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# Extension Factors for Trimester Yields of Milk and Fat

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## ABSTRACT

Evidence of problems with sire proofs of extended incomplete records suggests the desirability of another method of evaluating dairy bulls for milk that minimizes the need for extending records by instead considering yields of three parts of a lactation (days 1 to 90, 91 to 180, and 181 to 270) as distinct and separate traits. Records of less than 90 days (or 180 or 270 days) require extension to 90-day (or 180- or 270-day) equivalents. Last sample day production of 17,826, 15,282, and 12,115 first-lactation records of Holstein cows was used to calculate extension factors to predict remaining yields to days 90, 180, and 270 for months of freshening and days in milk. Cumulative remaining yield was computed as the product of days remaining to day 90, 180, or 270, yield on last sample day, and the appropriate extension factor. There were no differences in factors due to age, but factors were different for months of freshening and number of days in milk.

## INTRODUCTION

Standard procedures of sire evaluation for milk and fat yields in dairy cattle require 305-day equivalents for inclusion in the analysis. The reasons that are cited most frequently for extending incomplete or in-progress records are 1) reduction of bias from differential culling and 2) earlier identification of high producing cows for planned matings. Reports on extension factors and their application in dairy sire evaluation are in (3, 9, 11, 16). Studies have reaffirmed the appropriateness of extending incomplete records. Dommerholt (5) compared lactation curves and milk yields between incomplete and complete records of heifers and concluded that incomplete records can be used for estimating breeding values of sires by extrapolating such records. Famula and Van Vleck (6) also concluded that little accuracy in estimation of a sire's genetic merit was lost when part records of approximately 5 mo were extended and used to replace 305-day information. High genetic correlations between partial yields and complete yields also suggest evaluating sires on partial lactation records (14, 17).

In spite of the apparent high correlation between extended incomplete and complete records, there appear to be problems in the use of part-lactation records and extended records. First, indirect evidence suggests that inclusion of part records projected to a 305-day basis in sire evaluation may lead to proofs that change more than expected when more complete records are added later (2). Second, Famula and Van Vleck (8) examined relationships between sire evaluation and methods of extending records and found that sire proofs calculated entirely from extended incomplete records were overestimated. Their results showed that milk proofs from only complete records averaged 9% and 6% less than from extended incomplete records when records were extended from days 60 to 80 to 305 days and from days 130 to 160 to 305 days. No such differences existed between means for complete and incomplete records. The correlation coefficient between proofs from complete records and from incomplete records extended from 130 to 160 days was .94. The corresponding correlations for records extended from 60 to 80 days were from .66 to .81. These results suggest that proportion of incomplete records and length of periods over which they are extended might influence sire proofs. Selection based on early lactation production alone may increase

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production early in lactation relatively more than later in lactation and, thus, change the lactation curve (15). Extension factors that account for days open would be expected to increase accuracy of genetic evaluations, but the usefulness of adjustments for days open cannot be utilized fully when evaluations are based on first lactations if calculation of days open requires of second freshening. Danell (4) suggested separate evaluation of sires on part lactations of differing lengths, for example, 100, 200, and 305 days, as a means of rendering extension factors unnecessary. An overall breeding value for milk then could be found unnecessary. An overall breeding value for milk then could be found by combining the part indices. Lederer (10) has included milk yields over the first 100 days, second 100 days, and the next 105 days of the first lactation as distinct traits, with the entire 305-day yields of the second and third lactations in multiple trait sire evaluation.

The objective of this study was to develop extension factors for trimester (postpartum days 1 through 90, 91 to 180, and 181 to 270) yields that would be needed for an alternate sire evaluation procedure in which trimester yields would be distinct traits. Trimester traits would reduce the need to project records over long times. A review of methods for predicting total yield from part lactation records was presented by Danell (4). A method proposed by Miller et al. (12) and subsequently used in various forms (1, 5, 7, 18) appears to be the most precise of the methods available. The method estimates remaining yield by regression of the remaining part of the lactation on production of the last test day (LTD).

## MATERIALS AND METHODS

Data were obtained from two sources. Data from source 1 comprised first lactation milk production records on 2,400 Holstein cows from Cornell University's Teaching and Research Center (TRC) available from the Dairy Records Processing Laboratory (DRPL) at Ithaca, NY. Cows from this herd were sampled daily for milk. Data from source 2 were monthly test day milk and fat production records of first-lactation Holstein cows on Dairy Herd Improvement (DHI) program, also available from DRPL. Records of all cows with 3rd or 4th sample day on day 90 were selected for estimating factors for $M_{1,90}$ and $F_{1,90}$. There were 17,826 such cows. Similarly, 15,282 cows had their 6th or 7th sample day on day 180, and 12,115 cows had their 9th or 10th sample day on day 270. Sampling information of these cows was used to estimate factors for $M_{91,180}$, $F_{91,180}$ and $M_{181,270}$ and $F_{181,270}$. Milk and fat yields for these periods were designated as $M_{i,j}$ and $F_{i,j}$; $M_{1,270}$ and $F_{1,270}$ were included in this study as complete lactation information. With various parts as separate traits, the need for extension is minimized. For example, a record terminated or in progress on day 165 is extended to its 180-day equivalent instead of to 270- or 305-day equivalents, i.e., for 15 rather than 105 or 140 days.

