THE RATE OF GROWTH OF THE DAIRY COW.

II. Growth in Weight after the Age of Two Years.

By SAMUEL BRODY, ARTHUR C. RAGSDALE, and CHARLES W. TURNER.

(*From the Department of Dairy Husbandry, University of Missouri, Columbia.*)

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The characteristic feature of the curve for the gain in weight of the dairy cow during the first 2 years of extrauterine life is its cyclic nature, as shown in detail in the first communication of this series.[1] The purpose of this communication is to present data showing that after the age of 2 years the course of growth of the dairy cow is non-cyclic, orderly, and follows the course of a monomolecular chemical reaction; that is, after this age the percentage decline in growth in weight with age is constant.

The data presented in Table I are based on the weights of over 14,600 animals, covering practically the whole range of the duration of life of the modern dairy cow. This cow population is very homogeneous. All are Register of Merit Jersey cows; that is, pure bred and registered cows of the Jersey breed that have been tested for production by agricultural experiment stations and found to meet certain minimum requirements of the American Jersey Cattle Club in order to admit them to the Register of Merit. The average weights of Table I were computed from these records. The data are thought to be of exceptional value because in addition to the large number of animals, the wide range of age covered, and the homogeneity of the population, the weights are not complicated by a deposition of fat, as the dairy cow shows little tendency for fattening.

The average weights for different ages shown in Table I were computed from the individual records with the aid of a correlation table (Table II). It is necessary to point out that the ages represent the time the animals started on official test, while the weights, many

[1] Brody, S., and Ragsdale, A. C., *J. Gen. Physiol.*, 1920–21, iii, 623.

TABLE I.

Data on the Growth of the Dairy Cow (Jersey Breed).

Age.	No. of animals included.	Weight.		Standard deviation.	Coefficient of variation.	Average deviation.	Deviation.
		Computed from formula.	Mean observed weight.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
yrs.		*lbs.*	*lbs.*	*lbs.*		*lbs.*	*per cent*
2.25	3,155	803	808 ± 1.2	87 ± 0.74	10.8 ± 0.09	72	9
2.75	1,449	844	836 ± 1.6	89 ± 1.1	10.6 ± 0.13	72	8
3.25	1,523	875	872 ± 1.6	93 ± 1.1	10.7 ± 0.13	73	8
3.75	1,122	896	888 ± 1.9	92 ± 1.3	10.4 ± 0.15	72	8
4.25	1,171	913	916 ± 1.8	92 ± 1.3	10.1 ± 0.14	73	8
4.75	916	925	930 ± 2.2	100 ± 1.6	10.8 ± 0.17	76	8
5.5	1,692	938	938 ± 1.6	96 ± 1.1	10.2 ± 0.12	76	8
6.5	1,235	948	945 ± 1.9	98 ± 1.3	10.4 ± 0.14	78	8
7.5	965	953	952 ± 2.0	94 ± 1.4	9.9 ± 0.15	78	8
8.5	621	956	957 ± 2.6	97 ± 1.9	10.1 ± 0.19	79	8
9.5	364	958	962 ± 3.4	95 ± 2.4	9.9 ± 0.25	75	8
10.5	208	958.8	957 ± 4.4	94 ± 3.1	9.8 ± 0.32	76	8
11.5	108	959.4	968 ± 6.2	95 ± 4.4	9.8 ± 0.45	83	8
12.5	64	959.6	956 ± 6.1	72 ± 5.7	7.5 ± 0.45	54	6
13.5	32	959.8	961 ± 9.9	83 ± 7.0	8.6 ± 0.73	64	7
14.5	14		1,036 ± 20.6	114 ± 14.5	11.0 ± 1.4	96	9
15.5	9		975 ± 21.8	97 ± 15.4	10.2 ± 1.6	91	9
16.5	4		963 ± 43.5	129 ± 31.0	13.4 ± 3.2	106	11

(1) The ages are mid-values of the age intervals of Table II.

