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THE EFFECT OF DURATION AND FREQUENCY OF MILK YIELD RECORDING ON LACTATION CURVE MODELLING

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SUMMARY

Milk yields from an experimental backcross sheep population have been used to assess the impact of data availability on estimating lactation curve characteristics, including persistency and extended lactation. The data set consisted of 46,550 records from 151 lactating ewes whose records extended for at least 200 days. Truncating the data set at 200, 100 and 50 days showed that reliable measures of persistency and extended lactation were obtained when milk yield data was recorded up to 200 days into the lactation, but declined in accuracy substantially with earlier truncation. However, frequency of data recording had less impact on accuracy.

INTRODUCTION

Analysing characteristics of lactation curves allows the assessment of various lactation traits such as cumulative yield, persistency and extended lactation. These derived traits can be subsequently used in gene mapping and genomic selection studies (Raadsma *et al.* 2009b, Abdelsayed *et al.* 2011). Ideally, this lactation curve information will be based on the recording of daily milk yield data collected over an interval at least as long as the period of lactation to allow an accurate fitting of the lactation curve model. In order to assess extended lactation in dairy cattle, Haile-Mariam and Goddard (2008) used test-day records up to 610 days. However, given the abundance of available data up to 305 days in cattle, it is of interest to understand how accurate predictions will be of extended lactation, based on shorter time-series data. A related aspect is how frequently do lactation data need to be recorded in order to make accurate predictions.

MATERIALS AND METHODS

Lactation yield data from 151 backcross and double-backcross ewes from an Awassi × Merino experiment was used for this study, the details of which can be found in Raadsma *et al.* (2009a). The original data consisted of 46,550 daily milk yield records and about 9% of records have milk components (e.g. protein and fat content) recorded. Ewes included in this analysis were selected on the basis of having records for at least 200 days; nearly half (48%) had records for at least 300 days, and the maximum days in milk was 483.

The analysis consisted of generating subsets of these data based on the following selections:

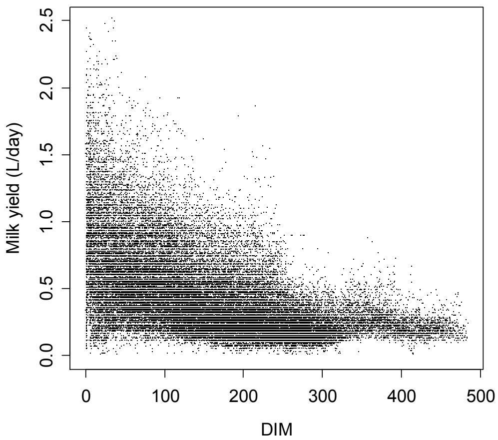
- Length of data recording: all records; truncating records up to day 200, 100, and 50
- Frequency of data recording: daily, every second day, every week, every second week

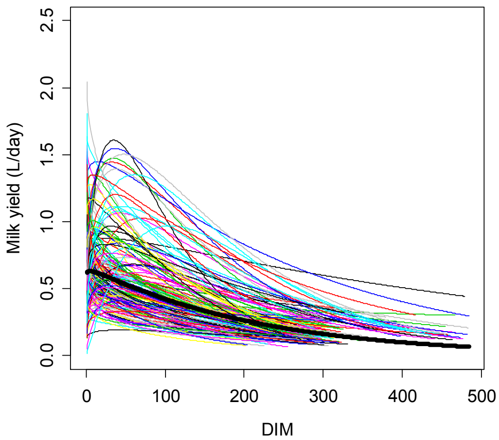
For each data set, the Wood lactation curve model (Wood 1968) was fitted using the nonlinear mixed model approach as described in Raadsma *et al.* (2009b). The form of the model is $y_{it} = \exp(k_i + b_i \log_e t - c_i t) + \varepsilon_{it}$ where y_{it} is the yield of ewe i at days in milk t, and where the 'parameters' k_i, b_i and c_i specify the shape of the lactation curve. This involves fitting a model to all the yield data simultaneously, with between-ewe variation of lactation curve shapes accounted for by random effects. To allow comparison of fitted lactation curves across the 151 ewes, their curves were adjusted to a common series of fixed effects, in a method described in Raadsma *et al.* (2009b). After this, the following series of derived measures was obtained for each ewe: (1) total milk yield (area under the lactation curve up to day 500); (2) time of peak milk yield; (3) quantity of peak milk yield; (4) persistency: model-based yield at day 100, as a proportion of the maximum yield; and (5) extended lactation: model-based cumulative yield from day 100 to 300, compared with that up to day 100. The above measures of persistency and extended lactation have been considered in Abdelsayed *et al*. (2011) and Jonas *et al*. (submitted). Following this, fitted lactation curves and derived characteristics across the data sets have been compared using simple descriptive and graphical methods.

