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COMPARATIVE EFFECTS OF ASI AND APR SIRE BREEDING VALUES ON THE LACTATION PROFILE OF PASTURE-BASED HOLSTEIN-FRIESIAN COWS

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SUMMARY:

Estimated Breeding Values (EBVs) of bulls are useful indicators of the genetic transmission ability of an animal of desirable traits to their progeny. Lactation profile differs between different merit cows but for pasture-based production systems, the impact of emerging EBV evaluation methods remains largely unpublished. In this study, Wood's incomplete gamma model ($Y(t) = at^b e^{-ct}$) was utilised to compare the effects of the Australian Selection Index (ASI) and Australian Profit Ranking (APR) EBVs on the shape of the lactation profile of first-parity, pasture-based Holstein-Friesian cows. Initial yield and the rate of increase to peak were significantly influenced by EBV choice, although peak yield was not. It was concluded that Wood's incomplete gamma function adequately modelled the lactation profile of pasture-based cows explaining over 90% of the observed variation irrespective of using ASI or APR sire breeding values.

INTRODUCTION

Knowledge of a breeding bull's genetic merit for dairy traits is central to improved milk production. A reliable indicator of superior performance and transmitting ability to progeny is the EBV of the sire. Previously, breeding objectives focused mainly on milk production traits (Miglor *et al.* 2005), which led to fertility decline. Consequently, breeding objectives changed to include survival and longevity traits (Buckley *et al.* 2003). Until 2001, the Australian Selection Index (ASI), based on production traits, was used as the EBV of choice for ranking breeding bulls. Stakeholders' demand led to the development of an alternative index; the Australian Profit Ranking (APR) whose aim was to maximise profit from genetic gain (ADHIS 2001). The hypothesis tested in this study was that the inclusion of temperament, longevity and survival in the APR index as opposed to their exclusion from the ASI index, would have an impact on the milk yield pattern of first parity dairy cows.

Mathematical models are used as tools to elucidate the underlying biological features of lactation in the presence of environmental perturbations (Wood 1967, Wilmink, 1987), for genetic evaluations and farm management decisions. Studies by Freeze and Richards (1992), Tozer and Huffaker (1999), Horan *et al.* (2005) and Roche *et al.* (2006) have demonstrated the effect of genetic merit, breed, parity, season, nutrition and pregnancy on the shape of the lactation curve but an important question that remains largely unanswered is: what impact does the inclusion of temperament and longevity traits in the EBV have on the lactation pattern of pasture-based cows? The objective of this paper was an attempt to answer this question and to evaluate the accuracy and reliability of the incomplete gamma function to adequately predict the lactation curves based on ASI and APR. Such information will help farmers make more informed decisions.

MATERIALS AND METHODS

57, 735 lactation records (1968 lactations) of multiparous Holstein-Friesian (HF) cows at the Elliot Dairy Research and Demonstration Station, Tasmania, collected from 1994-2005, were edited to exclude; parity >1 and cows with lactation length <100 or >350 days or test date records <7 , leaving a total of 11, 619 records (393 lactations). The study data also included cow and sire ID, calving date, calving season and calving year. Sire ASI and APR EBVs were obtained from Australian Dairy Herd Improvement Scheme (ADHIS) database for May 2006. The formulae were: ASI = 3.8 x Protein ABV + 0.9 x Fat ABV - 0.048 x Milk ABV; and APR = (3.8 x Protein ABV) + (0.9 x Fat ABV) - (0.048 x Milk ABV) + (3.9 x Survival Index) + (1.2 x Milking Speed ABV) + (2.0 x Temperament) In both EBVs, cows sired by bulls with ASI or APR value of 20 and above corresponding to the top 2% of the national bull ranking were classified as high merit, otherwise low merit.

The incomplete gamma function (Wood 1967) was used in fitting the lactation curve and was defined as:

$$Y(t) = a\, t^{b} e^{-ct}$$

where Y(t) is the average daily milk production at time *t*, a=a scaling factor to represent yield at the beginning of lactation; b and c are factors associated with the inclining and declining slopes respectively, of the lactation curve. The gamma model was logarithmically transformed; $\mathrm{Log}(y(t))=\log(a) + b\log(t) - ct$ and solved by ordinary least squares analysis for multiple regressions using the regression procedures (PROC REG) of SAS (SAS 2002). Least square mean estimates for week in milk (WIM) were computed using PROC GLM (SAS 2002) to fit herd data while WIM from test dates were used for individual curve fits. The magnitude and distribution of the residuals, R^2 and residual mean square error (RMSE) values of the model were used to examine the goodness of fit.

RESULTS AND DISCUSSION:

Daily milk yield, week in milk and age did not differ significantly between cows. Mean ASI for high and low merit cows were 21.7 and -18.2 respectively while the corresponding values for the APR was 34.9 and -23.2. Mean milk EBV was higher in the high merit cows and ranged between 130-190 and 31-39 for high and low merit cows respectively. Mean milk yield started at 16.3 ± 0.3l in week one, peaked at 18.6 ± 0.24l in week five and declined to 8.7 ± 1.9l in week 48 for high merit ASI cows while the corresponding values for the cows in low merit group were 16.3 ± 0.32, 18.7 ±0.25 and 13.1 ± 3.5l respectively. Mean milk yield among cows sired by bulls using APR followed similar patterns. The results of the fit of Woods incomplete gamma model are shown in Table 1, Figures 1and 2.

