THE EFFECT OF FREQUENCY OF MILKING ON PERSISTENCY OF PRODUCTION

by

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INTRODUCTION

It is recognized that the lactating ability of the dairy cow represents the algebraic sum of her environment, her inheritance and her age. While the inherent ability to produce milk largely determines a cow's production, it is also greatly influenced by environmental factors.

In more detail, the factors commonly thought to influence, at least in part, the process of milk production, are given below:

Initial capacity for milk production) Includes
Initial capacity for fat production) mammary development

Persistency (thought to be influenced by endocrine secretions)

Feed capacity

Feed utilization

Suppressing factors

By persistency of lactation is meant the degree with which production is maintained during a lactation period. It is obvious that, with a stipulated initial production, the yield for a lactation will depend upon the ability to maintain this production throughout the period.

Studies concerning the persistency of lactation in dairy cows are not restricted to recent investigations. Sturtevant (13) in 1886 advanced a method by which it could be measured, and Carlyle and Boll (4) in 1903 reported along similar lines. Since 1925, however, added attention has been given to this characteristic in view of a desire to formulate a suitable index to be used in practical work and also in studies of its inheritance.

A knowledge of the inheritance of persistency and the factors influencing its expression may have a practical value in the selection of dairy animals for commercial herds and also for feeding investigations. If a cow's persistency index were known, the value of a short time record made at a known stage of her lactation, would be enhanced.

REVIEW OF LITERATURE

The general shape of the lactation curve is well known. After parturition, it ascends rather rapidly until a maximum is reached, after which there is a gradual decline. The time at which the maximum is reached varies in different herds apparently because of both the care of the animals and their inherent tendencies. Turner et al (15) showed that with Holsteins the maximum day's production came at the 15th-16th, 18th, and 20th days for two, three and four time

milking, respectively. These authors suggested that the number of times milked per day and the milk yield were significant influencing factors. Eckles (5) presented data which indicate that under ordinary conditions the maximum may be reached around the thirtieth day and under official test conditions it is reached about the fortieth day. The data of Becker and McGilliard (1) indicate that the maximum is reached about the fourth ten-day period for Registered Jerseys and Holsteins, and at about the second ten-day period for common cows.

Various workers, including Sturtevant (13), Carlyle and Woll (4), May (9), and Brody et al (2), have calculated the percental decrease, which is a measure of the persistency, using the average of succeeding stages within the lactation. When large numbers of these records are included the percental decrease throughout the first part of the lactation has been concluded to be constant. The decrease has been represented by Brody et al (2) by the k-exponent in the exponential type of equation for a mono-molecular chemical reaction, the products of the reaction being removed.

It is known that a cow's milk production will drop off more rapidly with the approach of parturition than if she remains non-pregnant. Eckles (5) substantiated the work of

other investigators, (3, 8, 15) in this regard, by making a comparison of the records of nineteen non-pregnant cows with the records made by the same cows when bred to calve within twelve months of a previous parturition. His results clearly indicate that there is a marked falling off beginning about the 255th day of the lactation, thus decreasing the persistency. This would correspond approximately to the fifth month of gestation.

There have been repeated attempts to express persistency mathematically. Sturtevant (13) used herd averages and calculated the percental decrease from month to month. Turner (14) used essentially the same method for his first index of persistency, which was the average of the monthly percental decreases. McCandlish et al (10) expressed each month's production as a percentage of the first month's production. Ellinger (6) measured the slope of the lactation curve by using the ratio of the second ten-weeks' production, to the first ten-weeks' production. Carlyle and Woll (4) used the method that can be expressed by the formula, $100\ \frac{a-b}{a}$, in which a and b are used to represent, respectively, an early and a late week's yield. Theirs probably was the first quantitative expression formulated. While it may be used to represent the absolute decrease between the

two periods considered, it is not capable of expressing the rate of decrease.