RESULTS AND DISCUSSION

Figure 1 shows the milk yield data recorded over this study, using the full data set. Milk records extend up to 483 days in milk for some ewes. Figure 1 also shows the fitted Wood lactation curve models, having been adjusted to a set of common fixed effects. It clearly shows a range of lactation curve shapes, in terms of peak yield, persistency and extended lactation.

Figure 1. Milk yields (L/day) of the 151 lactating ewes. The LHS shows the raw data, and the RHS shows the fitted lactation curves (using the Wood model) adjusted to a common set of fixed effects. The overall mean curve is shown as the solid black curve.





Effect of duration of data recording. Data sets were truncated at 200, 100, and 50 days in milk. The effect of this, compared with that from the full data set, is explored through descriptive statistics (means, standard deviations and correlations) for each trait, as shown in Table 1. Note that while 151 ewe lactation records were used in the analysis, the fitted models were not available for all ewes, due to parameter values out of range; hence sample size (*n*) is sometimes under 151.

From Table 1, it is clear that cessation of recording at day 200 will result in reliable estimates of all measures. This is based on the similarity of means and standard deviations to those obtained from using all the records. Truncation at 100 or 50 days produces unreliable estimates for most measures. One exception to that is that detection of the peak yield value is reliable even when based on records up to day 50. One explanation of this is that peak yield usually occurs early in the lactation, as seen in Figure 1, and this is typically well before day 50. The correlations between the measures at different truncation days also support these findings, with weaker correlations obtained at days 100 and 50.

Effect of frequency of data recording. Data sets were subsetted by extracting records from every second day, every week, and every second week. In the results shown here, no truncation day was incorporated. The descriptive statistics for this study are shown in Table 2, using a similar format to that in Table 1. What is apparent is that reducing the frequency of data recording does still provide reliable estimates of the different lactation measures. The measure that was most sensitive to changes in recording frequency was total yield over the entire lactation, but even this was satisfactorily measured when the data were recorded weekly. Correlations between the measures based on different recording frequencies were generally quite high, particularly for persistency and extended lactation traits. Generally a correlation less than 0.8 would indicate significant changes in ranking of animals for performance recording.

Table 1. Descriptive statistics of derived lactation curve characteristics using all records (All), using records only up to day 200 (≤ 200), day 100 (≤ 100), and day 50 (≤ 50). Shown are the sample size (*n*), average (mean), standard deviation (SD), minimum (min) and maximum (max) values. Correlations are shown between the full and reduced data sets, for each trait.

								Correlation		
Trait	Subset	*n*	mean	SD	Min	Max		≤ 200	≤ 100	≤ 50
Time of	All	151	14.78	20.12	1.00	106.47	All	0.76	0.29	0.16
Maximum	≤ 200	151	13.22	30.72	1.00	332.99	≤ 200		0.17	0.11
(day)	≤ 100	131	7.82	18.26	1.00	104.30	≤ 100			0.76
	≤ 50	146	4.95	10.27	1.00	101.26				
Maximum	All	151	0.88	0.35	0.19	1.95	All	0.97	0.87	0.73
Yield (L/day)	≤ 200	151	0.91	0.37	0.19	1.97	≤ 200		0.89	0.77
	≤ 100	132	0.93	0.41	0.32	2.31	≤ 100			0.92
	≤ 50	146	0.99	0.51	0.34	3.47				
Total Yield (L)	All	148	149	67	43	385	All	0.95	0.85	0.69
(to day 500)	≤ 200	124	164	86	44	461	≤ 200		0.82	0.73
	≤ 100	58	210	154	31	751	≤ 100			0.88
	≤ 50	112	60	45	15	261				
Persistency	All	151	0.58	0.24	0.15	1.00	All	0.98	0.83	0.68
	≤ 200	151	0.56	0.23	0.15	0.97	≤ 200		0.83	0.68
	≤ 100	131	0.71	0.32	0.25	1.71	≤ 100			0.83
	≤ 50	146	0.62	0.51	0.07	2.41				
Extended	All	148	1.05	0.29	0.43	2.19	All	0.94	0.45	0.14
Lactation	≤ 200	124	1.10	0.39	0.47	2.90	≤ 200		0.40	0.13
	≤ 100	58	1.14	0.48	0.39	2.42	≤ 100			0.56
	≤ 50	83	0.53	0.40	0.04	2.05				

