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Abstract

The data consisted of 204,558 complete Holstein lactations in 2,100 herds compiled by the New York Dairy Records Processing Laboratory from 1959 to 1969 All lactation records had to have a 9th or 10th test day to be complete. The generalized least squares analysis used a model including mean, herd-year, and season-age-stage as fixed effects. The error term included random effects of cow and residual variation. Means for specified stages of lactation for milk and fat were estimated for lactations 1, 2, 3, and 4 or greater which were grouped by age of freshening, two age groups for the first three lactations and cne for fourth and later lactations.

Extension factors differed from current United States Department of Agriculture factors. The new factors emphasize the need to consider lactation number, season, and age at freshening in extending lactation records in progress. Extension factors differ for each lactation, especially between the first two and later lactations. To consider season of freshening is important for early stages of lactation. Age is important for factors for early stages of lactation but less so as length of lactation increases. Differences due to age also become less important as lactation number increases. Factors for third and later lactations are only slightly affected by age of cow.

Introduction

Reasons are several for extending records in progress to 305 days. The most important is to incorporate as many daughters as possible into evaluation of a sire. Presently, a substantial number of records on a bull are eliminated from sire evaluation procedures because only completed records for a given season are included. The second advantage of extended records is the early detection of high producing cows for planned matings.

Many workers (1, 2, 4, 5, 12, 13, 14) have developed factors for extending records in progress to complete 305-day lactation yield. From these reports extension factors can aid more rapid evaluation of sires and identification of the best dams for breeding to top artificial insemination (AI) sires in planned matings.

Extension factors currently in use by USDA were estimated by McDaniel et al. (5) from a combination of data compiled by USDA, Michigan, and Iowa State Processing Centers. These factors are also a combination of factors derived by McGilliard (6, 7). Two age groups were used, and separate factors were developed for cows less than 36 mo old and for cows greater than or equal to 36 mo of age.

The USDA report states that projection factors vary substantially between breeds and age groups and that different factors are needed for milk and fat. The rationale for only two age groups was based on findings by Lamb and McGilliard (4) and McDaniel et al. (5) that major differences from age lie between cows less than 36 mo of age and those greater than 36 mo of age. Season of calving was ignored for USDA factors. Other workers (11, 13) developing factors for extending part lactation records found age, season, and month of lactation were important sources of variation to consider in developing extension factors.

Materials and Methods

The data consisted of 204,558 complete Holstein lactations compiled by the Dairy Records Processing Laboratory at Cornell University including over 2,100 herds in New York state from 1959 to 1969. Each individual record consisted of 9 or 10 monthly test day milk weights and corresponding fat percentages for each test day. Records without a 9th or 10th test day were deleted because they do not provide a satisfactory basis for estimation of production at the end of the lactation.

The model describing individual observations for a specified lactation was:

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TABLE 1. Number of complete lactation records and overall daily milk and fat means for estimating extension factors by lactation.

Lactation	Number of records	Milk	Fat
		(kg)	
1	60,311	17.3	.64
2	42,528	19.8	.73
3	45,549	21.5	.80
≥ 4	56,170	21.8	.81

$$y_{ijk} = \mu + (HY)_i + (SAS)_j + \varepsilon_{ijk} = XS + \varepsilon$$

where y_{ijk} is the amount of milk or fat produced for an individual test day sample in the i^{th} herd-year and the j^{th} season-age-stage; μ is an unknown constant; $(HY)_i$ is the effect of the i^{th} herd-year; $(SAS)_j$ is the effect due to the j^{th} season-age-stage where there are 6 season-ages of freshening and 19 stages of lactation assigned by days in milk for test day samples; ε_{ijk} is the random effect associated with the k^{th} cow in the j^{th} season-age-stage and the i^{th} herd-year of freshening; X is the design matrix of μ, HY, and SAS; and S is the solution vector for μ, HY, and SAS.

The $(HY)_i$ and $(SAS)_j$ are fixed, and ε_{ijk} contains the random components due to cow and error and has zero mean and known variance-covariance matrix $V\sigma^2_e$.

Numbers of complete lactations in each analysis are in Table 1. The three seasons of freshening were Season 1 January to April, Season 2 May to August, and Season 3 September to December.

Age groups were assigned within lactations as in Table 2. Two age groups were assigned for lactations 1 through 3 and one age group for lactations 4 or greater. We attempted to stratify production since higher producing herds tend to calve earlier.