Sanders (12) is thought by Gaines (7) to be the first to present in detail a quantitative expression of persistency. Its advantage over Carlyle and Boll's (4) is that it does express the rate of decrease. He used the ratio of total yield to maximum day's yield, applying a correction for service period. Turner (14) proposed a second measure, $\frac{\text{total yield}}{\text{maximum month's yield}}$, which, fundamentally, is like that of Sanders with the one refinement, that his proposal to use maximum month's yield would tend to eliminate daily fluctuations.

The conclusion that production, after the maximum is reached, decreases at a constant rate throughout the remainder of the lactation, is borne out when the average of large numbers of records is used and gestation does not enter in. With recent investigators it is the basis for the exponential equation, referred to above, of Brody and coworkers (2) and of Gaines and Davidson (8).

The optimum length of time during which persistency should be measured has not been definitely settled. Different sections, each varying in length, within the lactation, have been used. The length of these periods have varied from a week to a complete lactation. Ellinger (6),

studying yields, found a marked increase in the coefficients of variation after the second ten-week period. This indicated to him that a new cause of variation appeared after the twentieth week or that a cause of increasing importance influenced the amount of milk after that time.

The literature shows that persistency is influenced both by environmental factors and by the individual's hereditary complex. For example, Magsdale and associates (11), conducted studies on the rate of secretion of milk as affected by an accumulation of milk in the mammary gland. They concluded that the rate of secretion for each hour, the products of the reaction not being removed, was about 95 per cent of that of the preceding hour. Sanders (12), studying the effects of certain environmental influences, concluded that the lactation curve depends partly on the genetic characteristics of the cow. Ellinger (6) concluded that "the yield of the same cow, in successive periods, varies, displaying a certain well known regularity." He found a significant difference between the Jersey and Danish cattle studied in respect to persistency, the Danish cattle being the more persistent. The work of Becker and McGilliard (1), Gaines (7), and Turner (14) also indicate that persistency is largely influenced by inheritance. No one, however,

apparently has offered an explanation as to the mode of its inheritance.

EXPERIMENTAL PROCEDURE AND DISCUSSION

This investigation is divided into two parts: 1. A study of daily yields for the first thirty days to determine how many days subsequent to parturition should be eliminated as not being typical of a cow's normal producing capacity. 2. A determination of persistency indices for cows milked both two and three, and two and four times a day, respectively, to ascertain whether variation in the number of daily milkings affects persistency.

The data used were taken from the records of the Kansas State College Ayrshire and Holstein herds. In general, the plan of management until 1923 was to milk all cows showing evidence of large production, four times a day. The system also provided for a three-time group in addition to the regular herd which was milked twice daily. In 1923 the four-time milking was discontinued.

Daily Milk Yields for the First Thirty Days

Because maximum yield is not reached, in most cases, until several weeks after parturition, daily yields for the first thirty days were plotted to determine whether there

was any break in the rate of increase which could be interpreted as the end of the convalescent period. This study involved the use of sixty-one records from thirty-seven cows as follows:

Breed	Times Milked	Number of Records
Ayrshire	3 (2 yrs. old)	4
Ayrshire	3 (3 yrs. old)	3
Ayrshire	3 (over 3 yrs)	3
Ayrshire	3	4
Ayrshire	2	17*
Holstein	4	12
Holstein	3	8
Holstein	2	10
	Total	61

*These records are from ten different cows

The broken line curve (See Figure I) is for Ayrshires milked three times a day and is comprised of several distinct groups, namely:

Four two-year-olds in first lactation.
Three three-year-olds in first lactation.
Three cows of different age in second lactation.
Four cows of different age in a later lactation.

There was no marked difference, in the curves of these different groups, from the curve for the average.