Cumulative milk yields were obtained for each cow by direct addition of daily yields, in the case of TRC records, and by use of factors based on test interval method (TIM) developed by Everett (6) in the case of DHI records. His factors give lactation credits to three identifiable stages of the lactation curve. Data were classified into 12 calendar mo of freshening and two ages at freshening (≤ 30, > 30 mo).

The formulation of the last test day method suggests how to estimate the extension factors:

$$y_{ijk} = y^{o}_{ijk} + (DR_j * LT_{ijk} * FAC_i) \quad [1]$$

where:

$y_{ijk}$ = predicted record of the kth cow freshening in the ith month with last available sampling on the jth day of lactation,

$y^{o}_{ijk}$ = known cumulative production up to the jth day in production,

$DR_j$ = number of days between day j and the upper limit of the period defining the trait (i.e., 90, 180, or 270),

$LT_{ijk}$ = last sampling day production on day j, and

$FAC_i$ = extension factor for cows freshening in the ith month.

The extension factor, $FAC_i$ in [1], was derived as:

$$FAC_i = \sum_{k=1}^{n}\sum_{j=f}^{u} (y^{+}_{ik} - y^{o}_{ijk}) / \sum_{k=1}^{n}\sum_{j=f}^{u} (DR_j * LT_{ijk}) \quad [2]$$

for all sampling days comprising $y^o_{ijk}$, where $y^+_{ik}$ is the cumulative yield from day f to u, where f is the 1st day in interval (i.e., 1, 91, or 181), and u is the last sample day; n is the total number of cows in the ith classification; and $y^o_{ijk}$, $DR_j$, and $LT_{ijk}$ are the same as in [1].

Factors were developed for each day from the lower to the upper limit of the intervals. Visual inspection revealed similar factors for consecutive days within a season of freshening. Days in lactation, therefore, were regrouped, and factors were calculated for 15-day periods. Separate factors were calculated for two groups for age at freshening. Estimated milk yields ($M_{1,\ 90}$, $M_{91,\ 180}$, and $M_{181,\ 270}$) from a sample of data source 2 and based on the calculated factors were compared with corresponding cumulative yields computed from applying factors of (6) to test precision of the extended records. Test statistics were average deviation and mean squared error of estimation.

## RESULTS AND DISCUSSION

Only the three 15-day intervals nearest to days 90, 180, and 270 will be discussed. For example, only factors for sampling days within intervals 46 to 60, 61 to 75, and 76 to 89 are discussed for $M_{1,\ 90}$, because in most applications a sampling day greater than 45 would be used to project remaining yield to day 90.

Examination of last sample factors for the two groups for age at freshening groups (≤ 30 and > 30 mo) did not indicate appreciable differences for the three traits in agreement with Wiggans and Van Vleck (17). Subsequently, age at freshening was ignored in computation of factors. Factors for the three 15-day periods nearest to days 90, 180, and 270 for data source 2 are in Table 1. Factors from the two sources (daily sample and monthly sample) showed remarkable similarity to two decimal positions for various stages of lactation for each of the three traits. Seasonal influences on the three segments of lactation were reflected in factors for the three traits. Extension factors for extending records with the sampling day in the last 15-day interval before day 90, 180, or 270 were essentially 1.00 for all months of freshening; hence, the nearly constant factors masked seasonal influence on this stage of lactation compared with other stages. Extension factors for spring and summer months tended to be smaller than factors for fall months. Seasonal effects on milk would be expected to assume more importance on short-term milk yields than on total yields, so individual months of freshening may be more appropriate than other definitions of seasons as usually used in studies of 305-day yields. As expected, factors are larger for extending a record with last sample day nearer to 90, 180, or 270 than factors used for extending records with last sample day further away from 90, 180, or 270.

TABLE 1. Extension factors for trimester[1] milk yields of Holstein cows.

| Mo. of freshening | First trimester ($M_{1,\ 90}$) days in milk | | | Second trimester ($M_{91,\ 180}$) days in milk | | | Third trimester ($M_{181,\ 270}$) days in milk | | |
|---|---|---|---|---|---|---|---|---|---|
| | 46-60 | 61-75 | 76-89 | 136-150 | 151-165 | 166-179 | 226-240 | 241-255 | 256-269 |
| January | .98 | .98 | 1.00 | .95 | .96 | .98 | .94 | .94 | .97 |
| February | .98 | .99 | 1.00 | .96 | .97 | .98 | .94 | .95 | .97 |
| March | .98 | .98 | 1.00 | .97 | .97 | 1.00 | .95 | .96 | .97 |
| April | .96 | .97 | 1.00 | .97 | .97 | 1.00 | .95 | .96 | .96 |
| May | .96 | .97 | 1.00 | .97 | .98 | 1.00 | .96 | .97 | .98 |
| June | .96 | .97 | 1.00 | .98 | .98 | 1.00 | .96 | .96 | .98 |
| July | .96 | .97 | 1.00 | .98 | .98 | 1.00 | .96 | .96 | .98 |
| August | .97 | .99 | 1.00 | .98 | .98 | .99 | .97 | .96 | .99 |
| September | .97 | .99 | .99 | .98 | .98 | .99 | .97 | .95 | .98 |
| October | .98 | .98 | .99 | .98 | .98 | 1.00 | .93 | .94 | .98 |
| November | .98 | .98 | 1.00 | .99 | .99 | .99 | .93 | .94 | .98 |
| December | .98 | .99 | 1.00 | .98 | .98 | .98 | .94 | .95 | .99 |

[1]Postpartum days 1-90, 91-180, and 181-270.

