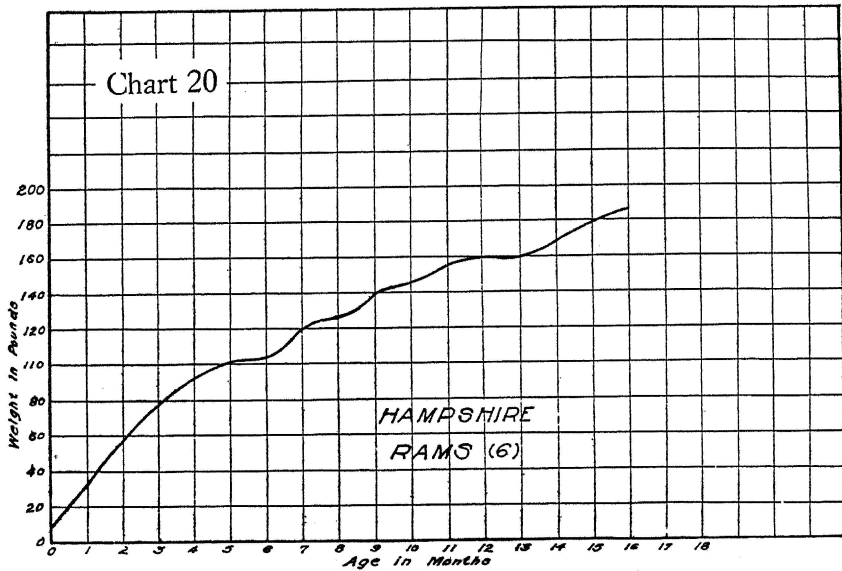
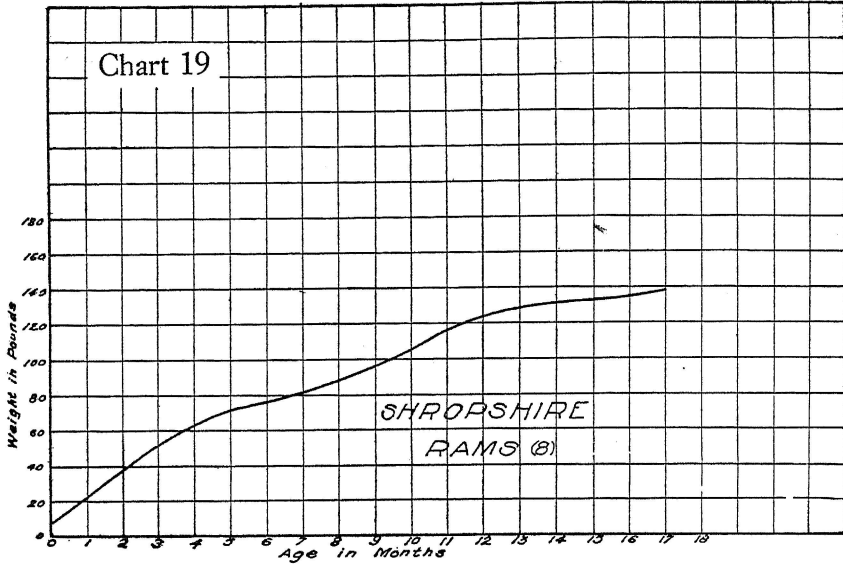
Our charts are presented in two forms, one showing the weights at various ages, the other showing the gains in weight made in monthly (28-day) periods. We will make no extended comment, beyond indicating that apparently these animals have grown in two cycles. The maximum of the first is not far from the date of birth, and the maximum of the second comes at about the 17th month with the Hampshire ewes, and at about the 12th month with the other breeds. The curves of the Hampshire rams are very irregular, and it is especially regrettable in this case that we do not have records of more individuals.

A recent publication⁷ contains the weights of sheep at various ages, and we have incorporated these observations with our own. The data were sufficient for our purpose in only two cases, that of Suffolk ewes, and ewes of a Shropshire-Merino cross, and unfortunately the birth weights of the latter are not available. The data are presented graphically in Charts 27, 28, 29, and 30.

⁷The Journal of Agricultural Science, Vol. 11, p. 258 (1921) Normal Growth in Animals. J. Alan Murray.



Charts 17 and 18.—Weight-age curves of Hampshire ewes (17), and Shropshire ewes (18).



Charts 19 and 20.—Weight-age curves of Shropshire rams (19), and Hampshire rams (20).

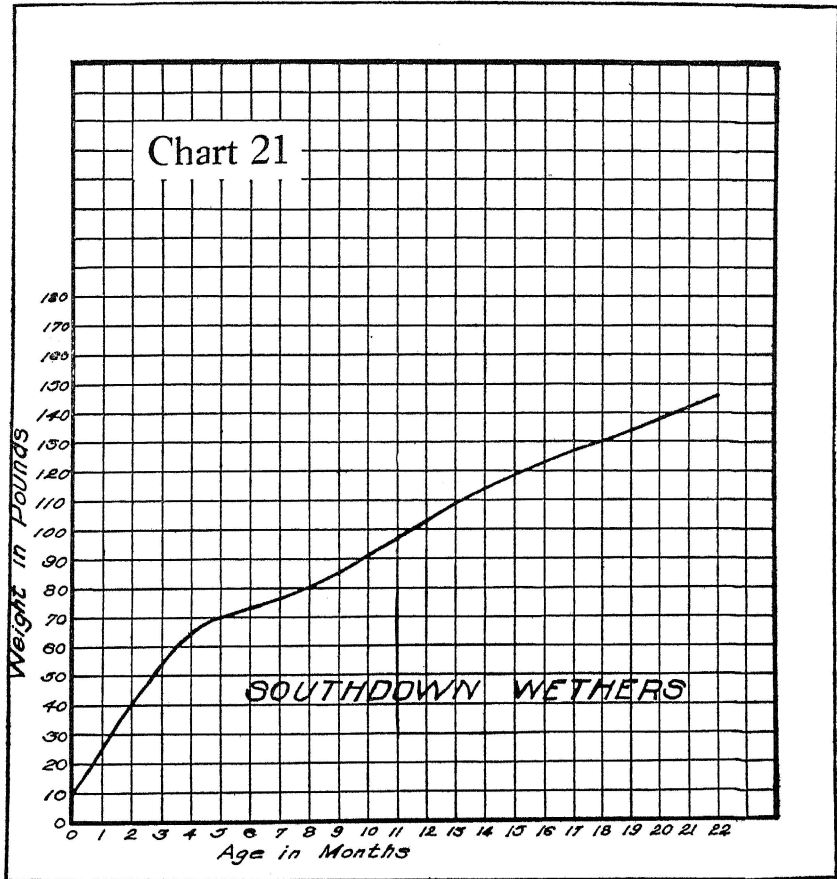
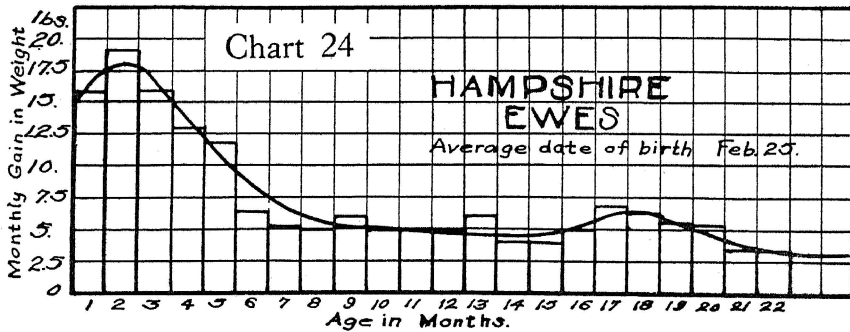
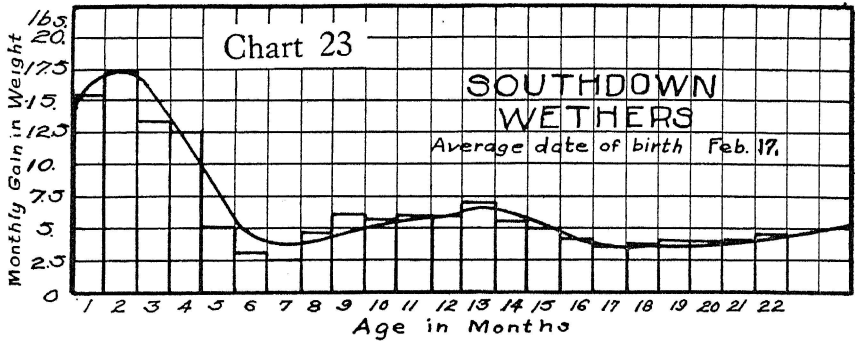
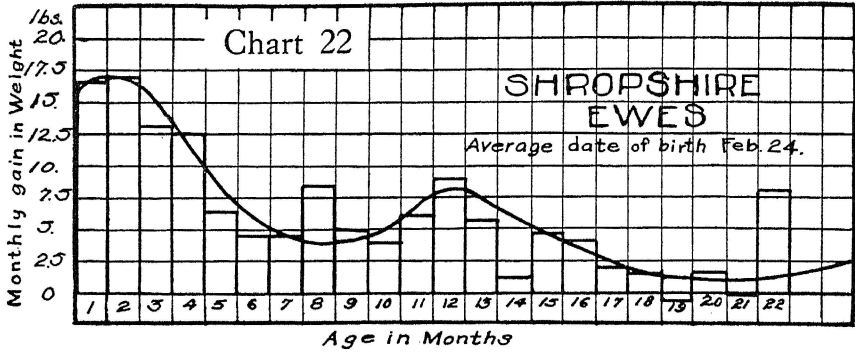
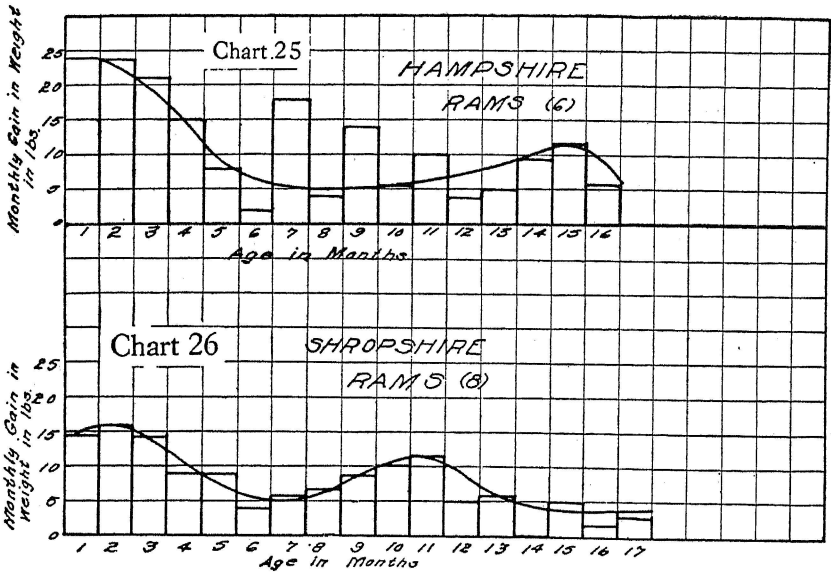


