THE RATE OF GROWTH OF THE DOMESTIC FOWL.

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If the weight of a mammal, for example the mouse, is plotted against its age, the resulting curve will be seen to show three fairly distinct waves, oscillations, or growth cycles. These waves or cycles are still more strikingly shown by plotting the velocity of growth against age as is seen in Fig. 1.

Robertson[1,2] found that the growth of each of these cycles can be represented by the equation of an autocatalytic monomolecular reaction. This fact, and the theories developed from the fundamental studies on cell growth by Sachs, Morgan, Driesch, Boveri, and Loeb,[3] which were reviewed in a previous paper[4] on the growth of the dairy cow, led Robertson[1,2] and Ostwald[5] to assume that the limiting factor of growth of each cycle is an autocatalytic monomolecular reaction. Assuming this tricyclic and autocatalytic theory of growth to be true for mammals, it becomes of interest to find out whether the same does not also hold for birds. The object of this paper is to examine data on the growth of the domestic fowl in the light of this theory.

Fig. 2, deduced from Table I, shows the rate of growth of the Rhode Island Red breed of fowl[6] from the time of hatching up to the age of

[1] Robertson, T. B., *J. Biol. Chem.*, 1916, xxiv, 363.

[2] Robertson, T. B., *Arch. Entwcklngsmechn. Organ.* 1907–08, xxv, 581; *Am. J. Physiol.*, 1915, xxxvii, 1, 74; Principles of biochemistry, for students of medicine, agriculture and related sciences, Philadelphia, 1920.

[3] Loeb, J., The dynamics of living matter, New York, 1906, 58–66; *Biochem. Z.*, 1907, ii, 34; *Biol. Centr.*, 1910, xxx, 347.

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

[5] Ostwald, W., Vorträge and Aufsätze über Entwicklungsmechanik der Organismen, Leipsic, 1908, v.

[6] Card, L. E., and Kirkpatrick, W. F., *Storrs Agric. Exp. Station, Bull. 96*, 1918.

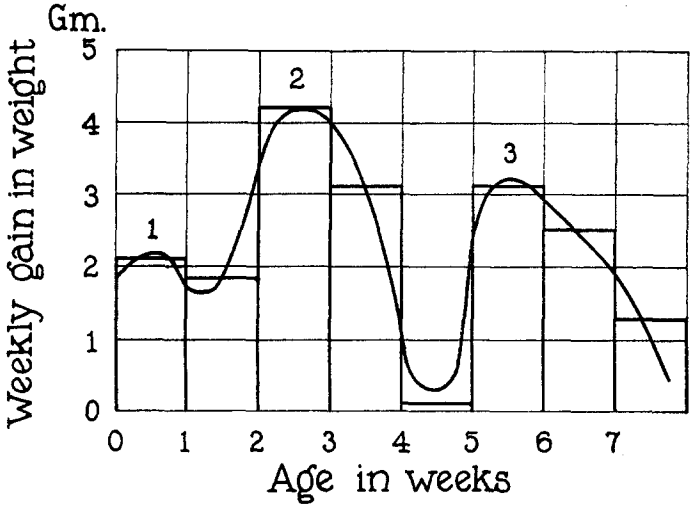

FIG. 1. The rate of growth of the white mouse plotted from data by Robertson.[1] Ordinates represent the weight (x) in grams gained per week; abscissæ represent the age (t) in weeks of the animals.