(3) Computed from the formula $X = 960\ (1-e^{-0.60\,(t+\,0.77)})$, where X is the weight at any birth age, t, in Column 1; 0.77 represents the time the fetus was carried *in utero*.

(4) Mean weight $= M = \frac{\Sigma\,(f.\,X)}{n}$. The symbols have the usual statistical meaning. Its probable error $= \pm\ 0.6745\,\frac{\sigma}{\sqrt{n}}$, where σ is the standard deviation.

(5) Standard deviation $= \sqrt{\frac{(f.\,d^2)}{n}}$. Its probable error $= 0.6745\,\frac{\sigma}{\sqrt{2n}}$.

(6) Coefficient of variation $= C = \frac{\sigma}{M} \times 100$. Its probable error $= 0.6745\,\frac{C}{\sqrt{2n}}$.

(7) Average deviation $= A.\,D. = \frac{\Sigma\,(f.\,d)}{n}$.

(8) Percentage deviation $= \frac{A.\,D.}{M} \times 100$.

TABLE II.

Correlation Table of Age and Weight of Jersey Cattle.

Weight classes.	Age classes in years.																		Total.
	2-2.5	2.5-3	3-3.5	3.5-4	4-4.5	4.5-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	
lbs.																			
400-450						1													1
450-500																			
500-550	8	2																	10
550-600	9	4	1	1															15
600-650	124	23	14	4	4	1		2	1										173
650-700	205	64	30	13	1	1	5	3	3		1								326
700-750	485	176	91	53	30	15	31	13	11	4	6	2			1				918
750-800	583	192	169	94	69	45	69	45	39	25	5	6	1	2	1				1,345
800-850	837	377	345	224	204	142	199	146	102	64	31	22	13	2		1	3	1	2,713
850-900	410	258	280	242	209	151	267	183	112	75	44	19	13	5	4				2,272
900-950	333	222	328	244	272	212	422	274	217	143	78	58	29	22	7	3	1	2	2,867
950-1,000	89	72	123	117	166	128	246	201	169	88	72	29	12	18	8	2			1,540
1,000-1,050	56	48	99	91	141	136	269	231	185	142	76	41	22	12	9	1	4		1,563
1,050-1,100	10	4	25	19	42	44	95	66	61	34	20	16	5	1		3	1		446
1,100-1,150	3	5	15	12	26	28	59	45	48	28	23	10	6		2	2			312
1,150-1,200	2		1	4	6	4	16	14	6	11	5	4	2	2				1	78
1,200-1,250	1	1	2	3	1	7	9	7	9	5	2	1	5			2			55
1,250-1,300				1			4	1											6
1,300-1,350							1	3	1	2									7
1,350-1,400											1								2
1,400-1,450									1										
1,450-1,500		1						1											2
1,500-1,550						2													2
Total.....	3,155	1,449	1,523	1,122	1,171	917	1,692	1,235	965	621	364	208	108	64	32	14	9	4	14,653

of which were estimated, were sent in by the breeders at the end of the year's testing. Theoretically, therefore, a correction should be made by a whole year; practically, however, such a correction is

