Projection of Partial Lactation Records and Calculation of 305-Day Yields in the Republic of Ireland

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Abstract

Standard lactation curves for 2160 contemporary groups were derived for projecting records in progress and short lactations to 305-day yields in the Republic of Ireland. Projection was based on the deviation of the last test day and previous lactation 305-day yields from the corresponding expected yields from the standard lactation curves. Calving season and age influenced the shape of the standard curves while level of production mostly affected the scale. Correlation between yields projected from lactations 51 days or more in length with realised yields were over 0.9 but accuracy increase with length of the record in progress.

Introduction

Lactation yield is currently the measure of milk production in the Republic of Ireland. Cumulative yields from lactations which dry naturally after 150 days or which are terminated for other reasons after 200 days are calculated by the test interval method for all purposes. In the annual breeding value estimation, valid lactation yields or truncated 305-day yields (for lactations going beyond 305 days) are weighted with factors which account for the varying amount of information, from different recording schemes (A4, A6 and A8), used to calculate the lactation yield in different parities. This practise, however, does not give credit to or distinguish cows with the potential, but not the chance to milk up to 305 days, from those without.

Projecting records in progress (RIP) and short completed lactations allow a measure of milk production based on a standard lactation length and increases the accuracy of genetic evaluation (Norman et al., 1985) especially where a repeatability model is applied. It allow farmers to know the expected lactation yield of their cows early which is useful for quota management and other cost saving management decisions. It facilitates multiple genetic evaluations per annum and early release of progeny test results. Early selection, especially of young bulls and bull dams, reduce generation interval and increase the rate of genetic progress.

Important considerations in projecting a lactation in progress include the potential of the animal to produce beyond the end date, and the pattern of production symbolised by its lactation curve. Accurate projection of a record in progress depends on how well the yield in the remaining days of the standard lactation period can be modelled. Methods whose accuracy does not hinge on the volume of available records will allow cheap and flexible milk recording schemes to be introduced without jeopardising the accuracy of projected yields. In this regards, the last test day method (Wiggans and VanVleck, 1979) is appealing because the stage and yield of a cow on the last test day is a good indicator of its ability to produce further. Another indicator, for later lactations, is the realised 305-day yield in the previous lactation. A standard lactation curve based on the mean yield of its contemporaries indicates the expected pattern of production which can guide the projection process. This is particularly important in a production system where the shape of the lactation curve may be significantly influenced by the calving season and other non-genetic factors.
The objective of this study was to adapt a standard lactation curve (SLAC) method for projecting records in progress and short lactations to a 305-day standard in the Republic of Ireland. This involves the derivation of standard lactation curves and projection factors required in the application of the SLAC method as a replacement for the current test interval method for calculating 305-day yields.

**The Standard lactation curve method**

The standard lactation curve method is based on the derivation of standard lactation curves for contemporary groups of cows defined to suit the production environment. A lactation is projected to the standard by predicting yields on a set of 15 fixed days in milk at intervals of 20 days from day 10. Extension of the lactation is achieved by predicting the yields for the fixed days in the unknown part of the standard lactation based on the last test day yield as well as the 305-day yield in the previous lactation where available. The prediction (Equation 1 below) use projection factors which are specific to the last test day and the day of the unknown yield and information from the standard lactation curve. A similar equation is used to predict yield for the fixed days before the first test by back prediction. In this case, \( y_k \) is the yield on the first test day.

\[
y_i = E(y_i) + b_1 \left[ Y_{P305} - E(Y_{P305}) \right] + b_2 \left[ y_k - E(y_k) \right]
\]

where:

- \( y_i \) = Predicted yield for day \( i \) of the lactation in progress
- \( E(y_i) \) = The expected yield on day \( i \) from the SLAC
- \( Y_{305PL} \) = The realised 305 day yield of the preceding lactation
- \( E(Y_{305PL}) \) = The expected 305-day yield of the preceding lactation.
- \( y_k \) = The yield on the last test day \( k \) of the lactation in progress
- \( E(y_k) \) = The expected yield on day \( k \) from the SLAC
- \( b_1, b_2 \) = The lactation projection factors.

