Efficiency of Test Day Models in Genetic Evaluation with Part Lactation Information

R A Mrode, G J T Swanson and C M Lindberg
Animal Data Centre Limited, Fox Talbot House, Greenways Business Park, Bellinger Close, Chippenham, Wiltshire SN15 1BN

Introduction

There has been much interest recently in genetic evaluations for milk production traits in dairy cattle using a Test Day Model (TDM). The advantages of a TDM include more accurate correction for environmental effects on Test Day records (TD), ability to model the lactation curve and estimation of persistency evaluations. In countries not implementing a TDM, the use of part lactation TDs usually involves projecting a 305 day yield. In some cases, especially for young bulls on test with most daughters having part lactations, the projection procedure could result in under prediction of the bulls' breeding values; which is the so called "rip-dip" effect. While the TDM has the advantage that it avoids the need for such projection, its efficiency in genetic evaluation, especially for young bulls with all or the majority of daughters with incomplete lactations, has not been examined.

This paper examines the efficiency of TD evaluations using a random regression model (RRM) utilising part lactation TDs for the genetic evaluation of bulls and cows.

Material and Method

The data consisted of 9,242,783 TD records for first lactation milk yield of 1,134,042 Holstein Friesian heifers that calved since 1991. A single-trait RRM fitting Legendre polynomials to model the lactation curve was implemented to analyse milk yield. The model was:

$$Y_{tljkn} = htd_l + \Sigma\, \beta_k\, v_{tr} + \phi_{jtn}\, a_j + \phi_{jtn}\, p_j + e_{tljkn}$$

where Y_{tljkn} is the test day record n of cow j made on day t within herd-test-day subclass l, for cow belonging to subclass k of age at calving by season of calving; β_k are the fixed regressions coefficients specific to the subclass k; v is the vector of the first five Legendre polynomials for the t^{th} day in milk; a_j and p_j are vectors of three random regressions for animal and permanent environmental effects respectively for animal j; ϕ_{jtn} is the vector of the first three Legendre polynomials for the test day n of cow j made on day t; and e_{tljkn} is the random residual. Gauss Seidel iteration with over-relaxation was employed to solve the mixed model equations, iterating on the data. Predicted Transmitting Abilities (PTAs) for 305-day milk yield were computed for every animal from the random regression coefficients after convergence. Persistency evaluations (PS) were calculated as in the Canadian Test day evaluation procedure (Schaeffer et al, 2000):

$$ps = \frac{(PTA_{280} - PTA_{60}) + 8_{280}}{8_{60}} \times 100$$

where PTA_{280} and PTA_{60} are Predicted Transmitting Abilities for bulls on days 280 and 60 respectively and 8_{280} and 8_{60} are the average yields of cows in the genetic base on days 280 and 60 respectively.

To examine the efficiency of RRM in utilising part TD yields, 114 young bulls with daughter group sizes varying from 25 to 93 and with at least 80% of daughters having 9 to 10 tests, were selected. These bulls were the sires of 4,697 heifers, of which 3,166 had 10 tests. The whole data set was re-analysed with the TD records of daughters of these bulls restricted to the first 2 TD records (that is TD records ≥ 3 were discarded). From this analysis, PTAs for 305 days yield were calculated for the 114 bulls and 3,166 heifers and compared with those estimated from the analysis with no restriction on TD records. In addition, for a better understanding of the comparisons, the 305 day PTAs were partitioned into contributions from parents and daughters in the case of bulls and parents and records for cows. The partitioning was achieved by partitioning the random regressions coefficients (Mrode and Swanson, 1999). Persistency proofs were also calculated and compared between both evaluations.

Further evaluations were produced where the TDs of all daughters of the 114 bulls were restricted to the first 4 TDs and then the first 6 TDs. Similar calculations and comparisons were then made as in the case where TDs were restricted to the first 2 TDs.

Results and Discussion

For the 3,166 heifers with 10 TDs, the simple and rank correlations between PTAs from 10 TDs and those from part lactation TDs are shown in Table 1. The distribution of differences between PTAs, together with the contributions from parents and TD records from evaluations with restriction on TDs (2, 4 and 6 tests) and 10 tests are given in Table 2. Similar statistics for bulls are also presented in Tables 1 and 2. The 0.91 correlation indicates that PTAs based on 2 TDs compared with those from 10 TDs for heifers could result in substantial re-ranking in heifer evaluations. However, with 4 and 6 TDs, the correlations increased to 0.96 and 0.98 respectively. These correlations, in addition to the small mean differences shown in Table 2, indicate good predictions of PTAs with the use of 4 and particularly 6 TDs in a RRM. However, the mean differences when split in terms of contribution from parents and TDs indicate that for up to 4 TDs there is over-prediction of contributions from parents and under-prediction of contributions from TD. This may indicate the need for adequate pedigree in TDM cow evaluations.