Chart 21.—Weight-age curve of Southdown wethers.



Charts 22, 23 and 24.—Weight-age curves of Shropshire ewes (22), Southdown wethers (23), and Hampshire ewes (24)



Charts 25 and 26.—Monthly gain in weight by Hampshire rams (25), and Shropshire rams (26).

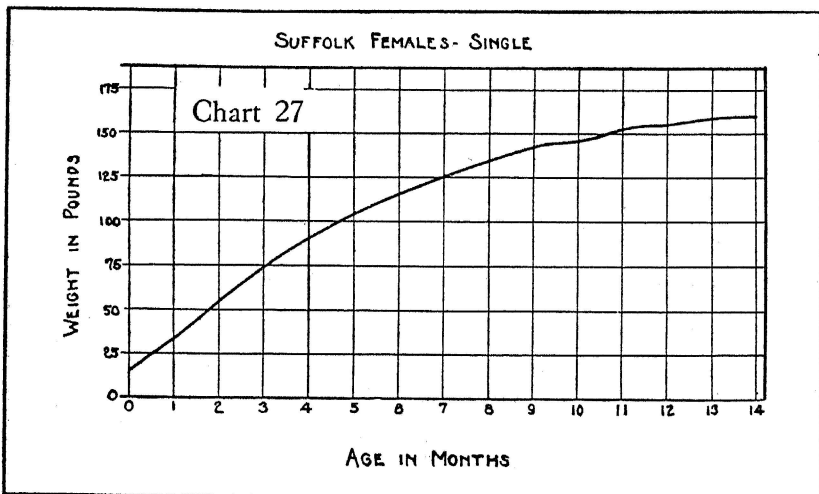


Chart 27.—Weight-age curve of Suffolk females.

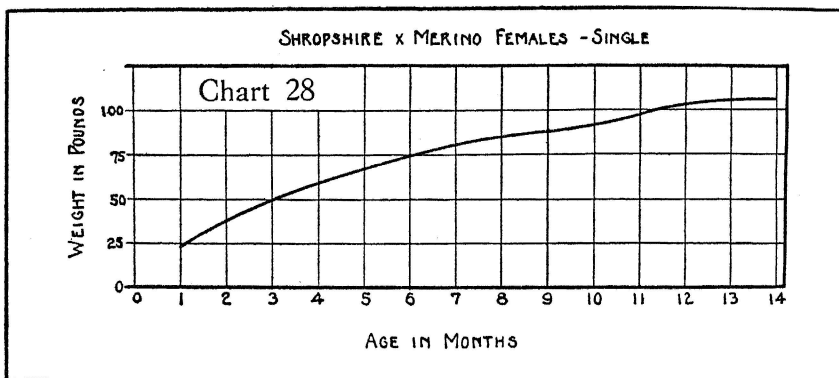
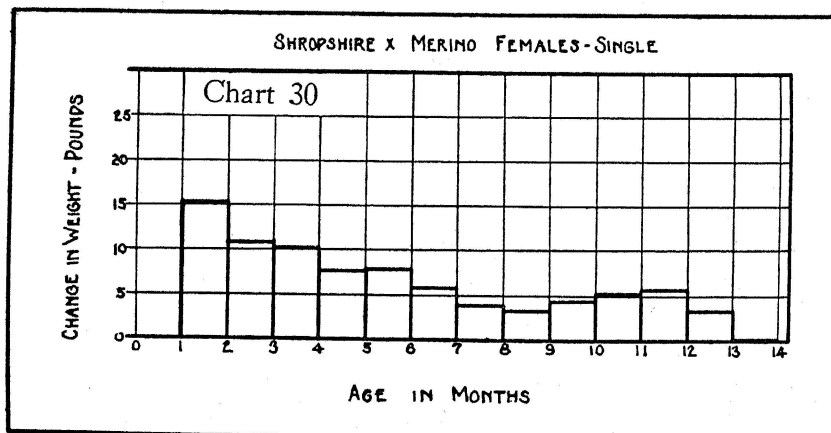
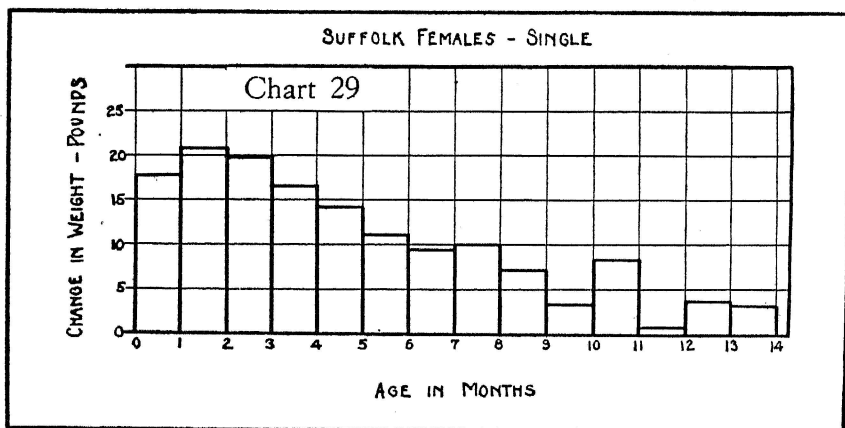


Chart 28.—Weight-age curve of Shropshire-Merino females.



Charts 29 and 30.—Change in weight of Suffolk females (29), and Shropshire-Merino females (30).

TABLE 7.—AVERAGE WEIGHTS OF SHEEP FROM WHICH CURVES WERE DRAWN.
(Average Weights in Pounds)

Age in months (28 days)	Shrop- shire ewes	Hamp- shire ewes	Shrop- shire rams	Hamp- shire rams	South- down wethers	Suffolk ewes	Shrop- shire Merino ewes
Birth	8.3	10.3	8.4	9.0	7.6	16.0	-----
1	24.7	25.9	23	33	22.7	33.8	22.6
2	41.5	44.8	39	57	39.7	54.5	38.0
3	54.3	60.7	53	78	52.8	74.2	49.9
4	66.8	73.6	62	93	65.2	90.7	60.1
5	73.0	85.2	71	101	70.3	104.9	67.4
6	77.3	91.3	75	103	73.0	115.9	75.3
7	81.6	96.3	81	121	75.4	125.3	81.0
8	90.0	102.0	88	125	79.0	135.4	84.9
9	95.0	107.9	97	139	84.8	142.2	88.2
10	98.8	112.7	105	144	90.4	145.5	92.5
11	104.7	117.4	117	154	96.2	153.7	97.6
12	113.4	123.3	122	158	102.0	154.3	103.2
13	119.0	129.1	128	158	108.8	157.9	106.6
14	120.0	133.0	128	168	114.3	161.0	106.6
15	124.5	136.9	133	179	119.0	----	----
16	128.6	142.1	135	185	123.0	----	----
17	130.5	148.9	138	183	126.5	----	----
18	131.8	155.3	----	199	130.2	----	----
19	131.0	160.8	----	----	134.0	----	----
20	132.4	166.0	----	----	138.0	----	----
21	132.0	169.6	----	----	142.0	----	----
22	140.0	173.2	----	----	----	----	----

GROWTH CURVES OF SWINE

F. B. MUMFORD, A. G. HOGAN, PAUL M. BERNARD

The data from which Chart 31 was drawn were taken from the records of the Adams Breeding Experiment, in charge of Dean F. B. Mumford. The dams of these pigs were experimental animals used in an investigation to determine the effects of early breeding. Some had been bred at the first appearance of heat, in some cases at 5 months of age. Our records indicate that the rate of growth of pigs from immature sows is not materially different from that of pigs farrowed by mature mothers.

