

THE RATE OF DECLINE OF MILK SECRETION WITH THE ADVANCE OF THE PERIOD OF LACTATION.

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

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

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It is well known among dairymen that lactation in the dairy cow is an orderly process with a fairly predictable average production of milk for each month of the lactation period. The milk flow rises for some time after calving, due, no doubt, to the improving condition of the animal, increased food consumption, and the perfection of the mammary gland.¹ This is followed by a steady decline until the animal goes dry. There are, of course, individual variations due to heredity and environment as regards the duration of the lactation period. The highly developed dairy cow is often milked for over a year; the beef cow goes dry as soon as the calf becomes self-supporting, which may be within 3 or 4 months. Most cows fall somewhere between these two extremes. For a given strain and breed of animal, however, there is a typical decline curve. The purpose of this article is to present the results of an investigation into the nature of this decline of milk secretion with the advance of the period of lactation. We have for this purpose compiled a very large amount of data in order to eliminate as far as possible individual variations. The data are presented in Table I and Fig. 1.

Milk secretion is, of course, a chemical or physicochemical process. Certain substances typical of blood are converted into other substances typical of milk. Like other chemical reactions the speed of milk secretion is within certain limits dependent on the supply of substances entering the reaction, for example food; on the removal of the products of the reactions, for example the removal of milk; and

¹ For other possible reasons *cf.* Osterhout, W. J. V., *Proc. Am. Phil. Soc.*, 1916, lv, 533. Osterhout, W. J. V., and Haas, A. R. C., *J. Gen. Physiol.*, 1918-19, i, 1.

probably on certain catalyzers produced by the pregnant uterus.² If milk secretion is a process of limited duration under a plentiful

TABLE I.
Observed and Calculated Values on the Decline of Milk Secretion in the Dairy Cow with the Advance of the Period of Lactation.*

Month of lactation.	Holstein† cows (average, 95 lactation periods). Milk yield per day.		Jersey‡ cows (average, 305 lactation periods). Milk yield per day.		Guernsey§ cows (average, 3,215 lactation periods). Milk yield per day.		Scrub¶ cows (average, 32 lactation periods). Milk yield per day.	
	Observed.	Calculated.	Observed.	Calculated.	Observed.	Calculated.	Observed.	Calculated.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	39.6	42.9	30.0	30.8	33.3	36.1	20.4	23.3
2	40.3	40.5	29.4	29.1	34.3	33.9	19.0	19.5
3	38.9	38.4	27.9	27.4	32.3	31.9	16.0	16.4
4	36.5	36.3	25.9	25.9	29.9	30.1	14.0	13.8
5	33.9	34.3	24.2	24.5	28.1	28.3	12.0	12.8
6	32.5	32.5	22.7	23.1	26.4	26.5	9.7	9.7
7	30.8	30.7	21.4	21.8	24.9	25.1	8.0	8.1
8	29.3	29.1	20.6	20.6	23.7	23.6	7.0	6.9
9	27.9	27.5	19.5	19.4	22.4	22.2	5.4	5.7
10	25.4	26.0	18.6	18.3	21.0	20.9	3.7	4.8
11	23.2	24.6	17.3	17.3	19.5	19.7		
12	20.1	23.3	17.3	16.3	17.9	18.5		

* Values calculated from the formula $M_t = M_0 e^{-kt}$, where M_t = milk production during any month, t ; M_0 is the theoretical value of the milk flow at the time of parturition; e and k have the usual meaning. The equation for the Holstein group is $M_t = 45.32e^{-0.00555t}$; for the Jersey group $M_t = 32.61e^{-0.005758t}$; for the Guernsey group $M_t = 38.3e^{-0.006051t}$; and for the Scrub group $M_t = 27.72e^{-0.01747t}$.

† Values for the Holstein cows were obtained on animals belonging to the University of Missouri herd.

‡ The data for the Jersey cows were obtained on animals belonging to dairymen in Missouri.