Table 1. Lactation parameter estimates and coefficient of determination for ASI and APR BVs

EBV	Level	No.	Lactation parameter estimates ±SE			PWK	PY	R^2	RMSE	DW
			a	b	c					
ASI	High	198	18.0±0.04	0.05±0.02	-0.02±0.001	3	18.1	0.94	0.05	0.60
APR	High	127	18.0±0.04	0.01±0.02	-0.01±0.001	1	17.9	0.90	0.06	0.34
ASI	Low	195	18.7±0.04	0.02±0.02	-0.02±0.001	1	18.5	0.88	0.07	0.45
APR	Low	266	17.9±0.03	0.09±0.02	-0.02±0.001	4	18.5	0.95	0.07	0.96

PWK=Peak week PY=Peak Yield DW=Durbin Watson statistic

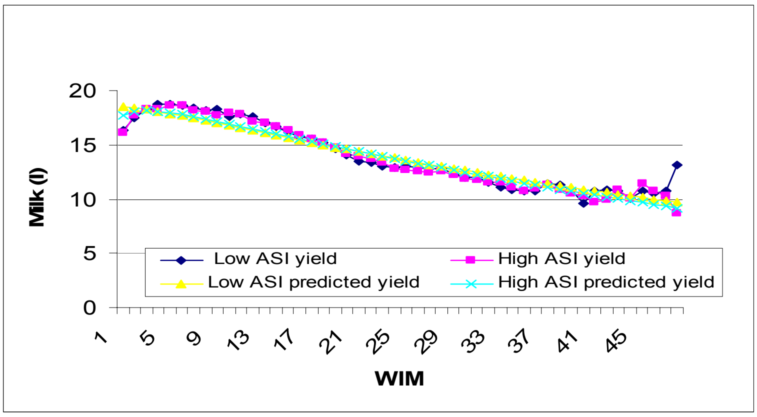

Figure 1: Predicted milk yield profile of high merit (ASI and APR) pasture-based Holstein-Friesian dairy cows fitted to Wood's incomplete *gamma* function.

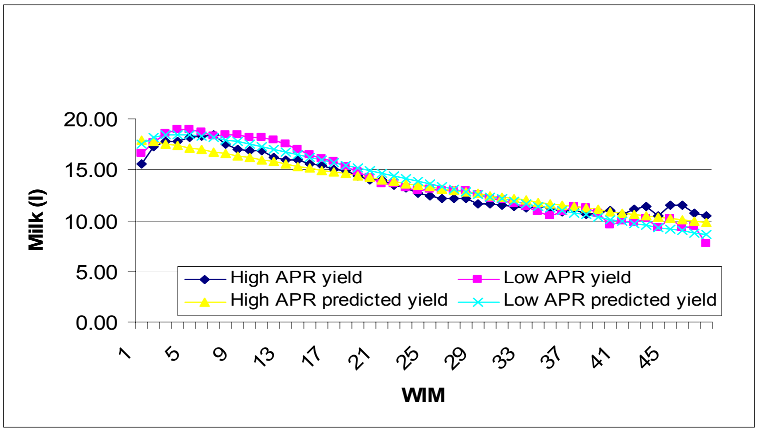

Fig 2: Predicted milk yield profile of low merit (ASI and APR) pasture-based Holstein-Friesian dairy cows fitted to Wood's incomplete *gamma* function.

The applied function represented a good fit to the data, with mean R^2 of approximately 0.90 and RMSE < 0.1, although the DW statistic, a measure of autocorrelation between adjacent times indicated positive serial correlations among residuals. Irrespective of EBV, the model under-predicted average milk yield in early lactation and then over-predicted mid-lactation. The magnitude of under prediction was highest at initial yield and ranged 1.5-2.0 l while the margin of error of prediction of peak yield was less than 1.0 l. A criticism of Wood's incomplete *gamma* model is the presence of serial correlations indicating biased predictions at certain lactation stages (Olori *et al.* 1999). Choice of EBV significantly influenced theoretical initial milk yield, (a), and incline to peak (b) in low merit cows, but only the incline and decline phases in high merit cows (Table 1).

Peak yield was not affected irrespective of the EBV but week at peak was attained later in High merit (ASI) and Low merit (APR) cows, both of which showed a prominent rise to peak. The absolute value of b parameter controls the magnitude of the curvature of the lactation pattern i.e. deviation from a straight line (Congleton and Everett 1980). Cobby and Le Du (1978) suggested that curves with no peak could be due to attainment of peak soon after calving or insufficient data in early lactation. Cows showing rise to peak, in this study, with first test day record in week1 averaged 56% while those not showing the rise averaged 61%.

Variation was greater between individual cows. RMSE averaged 0.14 irrespective of EBV, 57-70% of cows had adjusted R^2 values >60%, which is equivalent to good or very good fits. Mean parameter estimates (a, b, c) with standard deviations were 15.7±5.4, 0.25±0.32 -0.04±0.05, and 15.8±5.2, 0.26±0.28, -0.04±0.04 for high merit APR and ASI respectively while the corresponding values for the low merit cows were 16.1±4.8, 0.24±0.23 -0.04±0.04, and 16.1±4.8, 0.23±0.25, -0.04±0.05. The percentage of cows exhibiting standard curve shapes i.e. a peak followed by a gradual decline (b=positive), were 93.4, 92.9 (high merit), and 88.2 and 92.9 (low merit) ASI and APR EBV's respectively. Other factors affecting milk yield apart from genetic factors are parity, lactation stage and persistency, milking practices, age, body weight and condition, metabolic diseases, oestrous cycles, and pregnancy, as well as environment factors such as nutrition (Buckley *et al* 2003).

CONCLUSION:

In pasture-based HF cows, initial milk yield and incline to peak are significantly influenced by choice of EBV and should be borne in mind for feed management decisions. Wood's incomplete gamma function adequately modelled the lactation profile explaining over 90% of the variation irrespective of using ASI or APR sire breeding values. Further studies with multiparous cows would be needed to shed more light on the effect of EBV on lactation profiles.

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