Individual weights of the pigs were not taken until after weaning, when the pigs were about 8 weeks old. Before that time the litters were weighed together, and the sexes were not separated. The males were castrated very near the time they were weaned. The data up to eight weeks represent 15 litters, about 100 pigs.

Beginning with the ninth week there was some uncertainty as to the number of pigs to be included in obtaining average weights. Our original intention was to include all pigs whose weights were recorded. They were sold, however, when they reached a weight

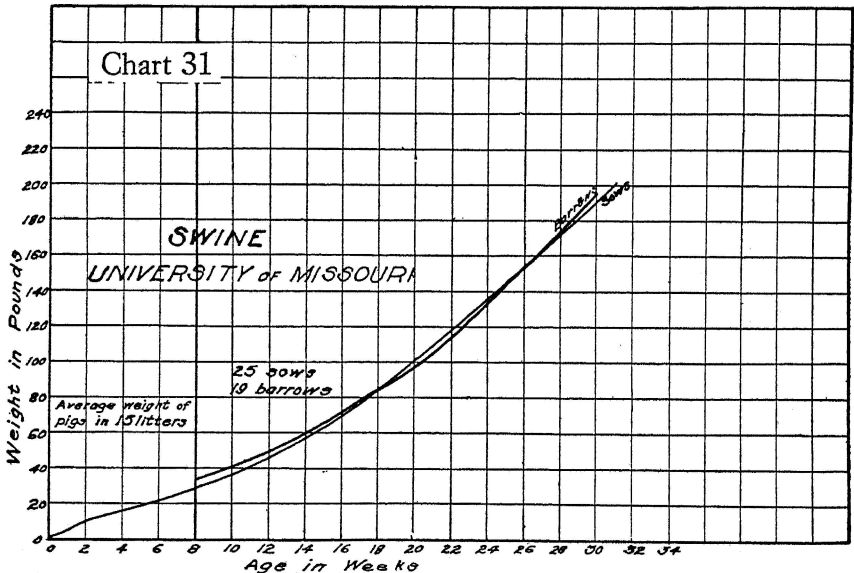
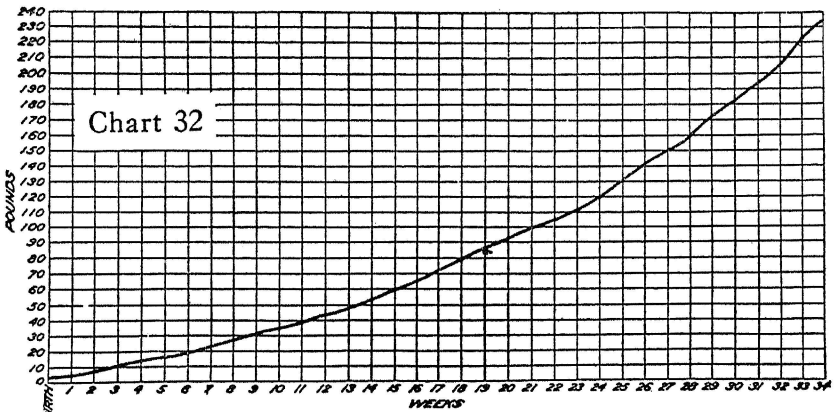


Chart 31.—Rate of growth of sows and barrows up to thirty weeks.

of approximately 250 pounds. Some of the animals attained that weight very much earlier than others, and the necessity of dropping out a large number of the heavy animals toward the latter part of the growing period made the curve very uneven. In some cases this decrease in numbers resulted in an apparent loss of weight, or a stationary weight for two or three weeks. It would clearly give a wrong impression under the circumstances to use all the animals, so the expedient was adopted of discarding, from the ninth week on, those growing most rapidly and those growing most slowly. Each extreme contained about 25 per cent of all the pigs, so our curves represent less than one-half of all the pigs whose weights were recorded.

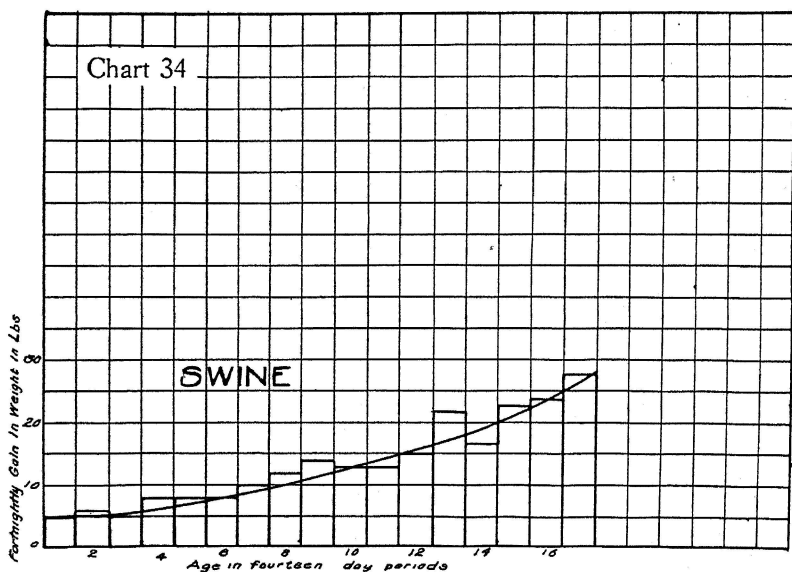
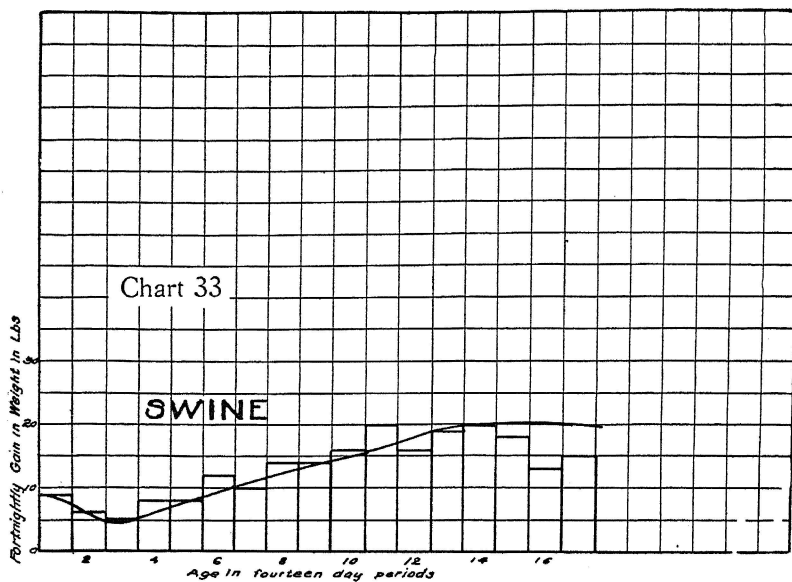


—Average weekly weights of 121 hogs at Bureau of Animal Industry Experimental Farm, Beltsville, Md.

After the pigs had been selected in the manner indicated, there remained 25 sows and 19 barrows. On the age-weight curve the sexes are plotted separately, and it will be seen that one curve can not be exactly superimposed on the other. They are essentially alike, however, and they are all plotted together in the Chart 33, showing the fortnightly gain in weight.

We do not have similar records of the weights of boars.

Chart 32, published in Farmers' Bulletin No. 874, U. S. Department of Agriculture, is included for comparison. We have estimated the average fortnightly gain in weight of these hogs, and present the calculations in Chart 34.



Charts 33 and 34.—The fortnightly gain in weight made by 43 hogs in the Missouri experiment (33), and by the 121 hogs in the Bureau of Animal Industry experiment (34).

TABLE 8.—AVERAGE WEIGHTS OF SWINE FROM WHICH CURVES WERE DRAWN.