For bulls, a correlation of 0.95 was obtained between PTAs from 2 tests with PTAs from 10 TDs, indicating that there will be some re-ranking of bull proofs. However, with 4 and 6 TDs, high correlations of 0.98 and 0.99 were observed indicating little or no re-ranking. This confirms the adequacy of proofs based on 4 or more TDs. As expected, mean differences between PTA based on restricted TDs and 10 TDs were small but the standard deviation of differences was large with 2 TDs.

From the distribution of the mean differences for evaluations based on 2 TDs and 10 TDs, 3 categories of bulls were formed, each with 4 bulls. Category 1 (C1) mean differences were at least +200 kg milk; category 2 (C2) mean differences were $\pm$ 5 kg milk and the last category, (C3) were bulls with a mean difference of –200 kg milk or less. From each category the mean lactation curve was plotted from all the daughters of the bulls after correcting TDs for age effects within season (Figure 1). For bulls in C1, daughters were persistent through the lactation with the peak of lactation not being very prominent. Fitting a typical lactation curve, as would be the case if only 2 or 4 TDs were available, resulted in under-prediction, a typical illustration of the “rip-dip” effect. The difference in persistency proofs for these bulls from evaluations based on 2 TDs and 10 TDs varied from +5 to +7%.

For bulls in C2, the curve is more or less a typical lactation curve which declines gradually after the peak. Hence the use of 2 TDs with a typical lactation fitted, gave very good PTA predictions. The daughters of bulls in C3 have lactation curves with a high early peak and rapid decrease as the lactation progresses. The early TDs are not characteristic of the whole lactation, hence fitting the initial high 2 TD resulted in large over-prediction in bull proofs. The difference between persistency proofs based on 2 TDs and 10 TDs ranged from –5 to –10% for these bulls. This is the opposite of the “rip-dip” effect and might be called the “rip-hype” effect as it gives high initial proofs which decrease as daughters complete their lactations.

The correlations between bull persistency proofs (PS) from evaluations based on 10 TDs with those from restricted TDs are in Table 3. The correlation of 0.84 between PS from evaluations based on 6 TDs and 10 TDs was un-expected given the high correlations in Table 1. This correlation increased to 0.92 if persistency proofs were calculated over a time period of 60 to 180 days. The latter day representing the stage in lactation where 6 TDs were available for daughters of bulls. An examination of the standard deviations of the differences between bull proofs based on 6 TDs and 10 TDs, indicate about two-thirds of the variation occurs in the period between 6 TDs and 10 TDs and may account for the lower than expected correlation of 0.84 between PS from 6 TDs and 10 TDs.

Conclusion

PTAs based on the initial 2 TDs compared with those from 10 TDs could result in substantial re-ranking in bull and cow proofs. With 4 to 6 TDs, RRM gave good initial predictions of the PTAs for 10 TDs of bulls and cows. The use of the initial 2 TDs in the evaluation of young bulls could still result in "rip-dip" effect for young bulls whose daughters are very persistent or its opposite effect "rip-hype", if initial TDs are very high but persistency is very poor. Correlations between persistency PTAs estimated from 6TDs and 10 TDs were lower than expected, indicating caution when interpreting persistency PTAs from limited TD information.

References

Mrode, R.A. & Swanson, G.T.J. 1999. Preliminary Test Day Genetic Evaluations in the United Kingdom, Involving the Use of Legendre Polynomials and WilminK Function. *Interbull Bulletin 20*, 94-99.

Schaeffer, L.R, Jamrozik, J,. Kistemaker, G.J. & Van Doormaal, B.J. 2000. Experience with a Test Day Model. *J Dairy Science (accepted)*

Table 1 **Correlations and Regressions of PTAs from Part Lactation Test Days with those based on 10 Test Days.**

	Cows No. of Test Days			Bulls No. of Test Days		
	2	**4**	**6**	**2**	**4**	**6**
Correlations	0.91	0.96	0.98	0.95	0.98	0.99
Rank Correlations	0.91	0.96	0.98	0.95	0.98	0.99
Regressions	0.87	0.92	0.97	0.86	0.91	0.97

Table 2 **Means and Standard Deviations (in brackets) of Differences between PTAs and Contributions from Parents and Yields based on Part Lactation Test Days and 10 Test Days**

	Cows No. of Test Days			Bulls No. of Test Days		
	2	**4**	**6**	**2**	**4**	**6**
PTAs	-25 (99)	11 (69)	2 (41)	-50 (116)	15 (72)	1 (36)
PA	81 (123)	114 (60)	73 (23)	-0.7 (2.5)	0.6 (2.0)	0.1 (1.1)
YD	-106 (124)	-103 (73)	-70 (41)	-49 (117)	15 (70)	0.8 (36)

