

Statistical analyses were carried out using the Statistical Analysis System (SAS version 9.2, SAS Institute Inc., Cary, NC, USA, 2009). Third-order Legendre polynomials (standardized for units of time) were fitted to lactation data using a random regression to obtain an average lactation curve for the population and for each cow using the following model:

$$y_{tm} = \sum_{i=0}^3 b_i P(x)_t^i + \sum_{i=1}^3 \alpha_{im} P(x)_{tm}^i + e_{tm}$$

where y_{tm} is the observation at time t in cow m for daily milk yield, b_i are fixed regression coefficients of days in milk on variable y (b_0 = intercept, b_1 = linear effect, b_2 = quadratic effect and b_3 = cubic effect); α_{im} are random regression coefficients of days in milk on variable y in cow m (α_{0m} = intercept, α_{1m} =linear effect, α_{2m} = quadratic effect and α_{3m} = cubic effect), x_{tm}^i is the observation of standardized days in milk at time t in cow m at the power 0, 1, 2, and 3; e_{tm} is the residual error associated with observation y_{tm} .

Random coefficients for each cow were obtained using the MIXED procedure assuming an unstructured covariance structure between the variance and covariances of the random regression coefficients of the model. Using the estimated random regression coefficients for each cow, parameters of the lactation curve for each cow were estimated. Analysis of variance for each of these parameters was performed with the MIXED procedure with a linear model that included the fixed effects of breed of the dam, mob, sex of calf, and the interaction between sex of calf and breed of the dam.

RESULTS

Predicted lactation curves from 32 to 160 dpp based on test-day records varied across genotypes and the shapes can be classified into two types according to the pattern of milk production (Figure 1). Type 1 (AA group): from Figure 1 it is evident that the highest milk production from AA cows was likely to have occurred somewhere during the first month of lactation or before 32 dpp, with a slow decrease until 83 dpp, thereafter it remained fairly constant until approximately 115 dpp after which it decreased rapidly towards weaning; Type 2 (AF, AJ and AK groups): milk production increased continuously from the beginning of the lactation period until it reached a peak around 80 dpp and then decreased until the end of the lactation. The effect of birth weight and differing breed proportions in the calf on lactation curve shape were investigated, however, no effect of bull breed ($P>0.05$), proportion of maternal breed in the calf ($P>0.05$) or birth weight of the calves ($P>0.05$) was observed. This indicates that it was primarily the genotype of the cow that determined milk production in this study.

DISCUSSION

The lactation curves for beef × dairy cows are of similar shape and resemble a typical lactation curve seen in dairy cows. The findings in the present study are similar to those of Walker and Pos (1963) in New Zealand, where AF and AJ cows reached peak lactation at an average 74 dpp; and to those reported by Chennete and Frahm (1981) whereby peak lactation in AJ cows was detected at approximately 70 dpp, followed by a steady decrease as lactation progressed. Post peak lactation, milk production levels were maintained until approximately 120 dpp when a decrease in milk production occurred for all three crossbred genotypes. Gaskins and Anderson (1980) reported peak lactation in AJ cows during the first month of lactation, which is earlier than reported in the present study, however, milk yield remained constant until 84 dpp in 2-year-old cows and until 112 dpp in 3-year-old cows. These results suggest lactation curve persistency in beef cows can be greatly improved by the introduction of genes from dairy breeds.

The days in milk at peak lactation reported here for AA cows is earlier compared to the findings of Jenkins and Ferrell (1984) and Hohenboken *et al.* (1992) using the “Jenkins” equation, however, the latter equation has been criticised since it repeatedly produced curves that peaked approximately around 60 and 70 dpp and also underestimated milk yield during the first month of lactation since it forces the curve through the origin (Hohenboken *et al.* 1992).

There is evidence (Oftedal, 1984) that the calf’s capacity to withdraw milk may be reduced in early lactation and that the residual milk left in the udder would stimulate mammary involution. An interaction exists between mammary evacuation and milk production, where cows suckled or milked more often produce higher levels of milk than those with infrequent mammary evacuation. Angus cows may be more sensitive to changes in mammary evacuation during early and late-lactation than the beef x dairy crossbred cows. The first drop in production seen in AA cows may be explained by the calf not being physically capable of fully evacuating the udder in the first few days due to physical consumption constraints and consequently, the residual milk left in the udder would stimulate the dam to reduce her milk production (Oftedal 1984). Then, as the calf grows and its ability to suckle increases, milk production stabilises at a level lower than peak to provide nutrients to the calf. Indeed, Blaxter (1961) suggested that milk yield is motivated towards the maximum possible growth rate of the offspring. Thus it is likely that a dam’s milk production would respond to the stimulus from her calf, although as a non-dairy animal, AA cows may have limited capacity to produce more milk. Energy requirements increase with increasing age and there is evidence (Baker *et al.* 1976) that if forage availability is adequate, calves receiving less milk during lactation could increase their pasture intake to compensate for the low energy intake from milk. In this study during late-lactation, calves reared by AA cows may have not been receiving enough nutrients from a suckling event; therefore to compensate they reduced their milk consumption in favour of consuming more pasture. This may explain the second drop in milk production observed towards the end of the lactation of AA cows, which is typical in AA cows in other studies (Minick *et al.* 2001).

CONCLUSIONS

Results from this experiment confirmed the hypothesis that increasing the proportion of dairy genetics in the beef herd is accompanied with an increase in milk production. Under non-limiting pasture quality and availability, AF, AJ and AK cows produced more milk throughout lactation than AA cows.

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