TABLE 2. Age groups at freshening for each lactation number.

Lactation	Age group	Age at freshening
		(mo)
1	1	≤ 28
	2	> 28
2	1	≤ 41
	2	> 41
3	1	≤ 53
	2	> 53
≥ 4	All grouped in one age category	

TABLE 3. Stages of lactation assigned by days in milk for test day samples along with intervals for each stage to find means for age-season of freshening.

Stage	Days in milk	Intervals in days (d_i)
1	0 - 20	20
2	21 - 25	5
3	26 - 30	5
4	31 - 35	5
5	36 - 40	5
6	41 - 45	5
7	46 - 50	5
8	51 - 60	10
9	61 - 70	10
10	71 - 90	20
11	91 - 120	30
12	121 - 150	30
13	151 - 180	30
14	181 - 210	30
15	211 - 240	30
16	241 - 270	30
17	271 - 285	15
18	286 - 295	10
19	296 - 315	10

A stage of lactation was assigned to each test day sample as in Table 3. Stages were assigned at differing intervals to estimate more accurately the lactation curve which can be divided into three segments:

1) The part from the day of freshening to the peak production is nonlinear and increases at a decreasing rate to the peak.

2) The part from the peak to approximately 270 days in milk is more nearly linear than the first grouping and, therefore, intervals can be larger.

3) The part near the end of lactation is when production decreases at an increasing rate and, therefore, intervals can be smaller.

Given three season groupings, two ages for each lactation, and 19 stages, the number of season-age-stages are 114 for lactations 1, 2, and 3, and 57 for lactations 4 and greater.

Estimates of season-age-stage subgroup effects were calculated by generalized least squares procedure as outlined by Searle (10) and Henderson (3). This method involved minimizing the following equations with respect to S where the variance-covariance matrix of ε is $V(\varepsilon) = V\sigma^2_e$: $(y - XS)'V^{-1}(y - XS)$. This leads to: $S = (X'V^{-1}X)^{-1}X'V^{-1}y$ where $(X'V^{-1}X)$ is the coefficient matrix of S in the normal equations adjusted for correlated errors. S is the solution vector for μ, herd-years, and season-age-stages. The variance-covariance matrix (V) is an estimate of the relationship between the production of a cow for particular stages in milk.

The variance-covariance matrix was estimated from data in the analyses for the entire 19 × 19 matrix by assigning each test day sample by the days in milk to a particular stage. Variance and covariances for adjacent test day intervals were so similar that with rounding errors, prohibited an inverse. This problem was solved by a 19 × 19 inverse matrix with elements derived from a 10 × 10 inverse matrix of test days rather than stages. This 10 × 10 inverse was expanded to a 19 × 19 inverse and analyzed. As an example, the covariance between stage 1 and stage 2 was the same as the covariance between stage 1 and stage 3. Expansion of the 10 × 10 inverse matrix of test days to a 19 × 19 inverse of stages is in Table 4. Calculations were separate for individual lactations to reduce the problem of bias from selection that would arise if subsequent lactations on the same cow were included in the analysis.

TABLE 4. Inverse elements of test day variance-covariance matrix (V^{-1}) as assigned to stages for milk and fat.

Stages	1 2 3	4 5 6 7 8	9 10	11	12	13	14	15	16	17 18 19
1 2 3	1, 1(a)	1, 2	1, 3	1, 4	1, 5	1, 6	1, 7	1, 8	1, 9	1, 10
4 5 6 7 8		2, 2	2, 3	2, 4	2, 5	2, 6	2, 7	2, 8	2, 9	2, 10
9 10			3, 3	3, 4	3, 5	3, 6	3, 7	3, 8	3, 9	3, 10
11				4, 4	4, 5	4, 6	4, 7	4, 8	4, 9	4, 10
12					5, 5	5, 6	5, 7	5, 8	5, 9	5, 10
13						6, 6	6, 7	6, 8	6, 9	6, 10
14							7, 7	7, 8	7, 9	7, 10
15								8, 8	8, 9	8, 10
16									9, 9	9, 10
17 18 19										10, 10

(a) Inverse Elements of V. C. V. Matrix of Test Day Data

First records on a cow generally are unselected; i.e., most cows are allowed to complete an entire first lactation before being culled. Second records on the same cows, however, are not free of bias from selection since only the better first lactation cows are allowed to remain in the herd and complete subsequent lactations. Therefore, when extension factors are from all lactations, additional statistical procedures are required to correct for this bias due to selection.