§ The Guernsey data were compiled from advance registry records from eastern and middle western states with a sprinkling from the Pacific Coast states.

¶ The values of the Scrub cows were interpolated from Chart 2, Bulletin 188 of the Iowa Experiment Station (1919).

² Cf. Lane-Clayton, J. E., and Starling, E. H., *Proc. Roy. Soc. London, Series B*, 1906, lxxvii, 505. O'Donoghue, C. H., *Quart. J. Micr. Sc.*, 1911-12, lvii, pt. 2, 187. Ribbert, H., *Arch. Entwcklungsmechn. Organ.*, 1898, vii, 688. Basch, K., *Deutsch. med. Woch.*, 1910, xxxvi, 987. Goltz, F., and Ewald, J. R., *Arch. ges. Physiol.*, 1896, lxiii, 362.

food supply, then there must be some factor other than food which limits the speed of the process. If the limiting reaction is chemical in nature then the decline of the speed of milk secretion should be expressed by the formula of some chemical reaction.

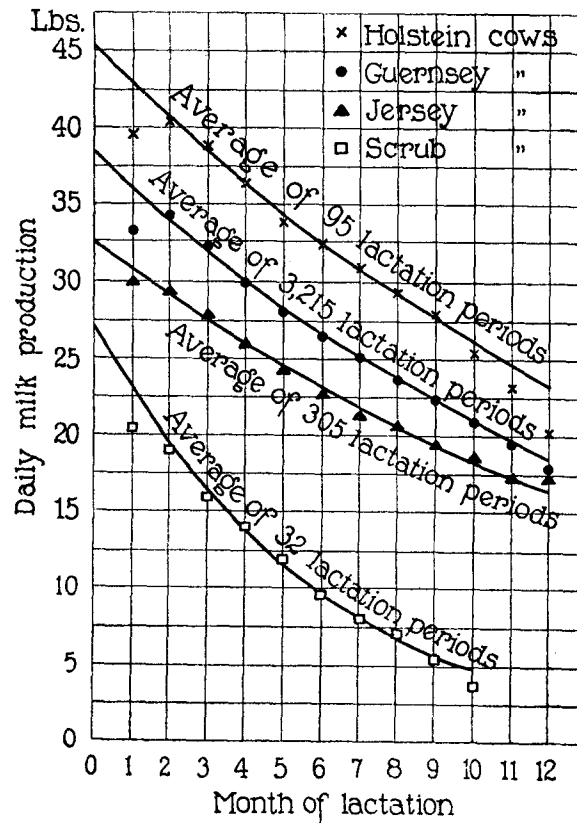


FIG. 1. The rate of decline of milk secretion with the advance of the stage of lactation. The observed values are placed along side the continuous lines of the equation $M_t = M_0 e^{-kt}$.

This possibility can be tested easily by attempting to fit formulæ expressing the course of chemical reactions to the milk data. Table I and Fig. 1 show that the equation of a monomolecular chemical reaction expresses the course of decline of milk secretion with the advance of the period of lactation.

There is some deviation of the calculated from the observed values for the first month of lactation for the reasons already explained. Some deviation is also to be expected during the last month or two, due to the condition of advanced pregnancy, to the less thorough milking practiced at the end of the lactation period, and to the fact that the water content of milk decreases during the last months, which gives the effect of a decreased milk flow. Of course the larger the number of animals, the better the agreement between observed and calculated values, which explains, in part at least, the much closer agreement for the Guernsey group of cows based on 3,215 lactation periods than for the Scrub group based on 32 lactation periods.

SUMMARY.

It is shown that the course of decline of milk secretion with the advance of the period of lactation may be expressed by the equation of a monomolecular chemical reaction; that is, the percentage decline of milk secretion with the advance of the stage of lactation is constant. This substantiates the idea that milk secretion is limited by a chemical reaction, and, in general, brings lactation into the class of processes the speed of which is determined by the concentration of a limiting substance.