Age in weeks	Before weaning	Average Weight in pounds	
		Sows (25)	Barrows (19)
Birth	1.8	----	----
1	8.5	----	----
2	10.5	----	----
3	14.5	----	----
4	16.8	----	----
5	20.8	----	----
6	22.0	----	----
7	27.0	----	----
8	30.0	28.8	34.0
9	----	32.6	37.4
10	---	35.8	42.0
11	---	41.2	45.2
12	---	46.2	51.0
13	---	52.6	56.1
14	---	57.9	60.7
15	---	63.8	66.5
16	---	71.2	72.6
17	---	76	79
18	---	86	84
19	---	94	91
20	---	102	99
21	---	110	107
22	---	119	115
23	---	125	124
24	---	136	134
25	---	145	144
26	---	154	154
27	---	163	164
28	---	171	174
29	---	182	186
30	---	190	195

RATE OF GROWTH OF THE DOMESTIC FOWL

H. L. KEMPSTER, E. W. HENDERSON

The rate at which a fowl grows is quite largely dependent upon environmental factors, such as temperature, sanitation, and suitable rations. If the weather is too cold, growth will be retarded, and if too warm food consumption will be less, with correspondingly slower growth. Sanitary houses and yards are of equal importance. The kind of ration and the method of feeding are also factors upon which growth is largely dependent. To secure optimum growth due attention must be paid to all these factors.

GROWTH OF EMBRYO

In the data from Lamson and Edmond⁸ and Hasselbalch⁹ the embryo increases gradually in weight with slight fluctuation. When the actual increase in weight is measured there appears to be a reduction in rate of growth on the 11th to 14th day with a second similar performance on the 17th day. As the embryo reaches maturity there occurs maximum rate of growth.

The increase in weight the last five days is 2.34 times the increase for the third five-day period, 15 times the second five-day day period, and 17 times the gain made during the first five days.

GROWTH OF WHITE ROCKS

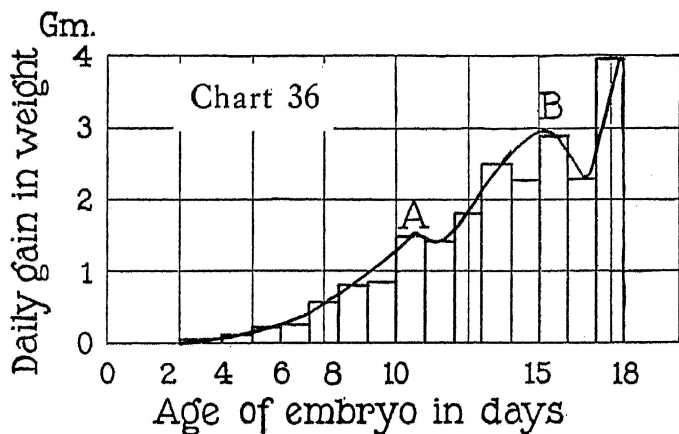
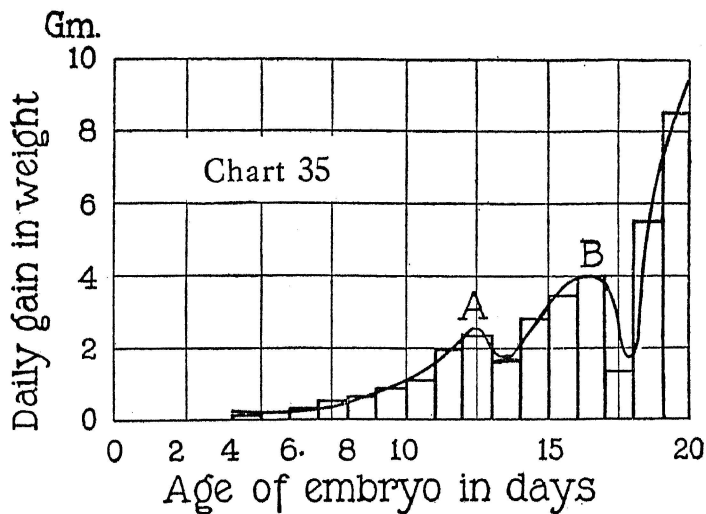
Studies on "Cost of Raising White Rocks", Purdue Agricultural Experiment Station Bulletin 214 by Professor A. G. Philips, with 450 chicks and covering two years' work, furnish data on growth of White Rocks.

From hatching to age of 24 weeks White Rock pullets weighed 5 pounds as compared with 6.43 for cockerels, and 6.33 for capons. Contrary to general belief there was no difference in the weight of capons and cockerels at the age of 24 weeks.

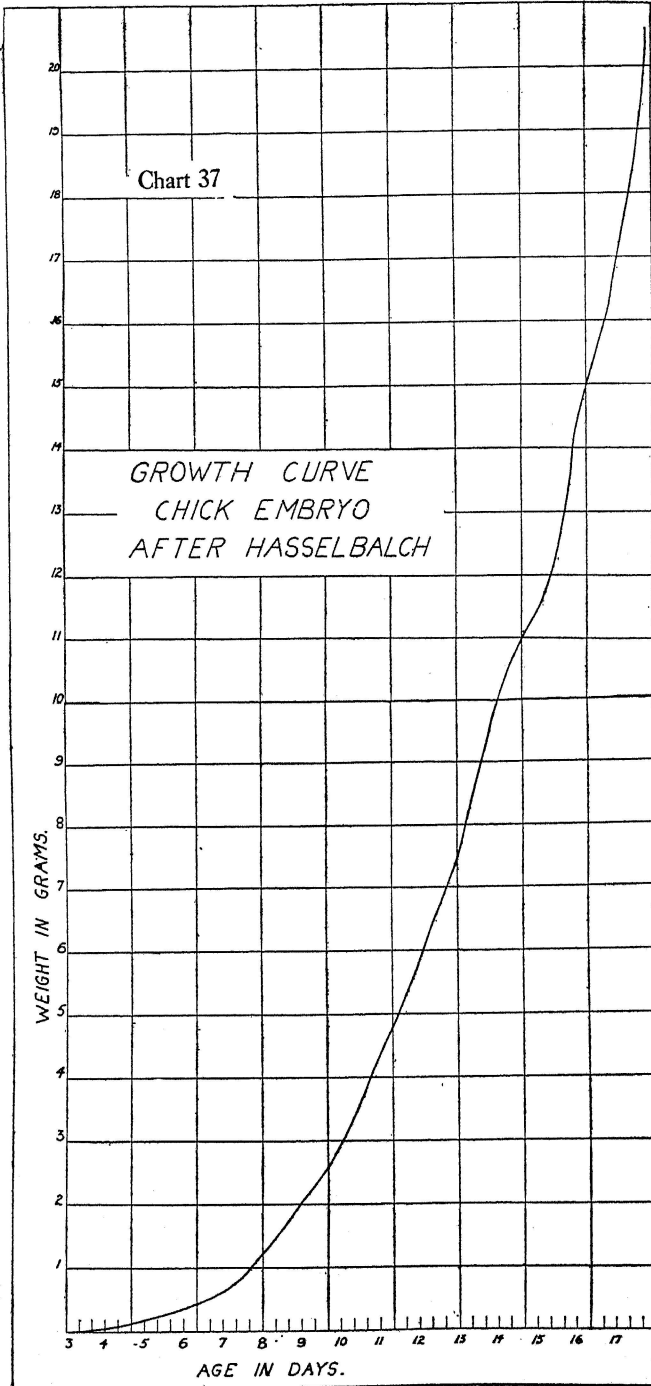
When the rate of growth is considered the pullets made the best gains from the 10th to 14th week, followed by a period of slow growth for a six-week period which in turn was followed by another period of high gains for four weeks, after which the in-

⁸Lamson, G. H., and Edmond, H. D., Storrs, Agr. Exp. Sta. Bul. 76, 1914.

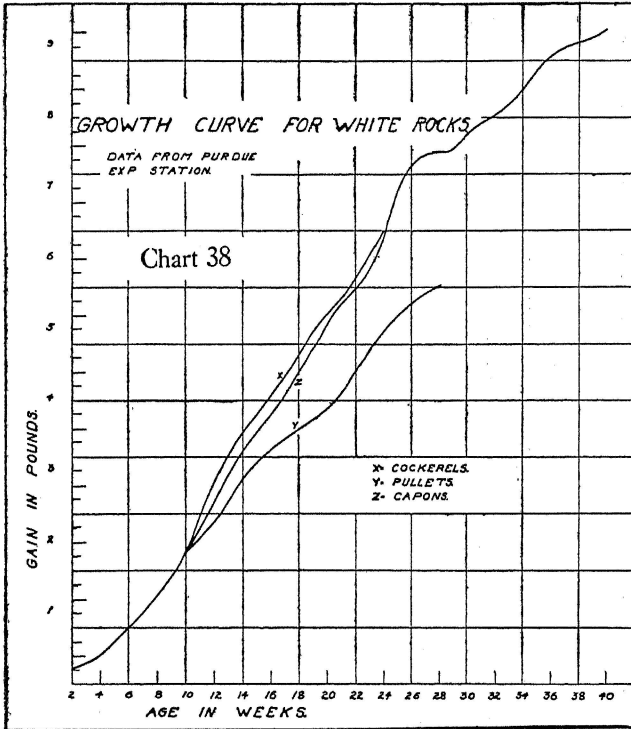
⁹Hasselbalch, K. A., Skand. Arch. Physiol., 1900, x, 364. Also Brody, S., J. Gen. Physiol. 1921, 111, 765.



