Effect of Proportion of Concentrates in Herd Ration on Lactation Curves

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ABSTRACT

The proportion of net energy in the herd's ration derived from concentrates as reported to Dairy Herd Improvement was the basis for defining five groups of milk production records from New York and New England. The relative daily milk production by season and stage of lactation was estimated for each group at two ages by a generalized least squares procedure. These solutions showed little variation due to the grouping by proportion of concentrates, but season of freshening and age were important. The mean yield did increase with an increasing proportion of concentrates, and, consequently, extension factors would differ by group due to these different means.

INTRODUCTION

Demands on feed grain production for direct human consumption may force a change in the emphasis on concentrate feeding for dairy cattle (10). An increased use of roughages might change the pattern of milk production during lactation.

The shape of the lactation curve is of interest since the projection of incomplete records depends on how milk production is distributed over the lactation. The current projection factors employed by the USDA (7) are separate for milk and fat by breed for two ages of freshening. Earlier work also indicated the importance of season of freshening (4, 5), and Appleman et al. (1) found peak production was important for extending records. One reason the USDA factors ignored season was to make the adoption of these factors more feasible for dairy record processing centers. The regression and ratio methods of extending records have received considerable attention in the literature (4, 5, 6, 11). The regression method is more accurate than the ratio (8), but the ratio factors are generally used because they are easier, since the regression method requires mean production for complete and part lactations (11). Workers (2, 3, 8) have suggested that the problem of estimating 305-day yield should be separated into the known part lactation and the unknown remaining lactation, with the latter being best estimated from the last known test day's production in the part record. The current study focused on lactation curves since they underlie extension factors. Differences in lactation curves would be reflected by any method of constructing extension factors. A recent study of age-season correction factors (9) indicated that these factors varied by region of the country and the possibility of a regional effect was considered.

The study is concerned with the effect of a general shift in proportion of concentrate feeding over lactation rather than the normal changes in concentrate feeding over lactation or the variation in feeding among cows within a herd. The relative feeding pattern within a herd might no change even with a shift in the total proportion of concentrates fed. The proportion of net energy from concentrates measured on a herd basis was used to investigate such a general shift in emphasis on concentrates fed. Such a measure is routinely available and, if important, could be used easily. Milk production records were classified into five groups on proportion of net energy from concentrates to determine if this grouping identified records with differing lactation curves. Since the study used data collected from the field, it necessarily was limited to the range of current feeding regimes and was dependent on the accuracy of determination of the proportion of concentrates. This measure was selected since it is affected by the amounts of concentrates, forages, and pasture in the ration. Even though reporting of feeding information may not be completely accurate, the

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five groups chosen for study are likely to be associated with different feeding practices.

EXPERIMENTAL PROCEDURE

Dairy Herd Improvement (DHI) milk production records from 468,598 Holstein cows in New York and New England were used in this study. Only records with herd feeding information, test day information, fresh date between June, 1966, and August, 1975, a normal termination code, and age less than 36 mo or 60 to 72 mo at freshening were selected from the files of the Dairy Records Processing Laboratory (DRPL) at Ithaca, NY. Herd feeding practices are categorized by defining five groups of records based on percent net energy (NE) from concentrates reported for the herd during the period when the record was produced. Percentages of net energy from concentrates included in each group as well as the numbers of records are in Table 1. Relative daily production for the various stages of lactation and several seasons of freshening was estimated for 20 sets of records, all combinations of cows of two ages in five feeding groups in two locations, New York and New England.

Following Keown (4), the model assumed for records in each age-group-lactation subclass was:

$$Y_{ijk} = HY_i + SS_j + e_{ijk}$$

where Y_{ijk} is the test day production in the ith herd-year (HY) and the jth season-stage of lactation (SS). The e's are random errors which are distributed with a mean of 0 and a block diagonal covariance matrix (V) where each block is a matrix of order the number of test days per cow and is the covariance matrix for those test days in the cow's record. The season-stage effects were defined to permit the season to exert different effects on the lactation curve. The seasons were defined as six successive 2-mo groups with season 1 being January and February. Nineteen stages of lactation were considered as in Table 2. The length of each stage was varied relative to how rapidly daily production changed. Therefore, 5-day stages were used near the peak of production and 30-day stages for the declining part of lactation. Short lengths for stages also were used at the end of lactation to reflect the period of sharper decline in production then. Nineteen stages for each of six seasons yielded 114 values to be estimated for each of the 20 sets of records. The model in matrix notation was $Y = X_1b_1 + X_2b_2 + e$, where b_1 is the vector of herd-year effects and b_2 is the vector of season-stage effects, and X_1 and X_2 are the incidence matrices for those effects. Estimates of the season-stage effects were obtained by solving the following equations for b_2:

$$\begin{bmatrix} X_1'V^{-1}X_1 & X_1'V^{-1}X_2 \\ X_2'V^{-1}X_1 & X_2'V^{-1}X_2 \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} X_1'V^{-1}Y \\ X_2'V^{-1}Y \end{bmatrix}$$

The variances and covariances which make up the blocks comprising V were estimated within herd-year for each of the 20 sets of data. The test day records on each cow were classified into one of 12 groups depending on her days in milk when the test day occurred. The 12-days-in-milk groups are in Table 3. A comparison with Table 2 shows that these groups either include several stages of lactation or

TABLE 1. Number of records in location, age at freshening, and % net energy from concentrates subclass.

Feeding group	% Net energy from concentrates	Number of records			
		New York		New England	
		<36 mo	60–72 mo	<36 mo	60–72 mo
1	⩽37	28,208	13,694	8,017	3,824
2	38–42	45,505	19,612	15,080	6,263
3	43–46	47,488	19,787	18,668	7,328
4	47–50	39,228	15,829	20,361	7,757
5	⩾51	68,306	26,112	42,422	15,109

TABLE 2. A comparison of solutions[a] for season-stage of lactation effects in herds fed different proportions of concentrates in New York State for cows freshening in January and February at less than 36 mo of age.

Day at end of stage	Stage no.	% Net energy from concentrate group				
		≤37	38–42	43–46	47–50	≥51
20	1	3.18	2.61	2.44	2.66	2.20
25	2	4.08	3.81	3.91	4.13	3.86
30	3	4.30	4.15	4.30	4.29	4.09
35	4	4.44	4.20	4.47	4.63	4.35
40	5	4.45	4.30	4.36	4.59	4.42
45	6	4.44	4.13	4.48	4.66	4.40
50	7	4.22	4.11	4.34	4.50	4.29
60	8	4.13	4.15	4.25	4.45	4.28
70	9	3.58	3.75	3.91	4.17	3.88
90	10	3.24	3.23	3.38	3.74	3.48
120	11	2.62	2.66	2.72	3.05	2.83
150	12	1.49	1.48	1.58	1.76	1.67
180	13	-.39	-.42	-.30	-.11	-.15
210	14	-1.98	-2.02	-1.90	-1.75	-1.70
240	15	-3.39	-3.37	-3.33	-3.16	-3.22
270	16	-5.21	-5.26	-5.23	-5.08	-5.19
285	17	-7.55	-7.70	-7.72	-7.45	-7.69
295	18	-9.10	-9.19	-9.35	-9.47	-9.36
305	19	-10.96	-11.52	-11.73	-12.20	-11.88

[a]The solutions are deviations from the average season-stage effect for each feeding group.

are the same as the stages. The longer intervals are necessary to allow a sufficient number of cows to have test days in adjacent groups so that covariances could be estimated. All cows were required to have at least 7 test days in a lactation period. If a cow went dry at less than 305 days, her production was included as zero for additional test days at 30-day intervals following her last test to complete a 305-day period.

The herd-year equations were absorbed into the season-stage equations making the coefficient matrix small enough to be inverted easily. For these generalized least squares equations, the accuracy of the calculations for absorption was checked as with ordinary least squares equations, by determining if the elements of each row of the resulting coefficient matrix summed to zero and if the right-hand sides summed to zero. The equations after absorption were not full rank since in the original form, the herd-year equations add to the stage-season equations. A Lagrange equation was added as a constraint to obtain a solution which forced the solutions to sum to zero. The augmented matrix was inverted and solutions obtained.