Another problem, somewhat analogous to the first, is the problem of using the correct V^{-1} matrix in the analysis. If more than one lactation were included in the analysis, the V^{-1} matrix must be augmented with subsequent lactation season-age-stages; the problem then is inversion of a matrix that has dimensions ($19n \times 19n$) where n is the number of lactations in the analysis. The inverse for subsequent records on the same cow also would include covariances between all stages of all lactations for any given cow. Therefore, if a cow had a first and a second lactation, the inverse matrix would be of the order (38×38) whereas if the cow had three records it would be of the order (57×57). By this method memory capacity of the computer is rapidly depleted because the differing number of inverses that must be stored is large.

Equations were collected for 114 season-age-stages absorbing herd-year equations as they were collected (3, 10). The absorption process in the generalized least squares procedure is more complicated since the design matrix must be multiplied by the inverse of the variance-covariance matrix. In this case, however, each record which may consist of up to 10 individual test day milk or fat weights is multiplied by the V^{-1} matrix. Since any one record can have only one sample in any period, this is simplified by summing the diagonal and off diagonal elements in the 19×19 inverse corresponding to the test day intervals.

The process of absorbing herd-year equations while collecting the equations facilitates calculation and requires storage of 115 equations at any time (114 equations for season-age-stages and 1 herd-year equation). Herd-years have solutions, but computationally they are impossible to estimate. Solutions for season-age-stage, however, are adjusted for herd-years. The number of herd-years absorbed for each lactation is in Table 5.

Rank of the coefficient matrix ($X'V^{-1}X$) is two less than its order since the season-age-stage (SAS) equations sum to the μ equation; and since herd-years have been absorbed, the rank of the absorbed coefficient matrix is one less as unabsorbed herd-year equations sum to the season-age-stage equations. Thus, two constraints must be imposed to obtain solutions, one constraint being the μ equation and the other a LaGrange multiplier that forced the sum of the solutions to be zero. Accuracy of the solutions was tested by regenerating right sides of the equations and observing how different these were from the actual right sides. All checks on the solutions were within 1/1000 of the actual right sides.

TABLE 5. Number of herd-years absorbed by lactations.

Lactation number	Herd-years absorbed
1	8207
2	7838
3	7956
$\geq$ 4	8067

To obtain multiplicative extension factors a mean must be added to the SAS solutions. This mean was the weighted mean for both ages over all test days. This overall weighted mean, $\hat{\mu}$, then was added to solution vectors (s_i). ($\hat{\mu} + s_i$) was then multiplied by the number of days (d_i) in milk for a particular stage. Intervals are in Table 3 along with the corresponding stage.

Appropriate means ($\hat{\mu}$) added to solutions to arrive at estimates are in Table 1. The average yield for each season-age subgroup peaked during the eighth stage, the 50th to 60th day of lactation. Wadell and Everett (14) showed that for the Cornell herd, peak production occurred at approximately 55 days, which agrees with these results.

The mean 305-day production from this procedure for a given season-age of freshening is $\sum_{i=1}^{19} d_i (\hat{\mu} + s_i) = P_j$. The six season-age means (P_j's) for each lactation were used to calculate ratio factors.

The extension factors are the ratio of the 305-day mean for a given season-age of freshening divided by the mean production for a particular length of time, n, in production:

$$(\text{E. F.})_n = P_j / \sum_{i=1}^{n} d_i (\hat{\mu} + s_i).$$

TABLE 6. Average production of milk for each lactation-age-season group.

Ages nested in lactations	Lactation 1	2	3	≥ 4
	(kg)			
Age 1				
Season 1	5122	5818	6378	6290
Season 2	5312	6016	6747	6839
Season 3	5114	5852	6407	6408
Age 2				
Season 1	5052	5811	6258	
Season 2	5199	5927	6586	
Season 3	5070	5785	6334	
Overall averages	5145	5868	6452	6512

Results and Discussion

Extension factors currently used developed by McDaniel et al. (5) are a combination of material collected from Iowa and Michigan Processing Centers. USDA factors are daily extension factors for each of two age groups, less than 36 mo of age and greater than or equal to 36 mo of age. Age and breed are the only variables taken into account in deriving these factors. USDA factors differ from our factors since they do not account for season and age within lactation and were derived solely from midwest data that may not be representative of all geographical areas.