Charts 35 and 36.—The rate of growth of the chick within the egg. (35) Plotted from data by Lamson and Edmond. (36) Plotted from data by Hasselbalch. (After Brody).



crease in weight decreased as pullets were reaching maturity. The cockerels made their best gains the 12th week, after which there was little fluctuation. The capons grew more rapidly each week until the 14th week, after which the rate of growth fluctuated from week to week. After the age of 28 weeks the growth was much less rapid, a gain of 1.76 pounds being made during the last 12 weeks.



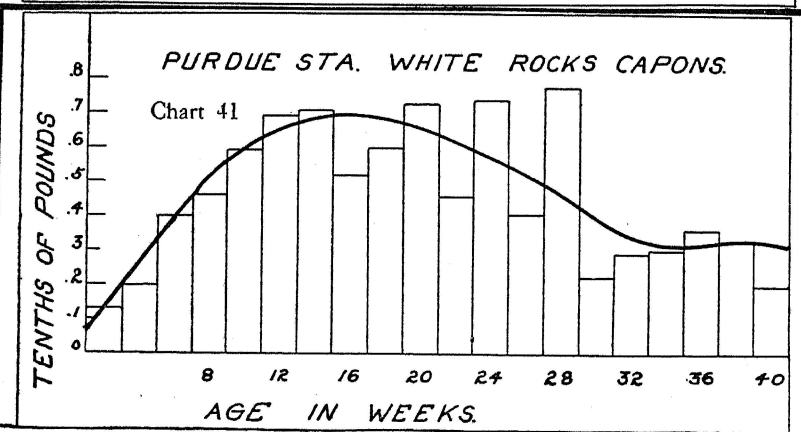
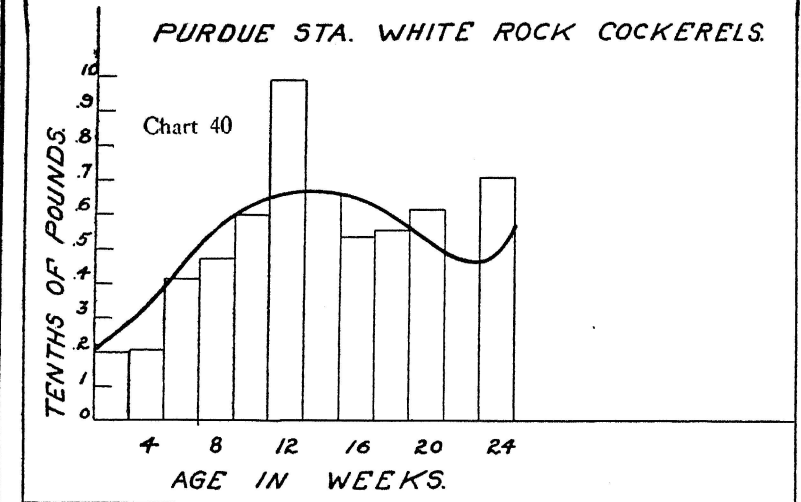
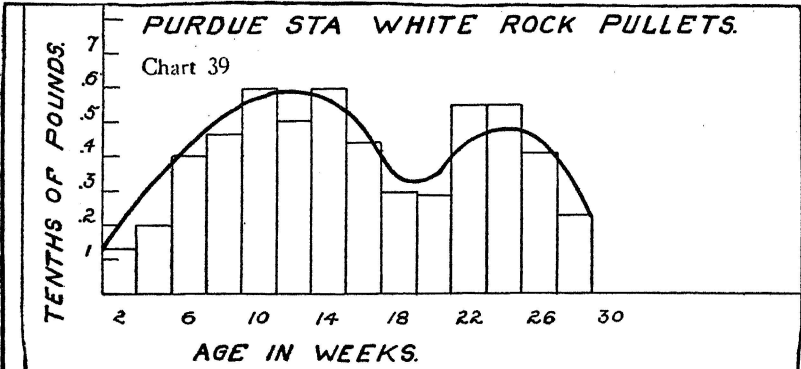


TABLE 9.—RATE OF GROWTH OF WHITE ROCKS.

Age in weeks	Pullets*	Weight in pounds Cockerels	Capons
0	.084	----	----
2	.2135	----	----
4	.4115	----	----
6	.8165	----	----
8	1.28	----	----
10	1.875	----	----
12	2.28	2.86	2.57
14	2.88	3.52	3.28
16	3.22	4.05	3.8
18	3.61	4.66	4.4
20	3.9	5.27	5.13
22	4.45	5.725	5.59
24	5.	6.43	6.33
26	5.41	----	6.74
28	5.64	----	7.52
30	----	----	7.75
32	----	----	8.05
34	----	----	8.36
36	----	----	8.73
38	----	----	9.07
40	----	----	9.28

Compiled from Bulletin 214, Purdue Agricultural Experiment Station. Prof. A. G. Philips.

*Average weight both sexes up to 10th week.

GROWTH OF WHITE LEGHORNS

The data from two experiment stations indicate that rate of growth is influenced by strain and climatic conditions. According to Storrs Agricultural Experiment Station Bulletin 96 by L. E. Card and W. F. Kirkpatrick, including data on several hundred chicks, the pullets weighed 3.28 lbs. at age of 24 weeks, while those from the Kentucky Agricultural Experiment Station, reported in the American Journal of Physiology, Vol. XLVII, No. 3, Page 393, by G. Davis Buckner, R. H. Wilkins, and Joseph H. Castle, weighed 2.65 at the same age. The pullets at the Storrs Station increased in rate of growth up to the eighth week, followed

by slight decrease. The rate of growth was fairly constant until the 20th week, after which it was much less.

With White Leghorn pullets at Kentucky there appeared also a slow period of growth at the 15th week. The cockerels at age of 28 weeks weighed 3.6 pounds as compared with 2.85 for the pullets.

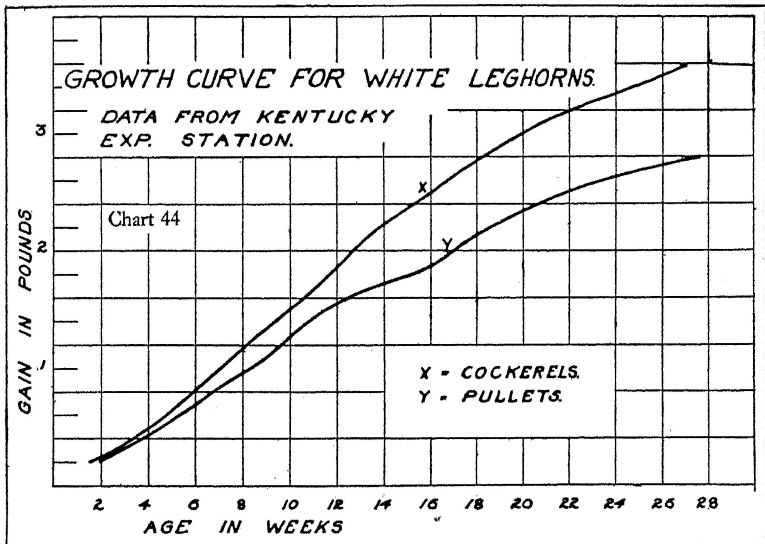
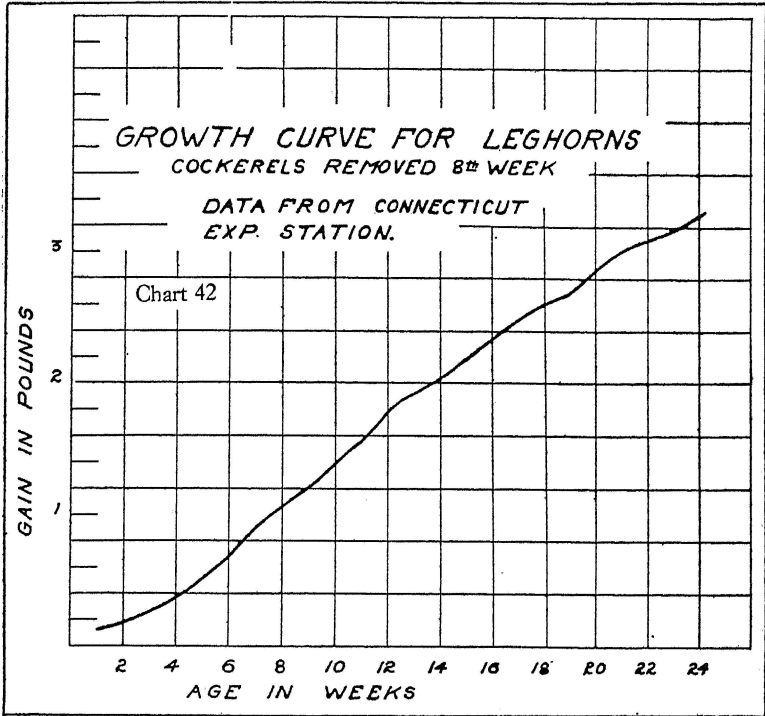
The Kentucky data are based on observation from 100 chicks.