Predicted Transmitting Ability (PTA), Parent Average (PA), Test Day Yield (YD)

Table 3 **Correlations and Regressions of Bull Persistency Proofs from Evaluations from Part Lactations with those from 10 Test Days**

	No. of Test Days		
	2	**4**	**6**
Correlations	0.64	0.71	0.85
Rank Correlations	0.55	0.62	0.80

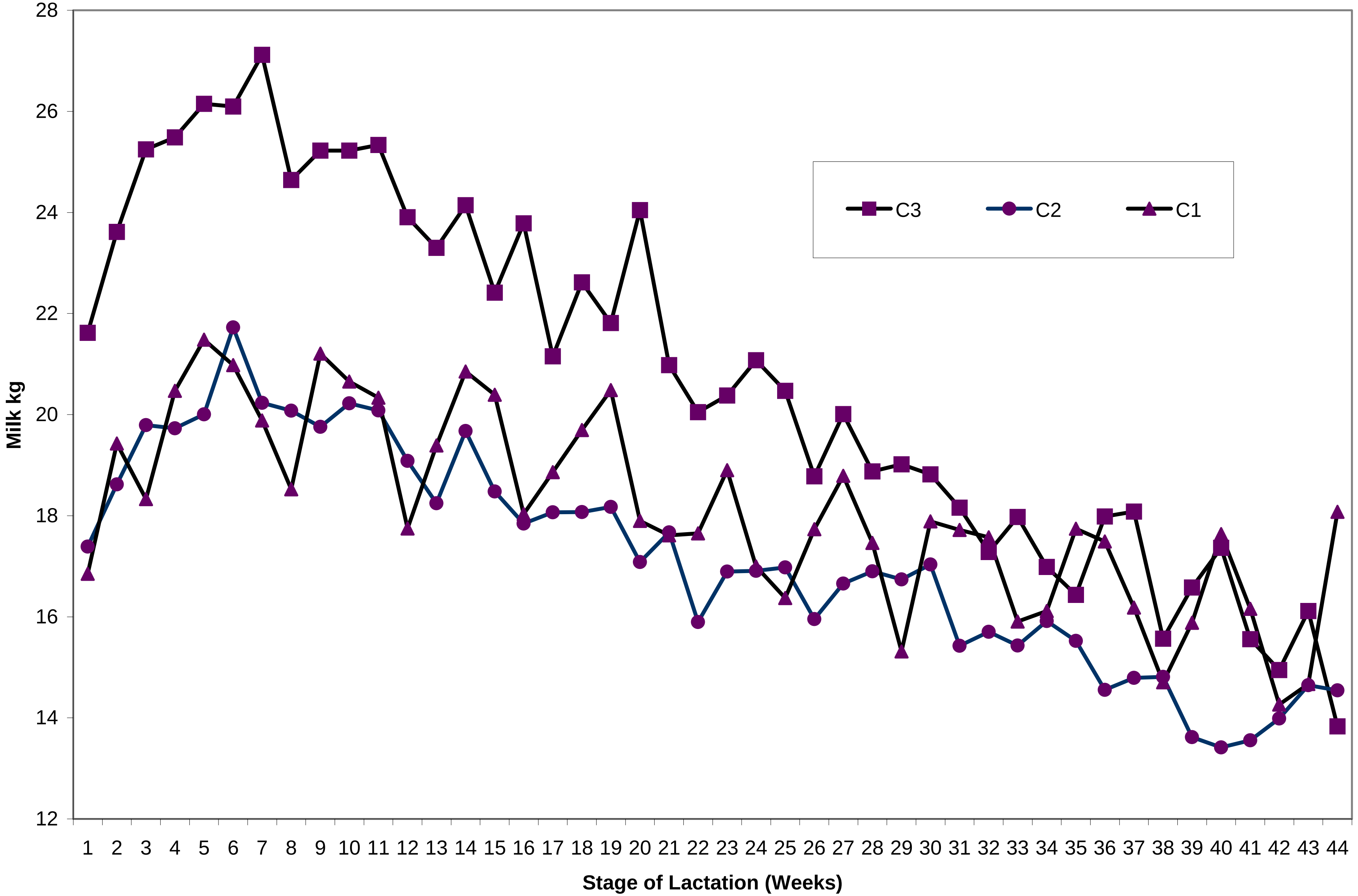

Fig 1: Mean Lactation Curves of Daughters of Bulls Under-predicted (C1), Accurately Predicted (C2) and Over Predicted (C3) Using Initial 2 TDs Compared with 10 TDs