Mean lactation production for each season-age (P_j) for milk is in Table 6. Table 6 shows highest average production for cows freshening in the second season (May to August). Production of cows calving in this season is consistently higher than other seasons for any age grouping.

The P_j for kilograms of fat for particular age-season groups is in Table 7. Trends are the same for fat yield as for milk of Table 6. Values in parentheses in Table 7 refer to average fat percentage for age-season groupings. These were calculated by dividing P_j for fat by P_j for milk. These percentages indicate that the second season (May to August) has the lowest fat percentage for any lactation-age group. This coincides with the season that has the highest mean production.

Extension factors for milk and fat are in Table 8 for first lactation records. Factors for other lactations for both milk and fat are in Tables 9 to 11. There is a seasonal effect for early stages of lactation. In Table 8 there is a marked difference between the two ages included in the first lactation. Factors are higher than those reported by McDaniel et al. (5) which do not account for season of freshening.

Factors become increasingly similar as stage of lactation increases. Once the peak period of production (stage 8, 50 to 60 days) has been reached, factors become much more uniform for seasons and for ages. If condensation of factors is desired, it would be best to combine those after the peak production. However, a small difference in an extension factor can make a difference of several hundred kilograms of milk in the extended record. Caution should be used in attempting to reduce the number of factors for computational ease. Daily factors have been calculated and are available upon request from the Animal Science Department at Cornell University.

Extension factors for the second and greater lactations (Tables 9 to 11) also show great seasonal as well as age differences. Age effects seem to decrease as lactation number increases. Seasonal differences also are less for third and greater lactations. Major differences in first and second lactations are important since the majority of records in progress that would be extended are in the first two lactations.

TABLE 7. Average production of fat and fat percent for each lactation-age-season group.

Age and season groups	Lactation 1	2	3	≥ 4
	kg (%)			
Age 1				
Season 1	195 (3.8)	226 (3.9)	244 (3.8)	245 (3.9)
Season 2	198 (3.7)	226 (3.8)	245 (3.6)	247 (3.6)
Season 3	194 (3.8)	225 (3.8)	245 (3.8)	245 (3.8)
Age 2				
Season 1	193 (3.8)	225 (3.9)	246 (3.9)	
Season 2	195 (3.7)	225 (3.8)	247 (3.8)	
Season 3	192 (3.8)	223 (3.8)	246 (3.9)	
Overall averages	194 (3.8)	225 (3.8)	245 (3.8)	245 (3.8)

TABLE 8. Multiplicative extension factors for yield of milk and fat by stages for the first lactation.

	Age ≤ 28 mo			Age > 28 mo		
Stage	Season 1	Season 2	Season 3	Season 1	Season 2	Season 3
			Milk yield			
1	15.374	16.474	15.594	16.867	14.896	15.203
2	12.064	12.756	12.266	12.977	11.690	11.914
3	9.836	10.362	10.038	10.508	9.579	9.725
4	8.249	8.658	8.442	8.691	8.050	8.164
5	7.089	7.427	7.259	7.418	6.941	7.032
6	6.216	6.495	6.373	6.477	6.091	6.176
7	5.527	5.775	5.676	5.728	5.433	5.505
8	4.489	4.699	4.642	4.588	4.451	4.502
9	3.791	3.981	3.930	3.847	3.786	3.817
10	2.899	3.060	3.022	2.899	2.932	2.944
11	2.166	2.298	2.263	2.148	2.222	2.214
12	1.747	1.856	1.825	1.730	1.808	1.792
13	1.482	1.565	1.537	1.467	1.534	1.517
14	1.301	1.359	1.334	1.288	1.340	1.322
15	1.168	1.206	1.185	1.158	1.196	1.179
16	1.071	1.090	1.076	1.064	1.086	1.073
17	1.036	1.048	1.039	1.032	1.046	1.036
18	1.018	1.023	1.019	1.016	1.022	1.017
19	.998	.998	.999	.997	.999	.998
			Fat yield			
1	15.498	15.476	15.520	17.119	16.539	15.918
2	11.979	12.202	12.095	12.905	12.609	12.246
3	9.761	10.134	9.885	10.637	10.270	9.917
4	8.190	8.583	8.292	8.820	8.558	8.249
5	7.063	7.445	7.136	7.592	7.353	7.082
6	6.223	6.591	6.290	6.713	6.455	6.229
7	5.569	5.922	5.635	6.046	5.781	5.589
8	4.518	4.843	4.636	4.759	4.722	4.583
9	3.841	4.138	3.943	4.008	4.019	3.888
10	2.946	3.187	3.054	3.009	3.102	3.012
11	2.212	2.390	2.298	2.223	2.334	2.267
12	1.789	1.922	1.856	1.787	1.885	1.833
13	1.518	1.612	1.561	1.511	1.587	1.547
14	1.329	1.390	1.352	1.319	1.375	1.343
15	1.187	1.224	1.197	1.177	1.216	1.193
16	1.079	1.098	1.082	1.070	1.095	1.079
17	1.041	1.052	1.042	1.035	1.049	1.039
18	1.021	1.026	1.021	1.019	1.024	1.019
19	.998	.999	.999	.997	.998	.998

