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Using lactation curves as a tool for breeding, nutrition and health management decisions in pasture-based dairy systems.

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Introduction

Milk yield and reproductive efficiency are crucial to profitable dairying. Although, genetic improvement in the last few decades has led to substantial increases in milk yield/cow, fertility and reproductive health have declined (Dematawewa and Berger, 1998).

In a pasture-based system, a 365 day calving interval is crucial for optimum profit. Hence the need to increase milk yield by improving persistence of lactation rather than peak lactation which puts increased stress on the cows at the time when they should be rebreeding. Peak milk yield, persistency and lactation length are the key components of the lactation profile. Dairy cows with high peak yields are more prone to metabolic and physiological disorders (Terkeli *et al* 1999). Although estimated breeding values (EBV) in dairy cows in Australia incorporates indices of economic value, such as survival and milking speed, the impact of the current breeding approach and management on the shape of the lactation profile is not clear.

Mathematical functions such as those previously used to describe a series of milk test day records (Wood, 1967, Wilmink, 1987), have the advantage of minimizing random variation while simultaneously summarising the lactation profile into biologically interpretable parameters.

The shape of the lactation curve provides valuable information about the biological and economic efficiency of the animal or herd and is useful for genetic evaluation, health monitoring, feed management decisions and planning purposes (Sherchand *et al*., 1995). Cow's genetic merit, breed, parity, calving season, nutrition, and pregnancy affect the shape of her lactation curve (Tozer and Huffaker, 1999, Roche *et al*., 2006). A robust model should adequately mimic the biological process of lactation and adjust for factors affecting it.

The functions available to model lactation profiles are many (Beever *et al*. 1991) but their suitability varies across systems. For instance, Olori *et al*. (1999) reported that the polynomial model gave the best fit in a farm-based study, while Garcia and Holmes (2001) found no difference in average lactation predicted by both diphasic and linear-based split-plot models.

The objectives of this study was to identify suitable lactation models and determine the factors affecting the lactation profile, in pasture-based dairy systems.

Materials and Methods

Test-day milk yield data from 428 herds in Tasmania, consisting of 65,000 milk yield records from 2002-2005, were edited to exclude incomplete lactations. The five empirical and two mechanistic functions used to evaluate average daily milk (kg/d) were:

Incomplete Gamma (IG) *Y(t) = a t be−ct* (Wood, 1967)

Modified Gamma (MG) *Y(t) = a te-ct* (Jenkins and Ferrel, 1984)

Mixed Log (ML) *Y(t) = a+bt1/2+clogt* (Guo and Swalve, 1995)

Exponential (EXP) *Y(t) = a+be-kt+ct* (Wilmink, 1987)

Polynomial (PR) *Y(t) = a+bt+ct2+ dlogt+ ε(logt)2* (Ali & Schaeffer, 1987).

Bicompartmental (BC) *Y(t) = a e-bt + de-ct* (Ferguson and Boston, 1993)

Dijkstra (DJ) *Y(t) = a exp[b(1-e-ct)/c-dt]* (Dijkstra *et al*., 1997)

where Y is milk yield (L/kg/cow/day), at time t (weeks), and a, b, c d and ε are parameters that define the scale and shape of the curve. Each model was fitted using the NLIN function of SAS; model accuracy was evaluated based on residual mean square error (RMSE), the magnitude and distribution of residuals, and the correlation between the observed and predicted values.

Results and Discussion

All the models, except MG, equally well portrayed the lactation profile (Table 1). Parameter estimates were significant ($P<0.05$), with large serial correlations indicating biased predictions at various lactation stages. Lactation curves of individual cow milk yields were more varied and exhibited the tendency for a second peak which was not accurately modeled. Lactation profiles differ between dairy regions in Tasmania (Figure 1) and herd size presumably due to differences in management and pasture growth rate. Production seems to be in favour of medium to large herds although the impact of higher yields on fertility remains to be seen. However it is interesting to note the lack of a distinct peak milk yield in early lactation. The results underscore the importance of

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feed intervention strategies during early lactation and suitable body condition score at calving to mitigate the impact of negative energy balance on peak milk yield.

Conclusion

Mechanistic models performed best with herd data and offer insights into the physiological basis of lactation, while the PR models fitted better overall. Future studies will focus on the genetic and phenotypic relationship between lactation curve parameters and reproductive traits as well as the comparative advantages of crossbred cows under the prevailing production systems.

Table 1. Initial, peak, mid-lactation and final milk yields (L/cow/day) of pasture-based Holstein-Friesian cows with residual mean standard errors (RMSE) obtained by fitting average milk yield data to seven lactation functions.

Milk Yield (L/cow/day)								
Actual		**Predicted Lactation models**						
Item		**EXP**	**IG**	**MG**	**ML**	**PR**	**BC**	**DJ**
Initial	12.0	12.7	13.2	2.3	12.8	12.1	12.0	12.0
Peak	14.6	13.9	13.8	15.1	13.9	14.2	14.3	14.5
Mid	12.4	12.0	12.0	13.7	11.9	11.8	11.9	11.9
Final	10.5	9.4	9.38	6.3	9.4	9.8	9.5	9.5
Peak week	4	5	5	17	5	5	4	4
RMSE		0.24	0.26	10.4	0.23	0.19	0.19	0.19

IG – incomplete Gamma, MG – modified Gamma, ML – mixed log,
Exp – exponential, PR – Polynomial, BC – Biocompartmental, DJ - Dijkstra

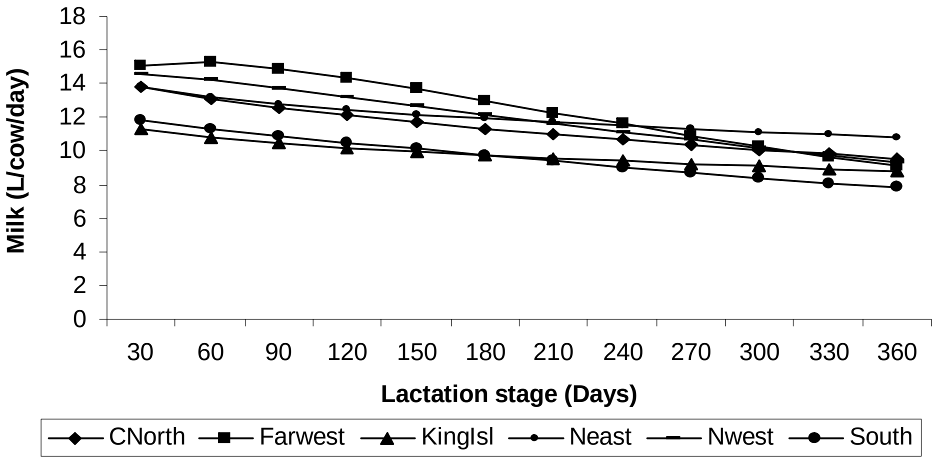

Figure 1. Predicted daily milk yield (L/cow/day) of Holstein-Friesian cows in different dairy regions of Tasmania

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