TABLE 2. Number of records and square roots (kg) of mean squared errors,[1] $(MSE)^{.5}$, of differences between estimated and actual trimester milk yield for two stages of lactation for each trimester.[2]

| Mo. of freshening | First trimester ($M_{1,90}$) days in milk | | | | Second trimester ($M_{91,180}$) days in milk | | | | Third trimester ($M_{181,270}$) days in milk | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 46-60 | | 61-75 | | 136-150 | | 151-165 | | 226-240 | | 241-255 | |
| | $(MSE)^{.5}$ | No. | $(MSE)^{.5}$ | No. | $(MSE)^{.5}$ | No. | $(MSE)^{.5}$ | No. | $(MSE)^{.5}$ | No. | $(MSE)^{.5}$ | No. |
| January | 45.8 | 675 | 33.4 | 355 | 44.7 | 577 | 34.7 | 303 | 44.0 | 367 | 36.3 | 271 |
| February | 49.5 | 514 | 44.7 | 374 | 50.9 | 485 | 36.1 | 211 | 45.5 | 269 | 38.5 | 138 |
| March | 53.0 | 571 | 43.7 | 272 | 42.6 | 491 | 34.2 | 251 | 42.9 | 236 | 36.4 | 172 |
| April | 52.7 | 348 | 38.2 | 258 | 51.4 | 277 | 36.3 | 223 | 47.1 | 217 | 38.3 | 81 |
| May | 52.8 | 375 | 44.0 | 167 | 42.6 | 252 | 37.6 | 144 | 42.2 | 165 | 32.9 | 112 |
| June | 46.9 | 426 | 41.6 | 185 | 43.4 | 253 | 32.3 | 152 | 46.5 | 166 | 38.7 | 202 |
| July | 55.1 | 672 | 39.0 | 423 | 40.5 | 553 | 33.4 | 187 | 43.4 | 389 | 44.3 | 283 |
| August | 47.7 | 738 | 37.8 | 435 | 37.0 | 598 | 29.2 | 503 | 45.4 | 533 | 34.2 | 423 |
| September | 45.7 | 741 | 38.6 | 460 | 40.4 | 491 | 30.6 | 671 | 43.7 | 676 | 38.7 | 354 |
| October | 46.8 | 846 | 35.8 | 242 | 38.9 | 597 | 28.4 | 413 | 49.4 | 485 | 41.8 | 346 |
| November | 45.6 | 572 | 39.3 | 430 | 41.9 | 473 | 36.9 | 386 | 50.3 | 470 | 36.5 | 203 |
| December | 44.8 | 378 | 39.3 | 572 | 46.5 | 553 | 40.0 | 293 | 44.4 | 453 | 36.0 | 217 |
| Average | 48.9 | 571 | 39.2 | 347 | 43.4 | 467 | 34.2 | 311 | 45.5 | 369 | 37.4 | 234 |

[1] $MSE = \sum_{i}^{N} (y_i - \hat{y}_i)^2/N$, where $y_i$ is actual and $\hat{y}_i$ is estimated trimester milk yield for N cows.

[2] Postpartum days 1-90, 91-180, and 181-270.

Factors in this study are all greater than .90 and less than or equal to 1.00. Factors are comparable to first lactation factors of Shook et al. (13) for adjusting yields for test intervals after last sample day. For cumulative yield for the 44-day interval after a last sample day occurring on day 46, a factor of .97 was obtained by Shook et al. (13). From Shook et al. (13) the interval yield is the product of days in the interval, 44, the last sample day yield, and the factor .97. The corresponding factor in the current study is between .96 and .98 depending on month of freshening. Similarly, a factor of .98 from Shook et al. (13) is used to calculate cumulative yield for the following 20 days if the last test day is on day 160. The corresponding factor in this study is between .96 and .99, depending on season of calving.

Table 2 shows square roots of mean squared errors of prediction for milk yields estimated by factors calculated in this study and actual cumulative yield modified by factors of Everett (6) based on TIM. Mean squared errors of prediction for periods nearer to 90, 180, or 270 were smaller than for periods further away for the same month of freshening.

## CONCLUSIONS

Factors can be used to predict remaining yields to days 90, 180, or 270 when sampling information for periods within 45 days prior to days 90, 180, or 270 is available. Factors for days outside the 45-day range are not reported here for brevity but may be obtained from the first author. Seasonal influence on short-term milk yields suggests that separate factors for each calendar month of freshening are preferable to factors for months of freshening grouped into seasons. Computer storage requirement of factors from this study is not large.

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