Factors for milk that have been developed from New York data show that USDA factors have been underestimating extended lactation production. Seasonal differences in New York factors show that this source of variation should be taken into account for extending records in progress. Differences due to age, especially in first lactation, show that cows that freshen early have been sharply penalized if their records have been extended by USDA factors.

Table 8 also lists extension factors for fat for first lactation. Factors for fat are much more uniform over seasons and ages than those for milk as expected since fat production is not as variable as milk. Factors for lactation 1 are similar for all age-season subgroups.

Factors for fat and milk are not similar; there is a definite need for different factors for extending milk and fat records. USDA factors differ for milk and fat; USDA factors for fat are consistently lower for stage than the ones in Tables 9 to 11.

Another difference between these factors and USDA factors is that the new factors have been adjusted for the particular herd and year

TABLE 9. Multiplicative extension factors for yield of milk and fat by stages for the second lactation.

Stage	Age ≤ 41 mo			Age > 41 mo		
	Season 1	Season 2	Season 3	Season 1	Season 2	Season 3
	Milk yield					
1	15.179	18.093	14.959	15.590	17.916	15.233
2	11.769	13.607	11.621	12.499	13.383	11.808
3	9.589	10.882	9.462	10.376	10.684	9.602
4	7.995	8.895	7.926	8.652	8.715	7.995
5	6.830	7.521	6.807	7.390	7.359	6.855
6	5.967	6.514	5.969	6.487	6.375	6.011
7	5.292	5.752	5.311	5.765	5.632	5.339
8	4.256	4.600	4.315	4.550	4.492	4.316
9	3.579	3.855	3.651	3.784	3.767	3.645
10	2.716	2.917	2.804	2.812	2.857	2.790
11	2.028	2.174	2.111	2.066	2.135	2.095
12	1.644	1.757	1.715	1.660	1.731	1.703
13	1.404	1.490	1.457	1.410	1.471	1.449
14	1.242	1.303	1.277	1.242	1.291	1.272
15	1.126	1.167	1.146	1.124	1.159	1.143
16	1.046	1.067	1.055	1.042	1.063	1.052
17	1.023	1.034	1.027	1.022	1.031	1.025
18	1.011	1.016	1.013	1.009	1.015	1.012
19	.997	.997	.998	.997	.997	.998
	Fat yield					
1	15.305	17.652	14.870	15.378	17.592	15.964
2	11.554	13.480	11.417	12.287	13.379	12.098
3	9.508	11.060	9.319	10.760	10.942	9.823
4	7.978	9.174	7.816	9.047	9.000	8.141
5	6.867	7.852	6.747	7.827	7.688	6.982
6	6.052	6.902	5.958	7.010	6.741	6.162
7	5.411	6.173	5.348	6.342	6.040	5.517
8	4.341	4.924	4.365	4.907	4.819	4.458
9	3.689	4.151	3.716	4.096	4.058	3.781
10	2.805	3.126	2.868	3.011	3.069	2.897
11	2.103	2.308	2.164	2.191	2.271	2.172
12	1.706	1.847	1.757	1.749	1.823	1.758
13	1.453	1.550	1.489	1.474	1.534	1.489
14	1.279	1.343	1.300	1.286	1.333	1.300
15	1.151	1.191	1.163	1.151	1.185	1.162
16	1.059	1.079	1.064	1.054	1.077	1.062
17	1.031	1.042	1.032	1.027	1.039	1.031
18	1.016	1.020	1.016	1.016	1.019	1.015
19	.997	.997	.998	.997	.997	.998

in which the cow freshened. Miller (8) reported that the herd-year of freshening is important and does influence production.