RESULTS AND DISCUSSION

Estimates of the variances and covariances among test day production from the data in the middle feeding group for cows less than 36 mo of age at freshening from New York State are in Table 3. These estimates illustrate trends in all 20 sets of records. Covariances declined as the test days became more separated in time. The records were least variable in the middle portion of lactation. Data from cows which ceased production before 305 days contributed to the larger variances in the last part of lactation since their production was zero. The generalized least squares procedure weights the data by the inverse of V. Therefore, the test days with the smallest variance are the most important in determining the solutions.

An example of the influence of the proportion of concentrates fed is in Table 2 which lists solutions for the season-stage effects for young cows freshening in January or February. The season-stage solutions for the different feeding groups were similar, indicating that the shape of the lactation curve was not affected greatly by the fraction of net energy from concentrates reported in DHI records. This similarity of the

TABLE 3. Estimated covariance matrix of test day milk production (kg) for cows less than 36 mo of age in New York in herds with 43 to 46% net energy from concentrates.

Days at end of period	Group[a]	Stage of lactation 1	2	3	4	5	6	7	8	9	10	11	12
20	1	11.5	5.1	6.8	6.2	5.4	4.7	4.1	3.4	2.8	2.1	1.4	1.4
40	2		11.9	7.1	7.9	6.8	6.0	5.4	4.7	4.1	3.4	2.7	2.1
60	3			11.3	8.0	7.1	6.4	5.6	5.0	4.3	3.5	2.8	2.5
90	4				11.1	8.1	7.2	6.5	5.7	5.1	4.3	3.5	2.8
120	5					10.3	7.6	6.8	6.2	5.6	5.0	4.1	3.2
150	6						9.6	7.3	6.6	6.0	5.4	4.9	3.7
180	7							9.2	7.2	6.6	6.0	5.4	4.4
210	8								9.3	7.5	7.0	6.3	5.2
240	9		Symmetric							10.2	9.1	8.1	6.6
270	10										14.5	12.6	10.1
295	11											26.6	15.5
315	12												36.3

[a]These are the groupings of days in milk used for estimating the variances and covariances of test days.

solutions was also evident for the other seasons of freshening and for the older age group. It was possible for the solutions to be similar and the actual production to vary by proportion of concentrate groups as in Table 4, since the solutions in each set were relative to all other solutions for that particular set of records and were not estimates of absolute daily yields. The close similarity among the solutions for all feeding groups indicated that the shape of the production curves was similar for all groups. Because actual production was higher for groups fed a greater proportion of concentrates, their curves were higher but with the same shape.

An example of the effect of season of freshening is in Fig. 1. Lactation curves of cows which freshened in March or April had higher peaks and declined more rapidly than curves of cows in the July–August group. The November–December group produced more than the July–August group until about 230 days and then dropped off sharply showing the effect of the summer months on cows in late lactation. These trends also were evident in the other proportion of concentrate groups.

An example of the effect of age is in Fig. 2 which illustrates that daily production of young cows declines less during the lactation than that of older cows. On an absolute scale, older cows produce more during the entire period, and their lactation yield advantage comes largely from early lactation. The solutions for the New England records followed the same pattern as

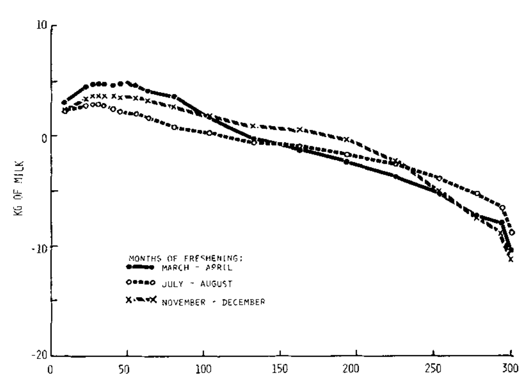

FIG. 1. Lactation curves for different seasons for New York State cows less than 36 mo of age from the low proportion of concentrates group. Points are deviations from the average season-stage effect.

TABLE 4. Average of season-stage milk production means (kg).

Age at freshening	Location	% Net energy from concentrate group ≤37	38–42	43–46	47–50	≥51
<36 months	NY	16.8	17.9	18.5	18.8	18.9
	NE	15.1	16.1	16.8	18.4	18.9
60–72 months	NY	21.9	23.4	24.1	24.6	24.6
	NE	21.3	22.7	23.8	24.2	24.7

for those from New York State, and there was little effect due to feeding group in either location, as in Table 5.