The average for the groups are presented in Table I and graphically in Figure I. The curves for the five groups of data indicate that, in general, the yields for the first 14-16 days fluctuate more than it does during the following ten days, and tends to increase at a more rapid rate than the yields for the next fifteen days. It seems especially

significant that not only the average for the different groups agreed fairly close, but also that the individual records making up these groups conformed closely with the average. Consequently, the first fifteen days are eliminated to allow for at least a partial recovery from the effects of parturition.

Table I

Daily Milk Production For First Thirty Days

	Ayrshires		Holsteins		
	(Times milked per day)				
Day	2	3	2	3	4
1					
2					
3				39.3	
4		31.01		45.2	48.3
5	31.7	32.74	37.66	47.8	52.1
6	33.1	33.51	37.0	49.6	55.4
7	34.3	36.46	39.5	52.8	58.5
8	35.4	36.76	38.0	54.7	59.5
9	35.1	38.[illegible]	40.8	56.9	60.6
10	36.0	38.21	40.7	56.1	61.0
11	36.3	39.58	41.5	56.8	62.4
12	35.6	40.11	41.3	57.1	63.1
13	35.7	41.66	42.6	56.3	63.3
14	36.7	41.41	42.8	58.1	61.7
15	37.5	42.03	41.8	57.1	67.0
16	37.3	43.01	43.2	55.4	67.7
17	35.9	42.51	42.5	57.7	68.1
18	36.6	43.46	43.5	58.1	68.9
19	36.8	43.89	44.6	57.8	69.6
20	38.0	43.67	44.3	57.2	69.6
21	37.5	43.09	43.8	57.4	71.5
22	37.2	43.73	41.7	56.7	71.0
23	37.0	44.97	43.0	57.0	70.9
24	37.3	44.77	45.0	59.0	70.6
25	37.9	44.61	45.4	58.0	69.8

Table I - Continued

	Ayrshires		Holsteins		
	(Times milked per day)				
Day	2	3	2	3	4
26	37.7	46.35	43.5	56.1	71.1
27	38.4	45.69	45.1	56.3	71.9
28	37.9	46.16	44.1	56.1	71.8
29	36.7	45.11	44.8	57.8	72.1
30	37.5	46.14	45.0	56.8	72.8

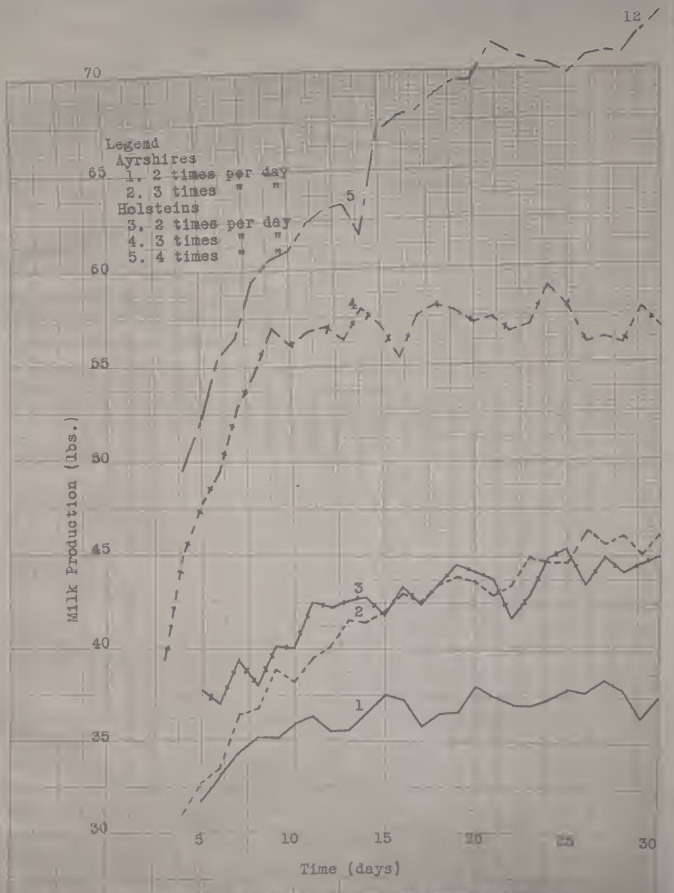


Figure 1. Milk Yields for the First Thirty Days.