Graphing the estimates of daily production leads to important conclusions that otherwise might not be readily apparent. An example of the graphs is in Fig. 1. The graph can be divided into three parts. Part 1 shows how production increases at a decreasing rate up to peak production between 50 and 60 days in milk. This part of the curve is nonlinear, and an exact function to describe this part of the curve would be difficult to formulate. Part 2 shows how production decreases once the peak has been reached. This section of the curve from the peak to 270 days in milk is linear and is decreasing at a nearly constant amount from stage to stage. This portion of the curve is uniform and would be easy to approximate by a function. Part 3 from 270 days in milk shows how the slope of the curve is decreasing at an increasing rate. One reason for the rapid decrease may be the effect the developing fetus is exerting on production. Schaeffer and Henderson (9) reported that farmers in the Northeast breed their cows back an aver-

TABLE 10. Multiplicative extension factors for yield of milk and fat by stages for the third lactation.

Stage	Age ≤ 53 mo Season 1	Age ≤ 53 mo Season 2	Age ≤ 53 mo Season 3	Age > 53 mo Season 1	Age > 53 mo Season 2	Age > 53 mo Season 3
	Milk yield					
1	18.530	16.593	16.683	16.684	18.548	15.182
2	14.058	13.257	12.814	12.868	13.981	11.788
3	11.313	11.098	10.366	10.403	11.150	9.567
4	9.283	9.230	8.606	8.594	9.056	7.996
5	7.851	7.834	7.345	7.300	7.616	6.847
6	6.798	6.835	6.395	6.348	6.572	5.995
7	5.967	6.073	5.654	5.597	5.793	5.322
8	4.675	4.814	4.514	4.440	4.595	4.298
9	3.873	4.000	3.788	3.696	3.827	3.627
10	2.858	2.984	2.859	2.759	2.874	2.769
11	2.086	2.191	2.125	2.032	2.131	2.078
12	1.668	1.758	1.715	1.637	1.723	1.689
13	1.412	1.485	1.452	1.393	1.464	1.438
14	1.242	1.297	1.270	1.231	1.285	1.263
15	1.123	1.161	1.140	1.117	1.156	1.138
16	1.042	1.062	1.050	1.041	1.061	1.050
17	1.020	1.031	1.024	1.019	1.030	1.024
18	1.009	1.015	1.011	1.009	1.014	1.011
19	.996	.997	.997	.997	.996	.998
	Fat yield					
1	17.142	19.716	21.948	16.045	18.313	14.300
2	12.992	14.643	17.122	12.293	13.984	11.058
3	10.533	11.898	14.580	10.082	11.396	9.050
4	8.726	9.725	11.848	8.359	9.312	7.583
5	7.450	8.275	9.909	7.151	7.891	6.543
6	6.534	7.225	8.621	6.297	6.878	5.779
7	5.805	6.357	7.668	5.597	6.131	5.183
8	4.637	4.926	5.819	4.458	4.856	4.233
9	3.907	4.099	4.747	3.746	4.060	3.605
10	2.951	3.002	3.403	2.821	3.041	2.787
11	2.191	2.183	2.410	2.095	2.242	2.110
12	1.764	1.741	1.888	1.693	1.798	1.720
13	1.488	1.467	1.566	1.440	1.516	1.464
14	1.296	1.282	1.347	1.267	1.320	1.284
15	1.158	1.149	1.190	1.143	1.178	1.153
16	1.059	1.055	1.075	1.055	1.073	1.059
17	1.029	1.028	1.038	1.027	1.037	1.029
18	1.014	1.013	1.018	1.013	1.018	1.015
19	.997	.996	.996	.997	.997	.998

age of 100 days after freshening. A fetus exerts an effect on milk production approximately 22 wk after conception. Thus, the fetus influences production on the average at about 254 days (100 + [22 × 7]). Therefore, the decrease in production at the 240 to 270 day interval in Fig. 1 may be due, at least in part, to the development of the fetus.

From curves for different seasons and different ages, cows that calve earlier do not peak as high as those that calve at an older age for the same season grouping although younger cows decrease in production at a slower rate than older cows.