Lactation extension factors depend on the height as well as the shape of the lactation curve. As shown in the following example, the factor for 35 days in milk differs depending on mean production. The extension factor for a record of 35 days is the ratio of 305-day production to 35-day production. To calculate these cumulative productions, the solutions from Table 3 for the high group and the means from Table 4 for cows <36 mo of age in New York will be used. To illustrate the effect of the mean, factors using the same solutions with the means from the low and high groups will be calculated. The required production values are computed as follows:

$$CP_n = \sum_{i=1}^{n} S_i + n\bar{d}$$

CP_n is the cumulative production through day n; S_i is the solution from Table 3 for the ith day in milk. The solutions for all days within a stage are the same. $\bar{d}$ is the average from Table 4.

TABLE 5. Representative season-stage effects of 2 net energy from concentrate groups, 2 locations, and 2 ages (kg)[a].

Period (days)	Location	Mar–Apr 38–42	Mar–Apr 47–50	Jul–Aug 38–42	Jul–Aug 47–50	Nov–Dec 38–42	Nov–Dec 47–50
				Less than 36 mo at freshening			
26–30	NY	4.51	4.39	3.15	2.78	3.61	3.53
	NE	4.15	4.37	3.20	3.05	3.46	3.43
71–90	NY	3.57	3.73	1.21	1.17	2.87	2.99
	NE	3.33	3.74	1.18	1.02	2.60	2.88
211–240	NY	-3.56	-3.41	-2.22	-2.36	-2.54	-2.56
	NE	-3.54	-3.50	-2.77	-2.72	-2.22	-2.05
				60–72 mo at freshening			
26–30	NY	8.80	8.01	5.65	5.96	6.99	7.96
	NE	7.97	8.45	5.77	6.20	7.05	7.57
71–90	NY	6.56	6.72	2.43	2.54	5.01	5.55
	NE	6.36	7.07	2.41	2.44	4.57	4.93
211–240	NY	-7.16	-7.71	-6.85	-7.27	-5.38	-5.47
	NE	-7.04	-7.46	-7.34	-7.93	-5.38	-5.55

[a]The values are deviations from the average season-stage effect for the particular location, feeding group, age subclass.

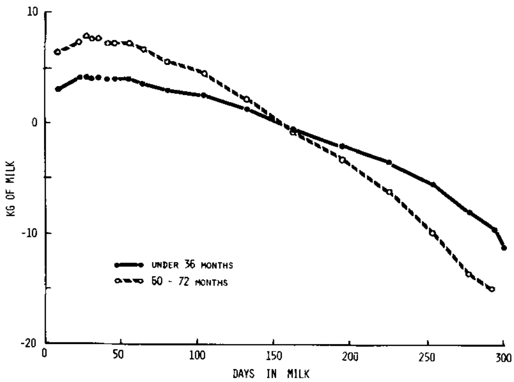

FIG. 2. A comparison of lactation curves for two ages of New York cows freshening in January or February from the low proportion of concentrates group (the two curves are deviations from their respective season-stage mean effects).

For the low mean

$$CP_{35} = (105.5 + 588)\text{kg} = 693.5 \text{ kg}$$

$$CP_{305} = (-178.3 + 5124)\text{kg} = 4945.7 \text{ kg}$$

$$\text{Factor}_{35} = CP_{305}/CP_{35} = 7.13$$

For the high mean

$$CP_{35} = (105.5 + 661.5)\text{kg} = 767.0 \text{ kg}$$

$$CP_{305} = (-178.3 + 5764.5)\text{kg} = 5586.2$$

$$\text{Factor}_{35} = CP_{35}/CP_{305} = 7.28$$

On a part record of 700 kg, this would result in a 105-kg difference in estimated 305-day yield due to the difference in means and not to any difference in shape of the lactation curve.

CONCLUSIONS

This work indicates that the proportion of concentrates fed as measured on a herd basis and reported in DHI records did not define groups of records with different lactation curves of different shapes. Since an important application of knowledge of lactation curves is extending part records to a 305-day equivalent, there is little support for employing the proportion of net energy from concentrates information when extending records, although improved accuracy might be possible by using herd average production.

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