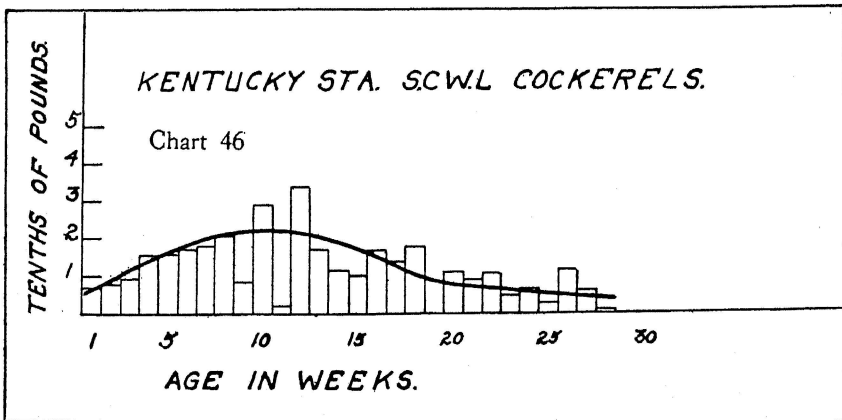
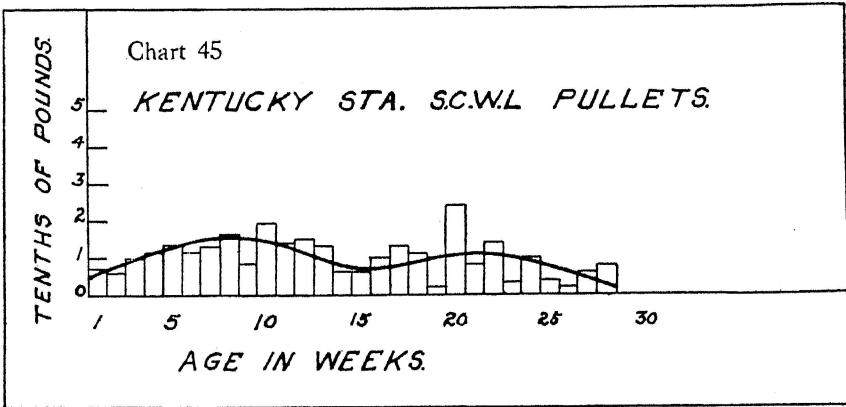
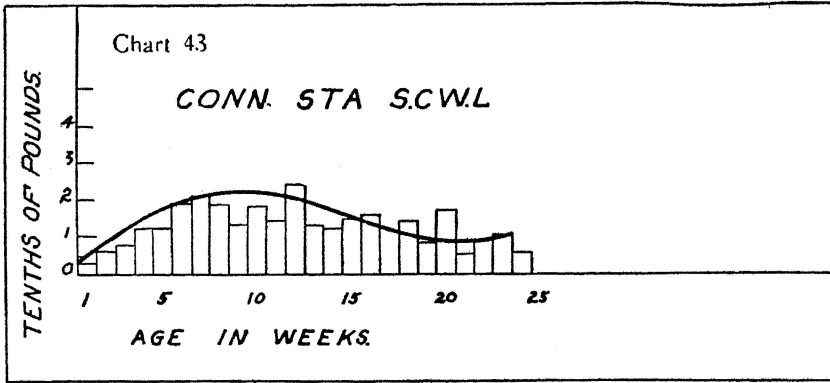
TABLE 10.—RATE OF GROWTH OF WHITE LEGHORNS.

Age in weeks	Pullets*	Weight in pounds	
		Pullets†	Cockerels†
0	0.081	0.091	0.093
1	0.116	0.16	0.164
2	0.18	0.218	0.242
3	0.262	0.317	0.339
4	0.381	0.433	0.49
5	0.506	0.568	0.64
6	0.695	0.685	0.816
7	0.902	0.82	0.988
8	1.09	0.984	1.2
9	1.225	1.06	1.28
10	1.41	1.26	1.57
11	1.56	1.4	1.59
12	1.8	1.55	1.93
13	1.935	1.68	2.1
14	2.06	1.74	2.22
15	2.20	1.8	2.32
16	2.36	1.9	2.49
17	2.49	2.03	2.63
18	2.63	2.14	2.81
19	2.72	2.16	2.9
20	2.9	2.3	3.01
21	3.05	2.38	3.10
22	3.12	2.52	3.21
23	3.227	2.55	3.26
24	3.284	2.65	3.38
25	----	2.69	3.41
26	----	2.71	3.53
27	----	2.77	3.59
28	----	2.85	3.6

*Compiled from Storrs Agr. Exp. Station Bul. 96. Cockerels removed at end of eighth week. L. E. Card and W. F. Kirkpatrick.

†Compiled from data from Kentucky Agricultural Experiment Station, American Journal of Physiology, Vol. XLVII, No. 3, December, 1918., page 393, by G. Davis Buckner, R. H. Wilkins, and Joseph H. Castle.





Charts, 43, 45 and 46.—Weight-age curves for Single Comb White Leghorns (Connecticut and Kentucky data).

GROWTH OF RHODE ISLAND REDS

Bulletin 96, Storrs Agricultural Experiment Station by L. E. Card and W. F. Kirkpatrick also includes data for several hundred Rhode Island Reds.

The Rhode Island Red pullets at the Connecticut Station averaged 4.29, while those from North Carolina Agricultural Experiment Station, by B. F. Kaupp, and reported in Poultry Science Vol I, No. 2, page 39, weighed 4.45 at the same age, 24 weeks. The pullets at Connecticut showed maximum rate of growth at age of 9 weeks, followed by a period of slower gains, which in turn were followed by a period of higher rate of growth.

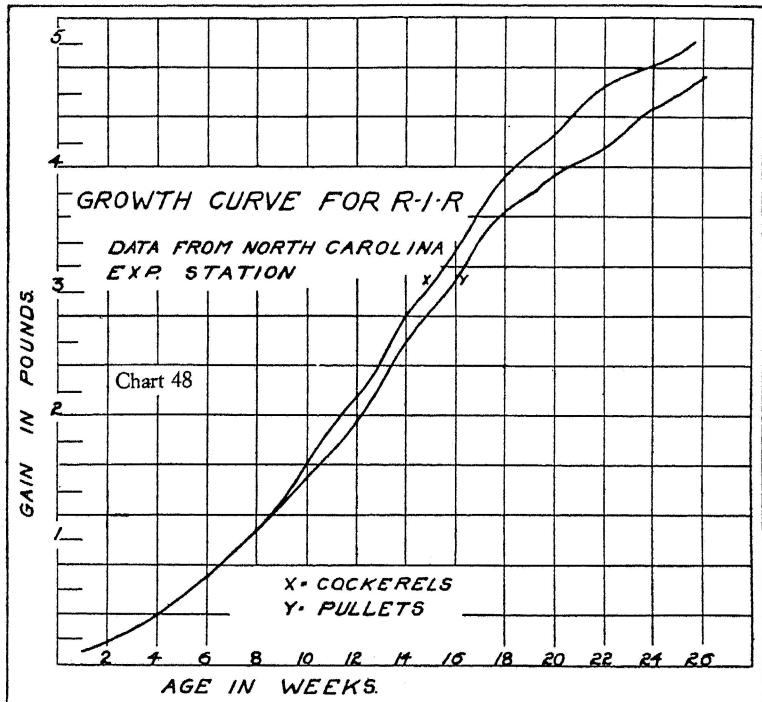
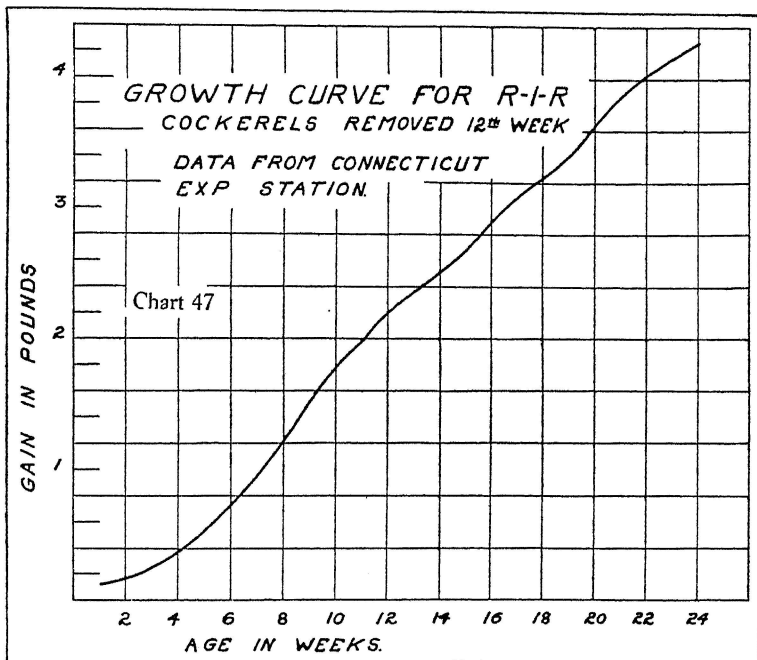
The North Carolina data failed to show any cycles of high and low rate of growth which characterized the data for White Rock, White Leghorn, and the Rhode Island Red pullets referred to above. The North Carolina data show a very slight difference in the weight of cockerels and pullets.