The prediction of yields for fixed days in milk in between tests is achieved by interpolation using Equation 2.

\[
y_i = g_i + \frac{(y_2 - y_1) - (g_2 - g_1)}{(x_2 - x_1)\times(x_i - x_1)} + (y_1 - g_1).
\]

where

- \( y_1 \) and \( y_2 \) = the observed daily yields
- \( y_i \) = the yield to be predicted
- \( x_1 \) and \( x_2 \) = the days \( y_1 \) and \( y_2 \) were measured respectively
- \( x_i \) = the day for which a yield is to be predicted where \( x_1 < x_i < x_2 \)
- \( g_i, g_1, g_2 \) = the expected yields \( E(y) \) on days \( i, 1 \) and \( 2 \) respectively.

Once the yields on each of the fixed days in milk have been predicted, the 305-day is can be estimated as the area under a curve derived by connecting points represented by the measured and predicted yields using Equation 3;

\[
Y_{305} = \sum_{i=1}^{n} 0.5\left[ y_i \times (\text{int}_i - 1) + y_{i+1} \times (\text{int}_i + 1) \right]
\]
where:

\[ Y_{305} = \text{the 305-day milk fat or protein yield} \]
\[ y_i = \text{the } i^{\text{th}} \text{ daily yield;} \]
\[ \text{int}_i = \text{the interval in days between the daily yields } y_i \text{ and } y_{i+1}; \]
\[ n = \text{total number of daily yields (measured and predicted).} \]

In applying this equation, a yield is predicted for day zero so that the first interval is that between day zero and the first test.

**Materials and Method**

**Data**

Test day and official 305-day yield records of about 0.6 million lactations from 0.26 million cows were extracted from the files of 4 major milk recording organisations in Ireland. The data was edited to retain lactations with a minimum length of 250 days and having at least 4 test day records. Other selection criteria include first test before day 50, maximum 75 days between successive tests. Lactations from cows calving at less than 21 months of age were dropped. The final data contained 341,652 lactations from cows in 5224 herds, calving mostly between autumn and spring of the following year.

**Derivation of standard lactation curves and projection factors**

Yields were predicted for a set of 15 days in milk at intervals of 20 days from day 10 to day 290. Yields on days before the first test and after the last test were obtained by fitting a standard lactation curve (Wilmink, 1987) to the available test day records. Lactations with extreme predicted values were dropped. Yields on the fixed days between measured yields were obtained by linear interpolation while a 305-day yield was calculated for each lactation. These were adjusted for season effect and to lactation 1 equivalent. Lactations were subsequently grouped into 20 level of production classes based on the herd mean 305-day yield per year. The mean yield on each of the 15 fixed days in milk was estimated for each level to obtain 20 herd curves. The effect of each calving season and each age class was then added to each herd curve resulting in 2160 standard lactation curves per trait with a curve for each contemporary group.

The difference between observed and expected yields on each of the 15 fixed days in milk, as well as the observed and expected 305 yields (expected yields were obtained from the corresponding standard lactation curve) was estimated for all lactations. Projection factors were derived by recurrent regression analyses involving the deviation of the yield on the last test and the previous lactation from their expectations.

**Test Run**

Complete lactation records of 79,158 cows in lactation one, 30,699 in lactation two and 11,322 in lactation 3 were truncated at day 50, 100, 150, 250 and 300 and projected to 305-day equivalent using the newly derived projection factors and Slakes. Yields projected from lactation longer than 250 days was assumed to be the realised complete lactation yield. The correlation between projected 305-day yields and the official TIM lactation yields of the same cows were estimated. The projected yields were deviated from the complete lactation yields and the square root of the residual variance was computed as an added measure of accuracy. Results are presented for protein yield.