The Effect of Frequency of Milking on Persistency of Production

It was desirable to determine the observable differences in persistency of fat production caused by the frequency of milking. In using data taken from the records of the college herds, it was hoped to get away from some of the disadvantages of advanced registry data, among which may be mentioned:

1. They represent selected data. Those not tested may be persistent with low initial yield or non-persistent with a high initial yield.
2. The number of times per day a cow is milked throughout the lactation is not known.

   Example: (Holsteins) A cow may be milked three times a day for 45 days and still come under Class "C".*
3. The feed and care of the animals varies markedly with different locations.
4. In case of Guernseys, it is not known if the record is for an entire lactation or is part of two lactations.
5. Temperature effects on yield.

*Classification "C" includes tests in which cows are not milked more than twice daily after the 45th day.

6. Dam-daughter comparisons not always available.

In this study only records from second or later lactations were used. First lactations were eliminated because they usually exhibit a characteristically greater persistency than later lactations.* All lactation records were also excluded that were abnormal or excessively short. From those that remained, records were selected from all cows having both a two and a three-time record for different lactations, or both a two and a four-time record for different lactations. In this way it was hoped to exclude the possibility of getting more persistent cows in one group than in the other.

As implied above, the records were started on the sixteenth day and calculated for successive thirty day periods. This plan excluded the possible discrepancies caused by differences in time between calving and the beginning of the first full 30 day month.

Of necessity, the data are meager and admittedly the results of uncontrolled environmental causes have been manifested in them. It is hoped, however, later to supplement

* The author's thanks are due Mr. Howard Bertsch who plotted many of these records under the direction of Dr. H. L. Ibsen.

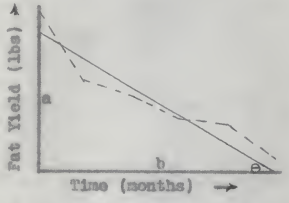
this with other data treated similarly.

It was mentioned above that the use of exponential equations, in determining indices, find their best use when average figures for large numbers of records are available. In this case it was desired to have a calculated index for each individual record concerned.

It seemed that, with the initial yield constant, the most persistent cow would yield the most in a given period of time. In particular cases, at least, it has been found that the ratio, $\frac{\text{Total yield for a given time}}{\text{Maximum month's yield}}$, gives lower indices for cows whose production increases after the first month than to cows that start in at the same initial yield and decline continuously from the start and yet produce less in a given period. When the ratio, $\frac{\text{Total yield for a given time}}{\text{Initial month's yield}}$, is used, somewhat better results are obtained. It is thought, however, to give too much stress to marked fluctuations which seemingly are environmental in nature.

It seemed that a more satisfactory description of persistency would be some index of the production trend calculated by the method of least squares. The index used was the tangent of the angle, Theta. Theta was taken as the angle formed with the intersection of the trend line and the base. The distances were measured in centimeters. It should

be kept in mind that the persistency index so expressed is inversely proportional to the degree of persistency. An actual case will be cited to illustrate this method. The average fat production in pounds for cow No. 264 on twice a day milking for the first six 30-day periods following the preliminary fifteen days was 37.40, 28.82, 27.60, 24.98, 23.58, and 20.26 respectively. These values, as well as the values for the trend as determined by the method of least squares, are plotted below:



Method of Plotting Index

The diagram also shows angle Theta formed at the intersection of the trend line and the base line. The distances a and b were measured in centimeters and the index used was the tangent ratio ($\frac{a}{b}$). In actual practice the time unit used was equal to two units on the ordinate.