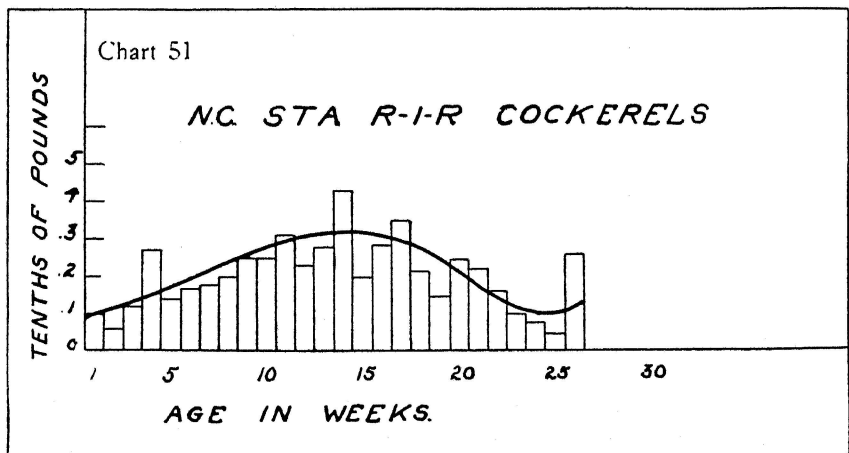
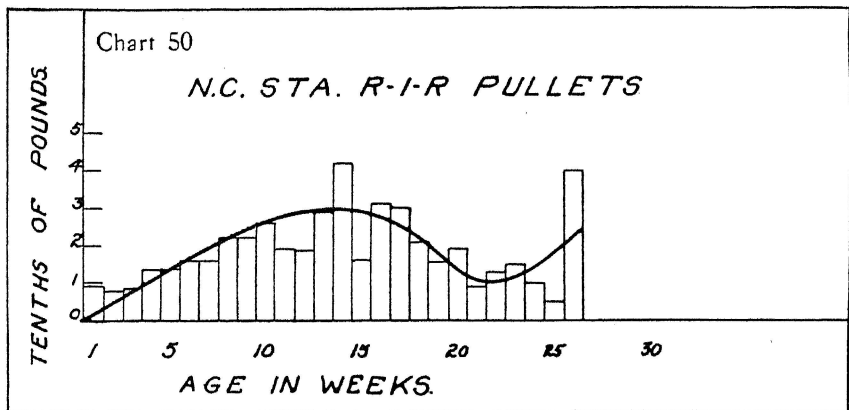
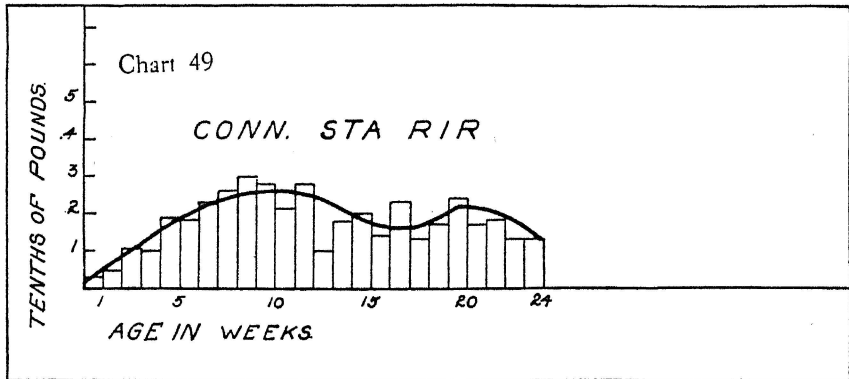
TABLE 11.—RATE OF GROWTH—RHODE ISLAND REDS.

Age in weeks	Pullets*	Weight in pounds	
		Pullets†	Cockerelst
0	0.082	----	----
1	0.115	0.09	0.10
2	0.162	0.17	0.16
3	0.264	0.26	0.28
4	0.364	0.4	0.41
5	0.538	0.54	0.55
6	0.737	0.7	0.72
7	0.968	0.86	0.9
8	1.228	1.08	1.1
9	1.525	1.3	1.35
10	1.805	1.56	1.6
11	2.014	1.75	1.91
12	2.29	1.94	2.14
13	2.39	2.23	2.42
14	2.56	2.65	2.85
15	2.76	2.81	3.05
16	2.9	3.12	3.33
17	3.136	3.42	3.68
18	3.26	3.63	3.89
19	3.436	3.79	4.04
20	3.68	3.98	4.28
21	3.85	4.07	4.5
22	4.	4.2	4.66
23	4.16	4.35	4.76
24	4.29	4.45	4.84
25	----	4.5	4.89
26	----	4.9	5.15

*Compiled from Storrs Agr. Exp. Station Bul. 96. Cockerels removed about twelfth week. L. E. Card and W. F. Kirkpatrick.

†Compiled from North Carolina Agr. Exp. Station, Poultry Science Vol. I, No. 2, page 39, B. F. Kaupp.





Charts 49, 50 and 51.—Weight-age curves of Rhode Island Reds (Connecticut and North Carolina data).

THE EQUIVALENCE OF AGE IN SOME
DOMESTIC ANIMALS

SAMUEL BRODY, ARTHUR C. RAGSDALE

Every animal goes through three stages of growth which may be termed first, second and third; or infantile, juvenile, and adolescent stages. The middle of each of these stages, and the junctions between these stages can be determined with considerable exactitude by plotting growth in terms of gain of weight per unit time at different ages against the corresponding ages. Such plots are shown in Charts 52 to 55. The highest point, the maximum, of each stage of growth is the center of that stage of growth. The ages at which the maxima of these stages occur was determined from these charts and tabulated in Table 12.

It can be shown¹⁰ that the age of maximum of a given stage in one animal is physiologically equivalent to the age of maximum of the corresponding stage of any other animal. This gives a method for determining the physiological equivalence of age in different animals. All that is necessary to determine the equivalence of age at any age after the last growth period, is to multiply the conceptional age of the maximum of the third or adolescent stage of growth by some appropriate number. Thus, multiplying the *conceptional* age of the third maximum by 13, gives for the mouse the value of 2.1 years, rat 3 years, rabbit 6.6 years, guinea pig 5.2 years, sheep 17 years, dairy cow 30 years, fowl 6 years. These values are very near the normal durations of life of these animals under the most favorable conditions of life. Any other equivalent age may be obtained by the same method. Some such equivalent ages are shown in Table 13.

The conceptional rather than the birth age is multiplied by the constant, because birth occurs at different stages in different animals. The mouse and rat are born blind and hairless, before the infantile period is over. The guinea pig, ox, sheep, and pig, on the other hand, pass the infantile period *in utero*, and by the time they are born, they have already begun on their second or juvenile stage of growth. This is clearly brought out in the charts already referred to. A calf at the age of birth is physiologically as old as a two- to three-weeks' old mouse or rat; or as old as a 1½- to 2-year old child.

¹⁰Cf. Brody, S., and Ragsdale, A. C. *Journal General Physiology*, Vol. 5, No. 2, 1922, p. 205.