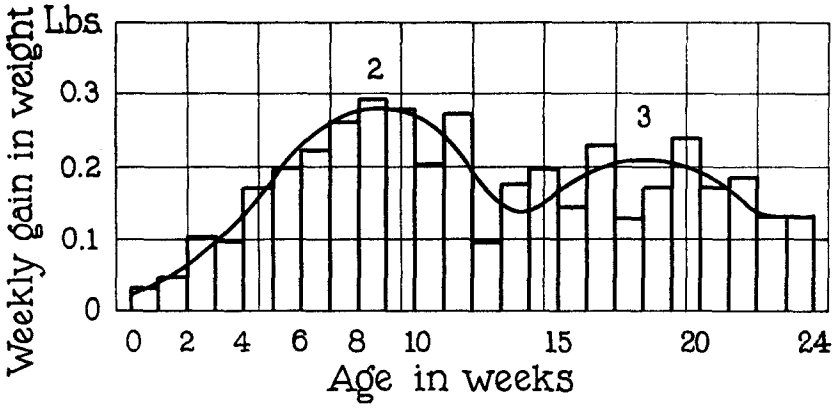

FIG. 2. The rate of growth of the Rhode Island Red fowl plotted from data by Card and Kirkpatrick.[6] Ordinates represent the weight (x) in pounds gained per week; abscissæ represent the age (t) in weeks of the birds from the time of hatching.

laying. This figure clearly shows the rate of growth to increase from the time of hatching up to about 8.5 weeks of age when the rate of

TABLE I.

Growth of the Rhode Island Red birds.			Growth of chick embryo.			
After Card and Kirkpatrick.[6]			After Lamson and Edmond.[9]		After Hasselbalch.[10]	
Age.	Weight.	Number of birds.	Age.	Weight.†	Age.	Weight.
wks.	*lbs.*		*days*	*gms.*	*days*	*gms.*
0 (hatched)	0.082	865			3	0.004
1	0.115	858	4	0.12	4	0.054
2	0.162	798	5	0.28	5	0.155
3	0.264	750	6	0.49	6	0.373
4	0.364	714	7	0.86	7	0.615
5	0.538	696	8	1.35	8	1.200
6	0.737	682	9	1.98	9	2.040
7	0.962	677	10	2.85	10	2.890
8	1.228	613	11	3.95	11	4.366
9	1.525	611	12	5.89	12	5.674
10	1.805	608	13	8.21	13	7.543
11	2.014	601	14	9.84	14	10.005
12	2.290	600	15	12.63	15	12.285
13	2.388	344*	16	16.05	16	15.210
14	2.566	343	17	20.05	17	17.500
15	2.765	343	18	21.36	18	21.545
16	2.907	288*	19	26.87		
17	3.136	288	20	35.50		
18	3.265	288				
19	3.436	253				
20	3.677	252				
21	3.851	251				
22	4.035	250				
23	4.165	250				
24	4.296	250				

* The males were removed at the end of the twelfth and fifteenth weeks. The other reductions in number are due to removal of chicks by crows and necessity of removing chicks due to limitations of range conditions.

† Average of ten embryos.

growth is at a maximum; from this maximum at 8.5 weeks the rate of growth decreases to a minimum at about 14 weeks. This is followed by another cycle with a maximum at about 18 weeks of age ending

somewhere between 24 and 28 weeks[6] of age when growth of non-fatty tissues probably ceases. That each of these postembryonic cycles follows the equation of an autocatalytic monomolecular reaction can be seen from their shape. This can be easily verified by taking t_1, the age of maximum growth at 8.5 weeks, and following the technique of computation described in the preceding paper on the growth of the dairy cow, we obtain the equation

$$\text{Log } \frac{x}{2.76 - x} = 0.182\ (t - 8.5)$$

which gives calculated values closely agreeing with the observed weights.

Age (t).	Observed weights.	Calculated weights (x).
wks.	*lbs.*	*lbs.*
0	0.082	0.078
1	0.115	0.114
2	0.162	0.168
3	0.264	0.251
4	0.364	0.363
5	0.538	0.516
6	0.737	0.717
7	0.962	0.961
8	1.228	1.233
9	1.525	1.521
10	1.805	1.800
11	2.014	2.040
12	2.290	2.240
13	2.388	2.390
14	2.566	2.505

Essentially similar results were obtained with other breeds of fowl such as the White Leghorn,[6] single comb White Leghorn,[7] and White Plymouth Rocks,[8] the several breeds differing only with respect to the several constants. From Fig. 2 it is clear that the equation will also hold somewhat less accurately for the second cycle with a maximum at 18 weeks.

[7] Lamon, H. M., and Lee, A. R., *U. S. Dept. Agric., Bull. 561*, 1917, 37.