It is seen that the index varies directly with the value of a. It will be realized that with a greater per-

sistency the trend line will come nearer to being horizontal than the one illustrated, and consequently, with this greater persistency, the value of a will be less. This in turn will give a lower index.

The data are presented in Tables II and III. A negative correlation between persistency and frequency of milking is indicated in the case of the Ayrshire records and for the Holstein records of both two and four time milking. The failure of the first group of Holsteins to show this same effect is attributed to the marked discrepancy of cow No. 179. If cows are more persistent when they are milked two times a day than when milked three times a day, one would expect an even greater difference between two-time and four-time milking. The meager data presented bear this out. In fact, the persistency for two-time milkings is nearly twice as great as for the four-time milkings.

It may be further stated that, in general with the records studied, the individual records were fairly consistent. There are, however, some rather outstanding exceptions. These include cows No. 255, 262 and 123. Perhaps even more unusual are the records of cows No. 279, 169 and 133, which show to a marked extent the opposite tendency relative to effect of frequency of milking on persistency of production.

Table II

Persistency Indices for Ayrshires*

Cow Number	Two-time milking		Three-time milking	
	a[1]	a/b[2]	a	a/b
209	9.7**	.382	10.2	.402
226	14.9	.547	11.1	.437
230	14.2	.559	15.9	.626
234	14.2**	.559	11.8	.465
246	4.9**	.193	6.9	.272
254	10.5**	.413	13.6	.535
255	3.1	.122	11.9	.469
257	13.5**	.531	17.2	.677
258	9.8	.386	13.9	.547
262	7.6	.299	21.2	.835
264	7.7**	.303	11.0	.433
279	19.7**	.776	15.2	.598
Total	129.8	5.110	159.9	6.296
Average	10.82	.426	13.33	.525

*Based on the first six 30-day yields.
(Five 30-day yields were used for 279)

**The average for two lactations was used.

1. Length of side opposite angle, Theta.

   While these values may be used for comparative purposes when all other values are obtained by the same chart, the values in column a/b may be compared to values obtained when other charts are used.

2. Tangent of angle, Theta.

Table III

Persistency Indices for Holsteins*

Cow Number	Two-time milking a	a/b	Three-time milking a	a/b
128	8.6	.339	9.8	.386
153[a]	6.7	.264	7.3	.287
154	8.3	.346	8.3	.327
160	14.1	.555	17.6[b]	.693
162	7.5	.295	6.3	.248
169	21.4	.843	8.3	.327
176	10.4	.409	12.3	.484
Total	77.5	3.051	69.9	2.752
Average	11.1	.436	9.99	.393
	Two-time milking		Four-time milking	
125	1.8	.071	13.4	.528
132	6.7	.264	10.1	.398
133	17.6	.693	13.7[b]	.539
147	5.0	.197	20.0	.787
151	8.6	.339	13.3[c]	.524
153[a]	6.7	.264	7.8	.307
Total	46.4	1.828	78.3	3.083
Average	7.73	.305	13.1	.514

* Based on the first eight 30-day yields

a. It will be noted that records from this cow appear in both parts of this table and show a uniformity in difference of persistency attributed to frequency of milking.

b. Seven monthly yields used.

c. Six monthly yields used.

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Only one possible explanation will be offered for the difference which has been attributed to frequency of milking. The results fit in with the assumption that there is a supply of the galactogic principle perhaps from the anterior pituitary stored prior to parturition. After the lactation starts the supply is more quickly exhausted with a greater frequency of milking.

CONCLUSIONS

The data presented above point to the following conclusions:

1. In general the convalescence following parturition extends over a period of about fifteen days. During this period the daily milk production rapidly increases. After that there is a smaller rate of increase until the maximum is reached.

2. The lactation trend is plotted by the method of least squares and the index to this trend is calculated by the tangent method. It has been demonstrated with the records studied that, in general, cows milked two times per day are more persistent than cows milked either three or four times per day. It also has been shown that there is a wide variation in individual cases.

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