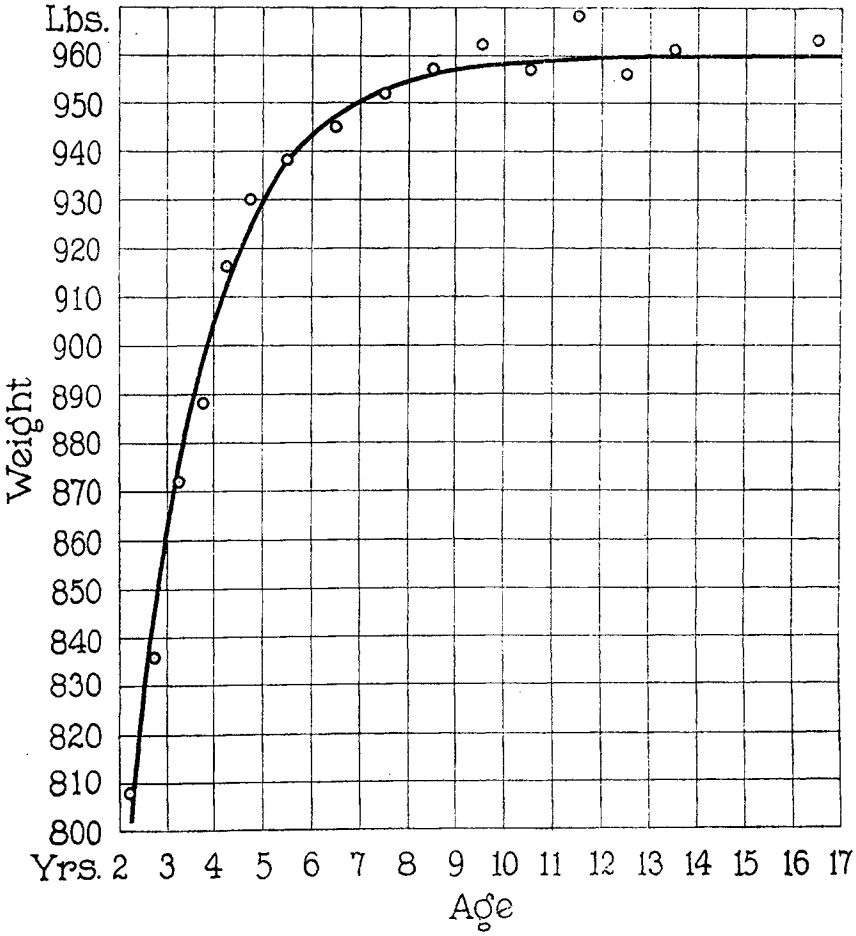

FIG. 1. Age-weight curve of the Jersey cow. The circles represent the observed values; the smooth line is the fitted curve of the equation $X = 960\ (1 - e^{-0.60(t+0.77)})$, when X is the weight of the cow at any birth age, t.

perhaps unnecessary inasmuch as the heavy milking dairy cow seldom gains and often loses in weight during the year on official test. No correction, therefore, has been made.

The course of growth after the age of 2 years is shown in Fig. 1. In accordance with the general theory on which these studies are based, *e.g.* that growth is limited by a chemical reaction, probably of the monomolecular type, the equation of the course of a monomolecular chemical reaction was fitted to the course of growth.

The equation of a monomolecular reaction is usually written

$$X = A(1-e^{-kt})$$

In the case of growth, A represents the weight of the animal at maturity, which is taken as an approximate measure of the initial concentration of the growth-limiting substance at the beginning of growth. X is the weight of the animal at any time, t, after the beginning of growth, which is taken as an approximate measure of the amount of growth-limiting substance transformed into the product of growth at the end of time, t. From Fig. 1, A, the weight of the Jersey cow at maturity is 960 pounds. Substituting the values of A, X, and t, and solving for k, the equation becomes

$$X = 960\ (1-e^{-0.60t})$$

where t is the conceptional age of the animal. In Table I weights are given in terms of birth age. For birth age $(t + 0.77)$ is written in the above equations in place of t, since the calf is carried *in utero* 0.77 years.

Table I and Fig. 1 show that the equation of monomolecular chemical reaction expresses very closely the course of growth in the dairy cow after the age of 2 years.

SUMMARY.

An extensive amount of data is presented on the growth in weight of the dairy cow from 2 to 17 years of age, covering practically the entire duration of life. The data show that after the age of 2 years the rate of growth declines in a non-cyclic manner. The course of decline in growth follows the course of decline of a monomolecular chemical reaction; that is, the percentage decline in growth with age is constant.