**Results and Discussion**

**Variation in Standard lactation curves**

Figure 1 shows the effect of the major calving seasons in Ireland on daily milk production at different stages of lactation. There was a strong influence of calving season on the shape of the lactation curves, which can affect the fit of standard models of the lactation curve (Olori et al., 1999). Cows calving in February or March exhibited the shape of a typical lactation curve. Others showed a late surge in yield often called the 'spring hump'. Figures 2 and 3 show some standard lactation curves derived in this study and the effect of season, calving age and level of production. Calving
season caused changes in the shape of the lactation in line with the influence of production season shown in Figure 1. Calving age and parity affected both the shape and height of the curves. Cows in later lactations were less persistent and produced much higher yields in the early stages of lactation than heifers, but the difference declined towards the end of lactation (see Figure 3). The herd level of production had a scale effect causing vertical shifts in the entire lactation curve.

**Correlation between projected and realised yields**

Table 1 shows the correlation between projected and realised 305-day protein yields in lactations 1 to 3. The correlation between realised yields (lactation length 251 or higher) and complete lactation yields obtained by TIM averaged 0.99. This indicates that the projection process was able to discriminate between cows with or without the potential to produce further in projecting short lactations. The correlation coefficients were slightly higher in lactation 2 and 3 because of the added information of the previous lactation yield in the projection. Correlation between projected and realised yields and the variance of projected 305-day yields increased with the length of the RIP. This suggests the need for variance expansion factors (VanRaden et al., 1991).

Interval between yields affects the number of interpolated yields while the length of the interval from calving to the first test determines the number of back predictions to be made. The correlation between projected and realised yields in this study (not shown) were not different between A4, A6 and A8 recording schemes implying that the interpolation process was not influenced by the variation in the frequency of recording in the various schemes. The same factors can thus be used to weight projected 305-day yields from the different recording schemes in breeding value estimation. Table 2 shows the residual standard deviation of projected 305-day yields from complete lactation yields by season of calving. These indicate a linear increase in the accuracy of projected yields with length of the RIP, which did not differ between calving seasons.

**Conclusion**

These results indicate that the SLAC method can be utilised in the Republic of Ireland to project records in progress and short lactation yields to a 305-day standard. The standard curves adequately describe the various patterns daily production and guide the projection process to avoid bias due to calving season, age, recording scheme and herd level of production. Appropriate lactation weighting lengths and variance expansion factors are required to account for the effect of lactation length on projected yields breeding value estimation.

**References**


**Acknowledgement**

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Table 1. Correlation between projected and realised 305-day yields estimated by the standard lactation curve (SLAC) method with complete lactation yields estimated by the Test interval method (TIM)

<table>
<thead>
<tr>
<th>RIP length (Days)</th>
<th>SLAC: Realised 305-day yield</th>
<th>TIM: Complete lactation yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lactation 1</td>
<td>Lactation 2</td>
</tr>
<tr>
<td>50</td>
<td>0.85</td>
<td>0.88</td>
</tr>
<tr>
<td>100</td>
<td>0.91</td>
<td>0.91</td>
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<tr>
<td>150</td>
<td>0.94</td>
<td>0.95</td>
</tr>
<tr>
<td>200</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>250</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>300</td>
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<td>1</td>
</tr>
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</table>

Table 2. Standardised deviation (kg) projected 305-day protein yields from complete lactation yields

<table>
<thead>
<tr>
<th>Length of record in progress</th>
<th>50</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
</tr>
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<tbody>
<tr>
<td>Calving Season</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Dec/Jan</td>
<td>26</td>
<td>21</td>
<td>15</td>
<td>11</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Feb/Mar</td>
<td>27</td>
<td>20</td>
<td>15</td>
<td>11</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Apr/May</td>
<td>23</td>
<td>18</td>
<td>15</td>
<td>12</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Jun/Jul</td>
<td>24</td>
<td>20</td>
<td>17</td>
<td>12</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Aug/Sept</td>
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<td>17</td>
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<tr>
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<td>19</td>
<td>17</td>
<td>12</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>

Figure 1. Effect of calving season on daily protein production at different stages of lactation.
Figure 2. Effect of calving season and level of production (L=low, H=high) on standard lactation curves (protein yield) of mature cows.

Figure 3. Effect of age/parity (1=age 24-26 months, 3=age 48-50 months) on daily standard curves of high yielding cows.