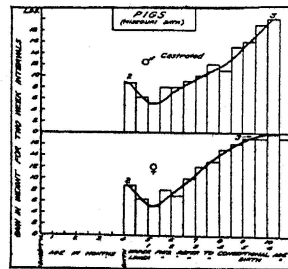
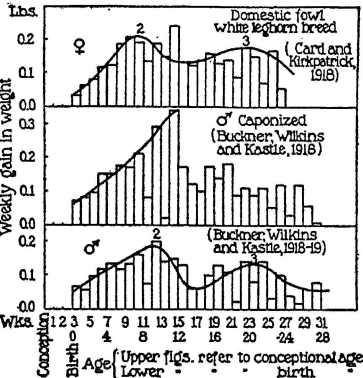
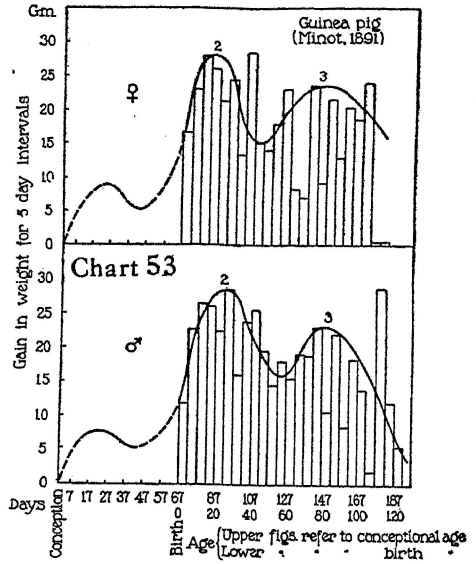
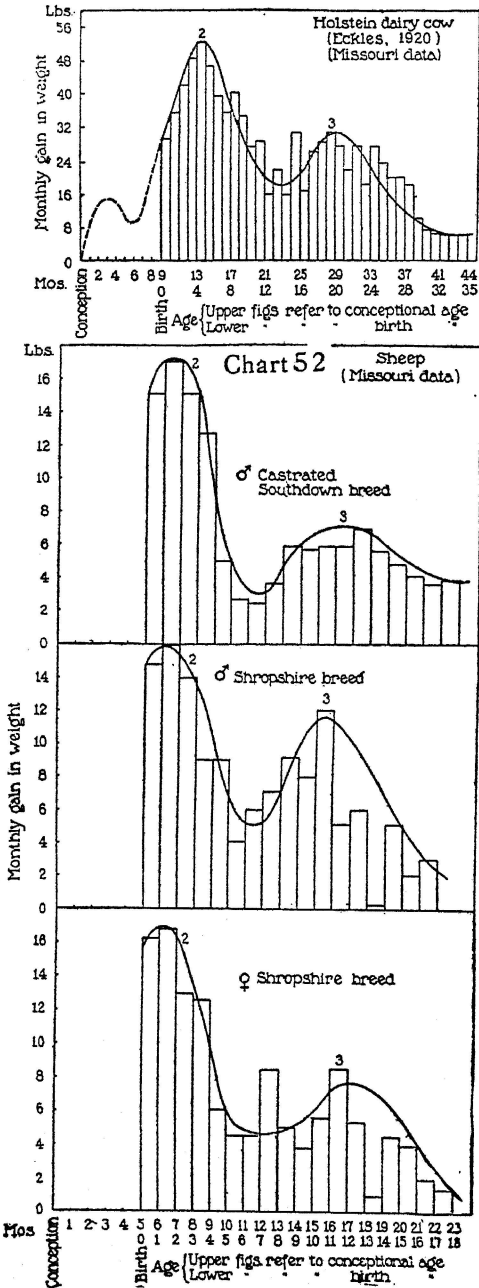
TABLE 12.—EQUIVALENCE OF AGE—AGE OF ANIMALS AT THE MAXIMA OF THE THREE CYCLES AND THE JUNCTIONS BETWEEN THE CYCLES.

	Age of max. of first cycle		Age of junction between first and second cycles.		Age of max. of second cycle.		Age of junction between first and second cycles.		Age of max. of third cycle.		Conceptional age at birth. days
	Concep. age. days	Birth age.	Concep. age. days	Birth age.	Concep. age. days	Birth age.	Concep. age. days	Birth age.	Concep. age. days	Birth age.	
Fowl	16	5 days before hatching	18	3 days before hatching	84	9 wks.	100	11 wks.	156	20 wks.	21
Guinea pig	23 (est.)	44 days before birth	32 (est.)	35 days before birth	85	2.5 wks.	115	7 wks.	145	11 wks.	67
Mouse	27	1.0 wks.	33	2 wks.	42	3 wks.	53	5 wks.	62	6 wks.	20
Ox. (dairy cow)	160 (est.)	4 months before birth	190	3 months before birth	420	4.5 mos.	690	13.5 mos.	850	19 mos.	285
Pig							158	5 wks.			120
Rabbit	40	10 days	65	5 wks.	110	11 wks.	160	18 wks.	185	5 mos.	30
Rat	31	9 days	38	16 days	47	3.5 wks.	56	5 wks.	86	9 wks.	22
Sheep					195	6.5 wks.	360	7 mos.	480	11 mos.	150
Man	345	2 mos.							5300	13.7 yrs.	285

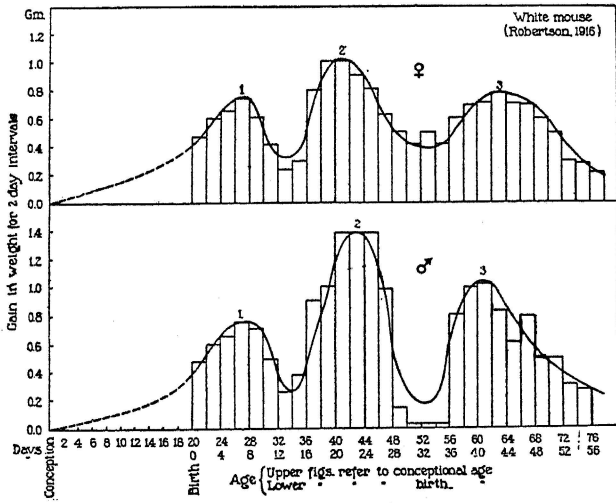
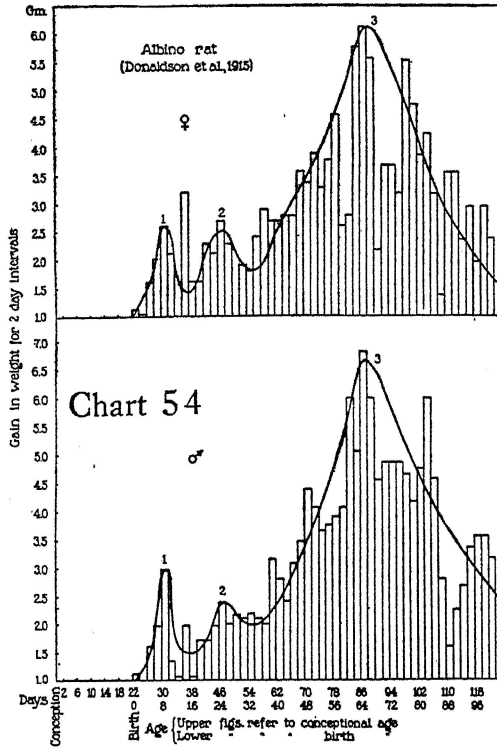
TABLE 13.—EQUIVALENCE OF AGE AFTER THE AGE OF THE THIRD CYCLE.

(Values obtained by multiplying the conceptional age of the maximum of the third cycle by a constant indicated at the head of each column.)

	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13
Domestic fowl (years)	0.8	1.2	1.7	2.1	2.5	2.9	3.4	3.8	4.2	4.6	5.1	5.5
Guinea pig (years)	0.7	1.0	1.4	1.8	2.2	2.6	3.0	3.4	3.8	4.2	4.6	5.0
Mouse (months)	3.8	5.5	7.6	9.7	11.7	13.8	15.8	17.9	20.0	22.3	24.1	26.2
Ox (dairy cow) (years)	3.9	6.2	8.3	10.9	13.2	15.5	17.8	20.2	22.5	24.8	27.2	29.5
Rabbit (years)	0.9	1.4	1.9	2.5	3.0	3.5	4.0	4.4	5.0	5.5	6.0	6.5
Rat (months)	5.0	7.9	10.7	13.6	16.8	19.3	22.2	25.1	27.9	30.8	33.6	36.5
Sheep (years)	2.2	3.5	4.8	6.2	7.4	8.8	10.1	11.4	12.7	14.1	15.4	16.7



Charts 52 and 53.—Growth Curves in Terms of Gain and Weight per Unit Time at Different Ages against Age. The height of rectangles represent gains in weight for the ages shown on the abscissae. See also Chart 54.



SOURCES OF DATA

Rat.—Donaldson, H. H., *The Rat*, Memoirs of the Wistar Institute of Anatomy and Biology, No. 6, 1915.

Mouse.—Robertson, T. B. Jr., *Biol. Chem.* 1916, xxiv, 369.

Guinea Pig.—Minot, C. S. Jr., *Physiol.*, 1891, xii, 97.

Rabbit.—Minot, C. S. *The Problem of Age, Growth, and Death*, New York and London, 1908, pp. 254.

Dairy Cow.—Eckles, C. H., *University of Missouri Agr. Exp. Station Research Bul.* 36, 1920.

Fowl.—Card, L. E. and Kirkpatrick, W. F. *Storrs Agr. Exp. Station Bul.* 96, 1918; Buckner, G. D., Wilkins, R. H., and Castle, J. M., *Am. Jr., Physiol.*, 1918-19, xlvii, 393.

Sheep and Pigs.—Data presented by Dr. Hogan in another section of this bulletin.