[8] Phillips, A. G., *Purdue Univ. Agric. Exp. Station, Bull. 1906*, 1916; *Purdue Univ. Agric. Exp. Station, Bull. 214*, 1918.

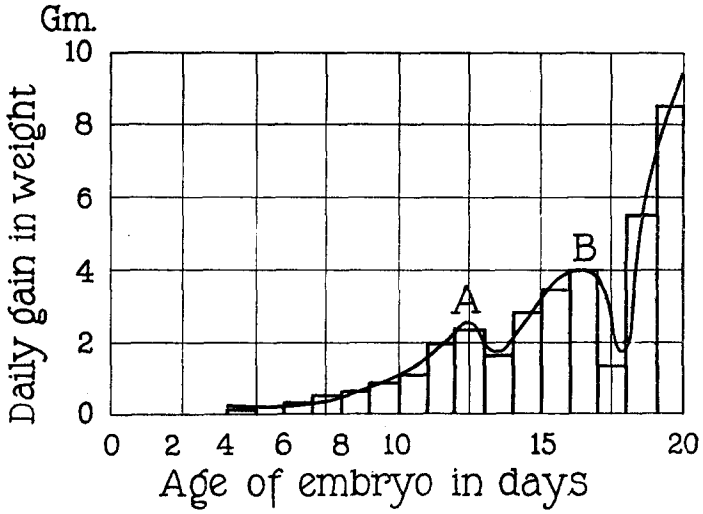

FIG. 3. The rate of growth of the chick within the egg plotted from data by Lamson and Edmond.[9] Ordinates represent the weight (x) in grams gained per day; abscissæ represent the age (t) of the embryo from the beginning of incubation.

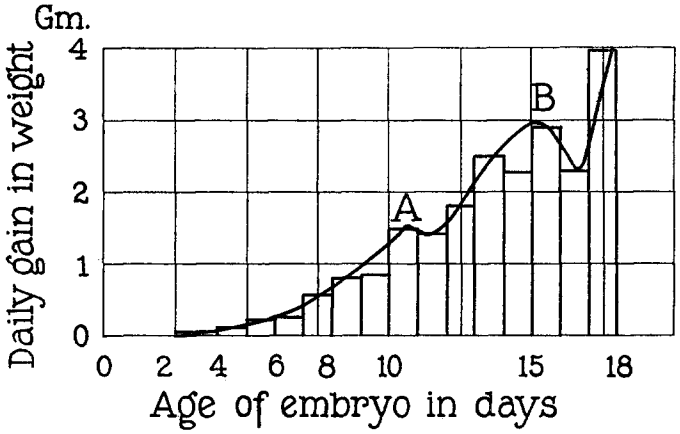

FIG. 4. Same as Fig. 3 plotted after data by Hasselbalch.[10]

The mammal was seen to go through at least three cycles during its growth period; if the tricyclic theory of growth is also true for the bird, then the fowl must go through a complete cycle during its embryonic period of growth. Figs. 3 and 4, curves of the embryonic period of growth, show this to be the fact;[9,10] indeed it seems as if the curve of the embryonic period of growth shows two cycles with maxima at A and B.

SUMMARY.

This paper points out the fact that the growth period of the domestic fowl is analogous to that of the mammal, being composed of three, or perhaps four, cycles; two of these cycles are postembryonic with maxima at about 8 and 18 weeks varying somewhat with the breed and two or at least one, are embryonic with maxima at 11 to 12 and 15 to 16 days of age. Hatching occurs during the first part of the second or third cycle resembling in this respect the guinea pig[11] rather than the mouse.[1] The velocity curves of each of these cycles are similar to and can be represented by the equation of an autocatalytic monomolecular reaction.

The author is indebted to Mr. H. L. Kempster, Department of Poultry Husbandry of this Station for supplying him with some references in this paper.

[9] Lamson, G. H., and Edmond, H. D., *Storrs Agric. Exp. Station, Bull. 76*, 1914.
[10] Hasselbalch, K. A., *Skand. Arch. Physiol.*, 1900, x, 364.
[11] Read, J. M., *Arch. Entwcklngsmechn. Organ.*, 1912–13, xxxv, 708.