Study implications. With serious attention now being paid to assessing lactation persistency, and even more importantly, extending lactation as part of an all-year round strategy, it is important to understand if databases collected can be used to assess these measures prior to using them in subsequent genetic analyses. For example, in cattle, we may want to assess milk yields beyond the usual 305 days. This study shows that measures of extended lactation will be unreliable unless the period of data collection extends well into the period of extended lactation, i.e. data had to be available up to 200 days to make reliable predictions for yields in the range 100 to 300 days.

This study has also shown that for the measures considered here, it is not necessary to record daily values, as accurate estimates can be obtained with less frequently collected data. While this may not be an important issue in many production or experimental flocks / herds, there are situations particularly in developing countries where daily recording of milk yield is not viable. However, while it has been shown that less frequently recorded data will produce reliable measures, there remains the question of what are the most optimal sampling days over a lactation cycle when data should be recorded. This is currently being investigated.

Table 2. Descriptive statistics of derived lactation curve characteristics using all records (All), using records every second day (2nd day), every week (Wk), and every second week. (2nd wk). See Table 1 for additional notes.

								Correlation		
Trait	Subset	*n*	mean	SD	Min	Max		2nd day	Wk	2nd wk
Time of	All	151	14.78	20.12	1.00	106.47	All	0.95	0.74	0.56
Maximum	2nd day	151	15.51	19.89	1.00	104.19	2nd day		0.68	0.46
(day)	Wk	151	11.49	14.70	1.00	59.30	Wk			0.86
	2nd wk	151	18.00	18.24	1.00	95.84				
Maximum	All	151	0.88	0.35	0.19	1.95	All	0.86	0.82	0.72
Yield (L/day)	2nd day	151	0.89	0.39	0.19	2.18	2nd day		0.51	0.39
	Wk	151	0.88	0.44	0.27	2.79	Wk			0.96
	2nd wk	151	0.85	0.49	0.23	2.97				
Total Yield (L)	All	148	149	67	43	385	All	1.00	0.99	0.99
(to day 500)	2nd day	145	150	67	45	384	2nd day		0.99	0.98
	Wk	148	151	67	55	388	Wk			1.00
	2nd wk	148	149	67	60	400				
Persistency	All	151	0.58	0.24	0.15	1.00	All	0.92	0.81	0.61
	2nd day	151	0.58	0.24	0.14	1.00	2nd day		0.63	0.38
	Wk	151	0.59	0.21	0.10	0.98	Wk			0.91
	2nd wk	151	0.65	0.23	0.11	1.00				
Extended	All	148	1.05	0.29	0.43	2.19	All	0.99	0.94	0.89
Lactation	2nd day	145	1.06	0.29	0.44	2.14	2nd day		0.94	0.89
	Wk	148	1.06	0.25	0.49	1.77	Wk			0.95
	2nd wk	148	1.10	0.26	0.55	2.02				

CONCLUSIONS

Understanding the causes of variation in lactation curves requires milk yield data to be collected at appropriate times. This study has demonstrated that for assessing extended lactation and persistency in particular, it is essential to collect data until well into the period of extended lactation. However, frequency of data collection is not so critical. Nonetheless, it is important to understand what the most critical periods are over a lactation cycle where data should be collected more intensively.

REFERENCES

Abdelsayed M., Raadsma H.W. and Thomson P.C. (2011) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **19:** (in press).

Haile-Mariam M. and Goddard M.E. (2008) *Animal* **2:** 325.

Jonas E., Thomson P.C., Hall E.J.S., McGill D., Lam M.K. and Raadsma H.W. (2011) "Mapping quantitative trait loci (QTL) in sheep. IV. Analysis of lactation persistency and extended lactation traits in sheep". Submitted.

Raadsma H.W., Jonas E., McGill D., Hobbs M., Lam M.K. and Thomson P.C. (2009b) *Genet. Sel. Evol.* **41**(45).

Raadsma H.W., Thomson P.C., Zenger K.R., Lam M.K., Jonas E., Cavanagh C., Jones M., Attard G., Palmer D. and Nicholas F.W. (2009a) *Genet. Sel. Evol.* **41**(34).

Wood PDP (1968) *Nature* **218:** 894.