Cows that calve in season 1 have a higher peak production than those that calve in other seasons while cows that calve in season 3 have the lowest peak production.

Trends in the graph for milk yield also apply to fat yield.

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TABLE 11. Multiplicative extension factors for yield of milk and fat by stages for the fourth and greater lactations.

Stage	Season 1	Season 2	Season 3	Season 1	Season 2	Season 3
	Milk yield			Fat yield		
1	18.431	21.757	17.067	19.432	37.789	17.968
2	14.038	15.905	13.131	14.506	23.586	13.562
3	11.321	12.518	10.593	11.809	17.487	10.920
4	9.253	10.020	8.734	9.574	13.110	8.916
5	7.793	8.354	7.419	8.052	10.557	7.544
6	6.751	7.158	6.445	7.007	8.882	6.571
7	5.921	6.252	5.691	6.172	7.665	5.835
8	4.656	4.888	4.547	4.837	5.733	4.662
9	3.845	4.029	3.801	4.001	4.632	3.905
10	2.844	2.976	2.864	2.956	3.304	2.947
11	2.077	2.176	2.125	2.158	2.347	2.185
12	1.665	1.746	1.716	1.728	1.847	1.759
13	1.411	1.477	1.454	1.461	1.539	1.485
14	1.242	1.293	1.272	1.279	1.330	1.295
15	1.124	1.159	1.142	1.148	1.180	1.157
16	1.044	1.063	1.052	1.056	1.071	1.060
17	1.021	1.031	1.025	1.028	1.035	1.029
18	1.010	1.014	1.011	1.013	1.015	1.014
19	.996	.996	.997	.996	.994	.997

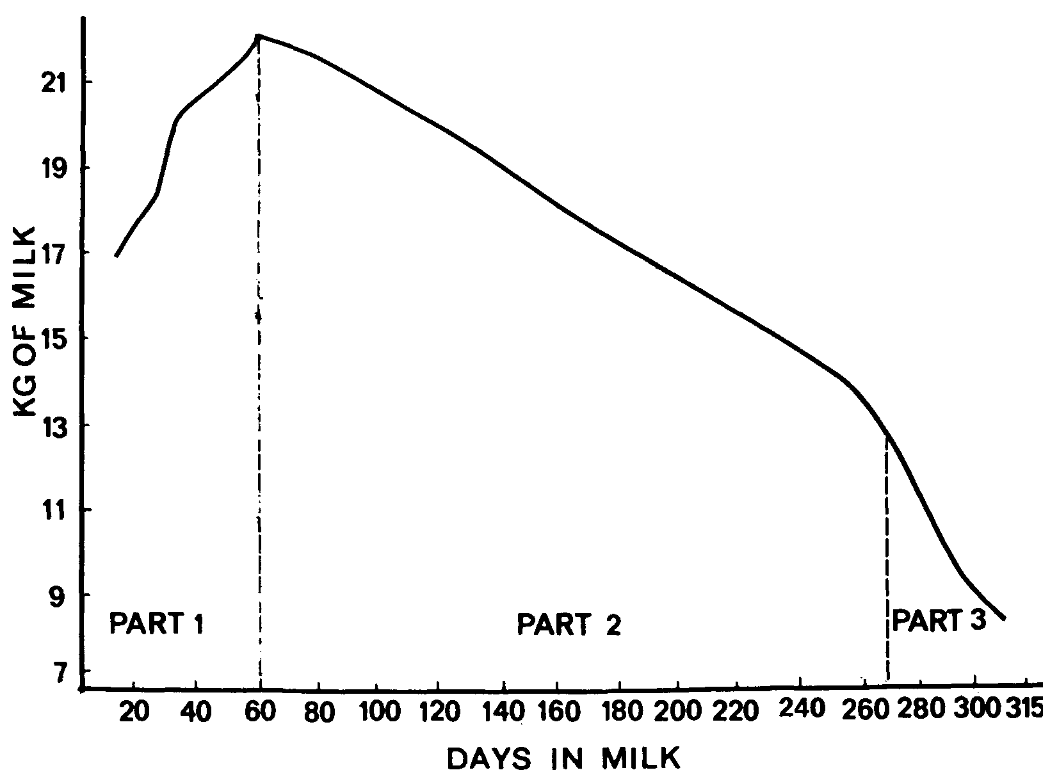

FIG. 1. Example of curves for estimates of daily production for milk.

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