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NON-GENETIC SOURCES OF VARIATION IN LACTATION CURVE TRAITS OF DAIRY CATTLE IN KENYA

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Abstract

Lactation curves are a graphical representation of the milk production profile of a cow from parturition to drying up. They provide information about the productivity of the cow and offer a means of explaining features of the milk production patterns on the basis of the biology of mammary glands. 61,240 test day milk yield records were used to evaluate the effect of non-genetic sources of variation in lactation curve traits. A univariate fixed effect model was fitted to the data to evaluate the effect of the breed of the animal, parity/lactation number, shape of the lactation curve, the interaction of the herd, year and season of calving (HYSc), age of the cow at calving (in months) (CAGE) and days in milk at first test day milk sampling (DIM) on total lactation milk yield (TMY), peak milk yield (MYmax), time of peak milk yield (DIMP) and persistency (S). All the sources of variation fitted significantly influenced TMY. Breed, parity, HYSc and CAGE significantly influenced MYmax. Parity, HYSc and DIM were significant for DIMP and S. Lactation curve traits were influenced by various factors at varying thresholds. Therefore, these factors should be accounted for in a genetic evaluation process by including them in the model as fixed effects. At farm level, management decisions such as selection and culling, and feeding should made putting these factors into consideration.

Keywords: Milk yield, Lactation curves, Sources of variation, Dairy cattle

Introduction

Milk yield refers to the quantitative output of milk by an animal during a session of milking. It is expressed in various forms; as milk output at a given time of sampling (test day milk yield), as a sum of milk output from parturition to drying up (Lactation milk yield), or functions thereof attributed to the lactation curve such as persistency, peak milk yield and time of peak milk yield (Farhangfar and Rowlinson, 2007; Ilatsia *et al.*, 2007a; Leclerc *et al.*, 2008; Mark, 2004). Lactation curves are a graphical representation of the milk production profile of a cow from parturition to drying up. The curves provide information about the productivity of the cow and offer a means for explaining features of the milk production patterns on the basis of the biology of mammary glands. Consequently, lactation curves are important in management decisions making processes and in genetic analysis (Macciotta *et al.*, 2005; Silvestre *et al.*, 2006). In genetic evaluation of dairy performance using phenotypic information, appropriate correction of the data for various known sources of variation forms the first step of a genetic evaluation process. This step is important in facilitating sound selection decisions since it removes inequalities in observed performance that arise from non genetic sources. In addition, quantifying the effects of the various sources of variation in performance is important in enhancing efficiency of dairy production through responsive management (van Bebber *et al.*, 1997). Some of the known sources of variation in milk production performance are attributed to factors such as changes in weather (climatic) conditions, management on the farms, physiology of the animal, animal populations and even changes in definition of production traits (van Bebber *et al.*, 1997). Factors influencing milk yield performance of cows in the tropics have been reported (Hatungumukama et al., 2008; Ilatsia *et al.*, 2007b; Kahi *et al.*, 2004; Rhone *et al.*, 2008). However, the diversity of production environments within the tropics and constantly changing production conditions warrant more regular and location specific evaluation to update these factors. Despite this, studies on factors influencing lactation curve traits in Kenya are totally lacking. It is therefore important that various sources of variation in animal performance are evaluated in all the farms participating in national animal performance recording to ascertain which effects are important for on farm decision making and also inclusion in the national genetic evaluation models. This study aims at evaluating the effect of non genetic factors that affect lactation curve traits.

Material and Methods

Test day milk yield (TDMY) records from 4 parities of Ayrshire, Holstein Friesian, Jersey, Guernsey and Sahiwal that calved down between 1990 and 2006 were extracted from the national dairy cattle database at the Livestock Recording Centre (LRC) in Naivasha, Kenya. Animals lactated beyond the 305 days; consequently records were right truncated at 305 days in milk (DIM) resulting in a dataset that had 10 TDMY samples per lactation. The data were edited to remove records of lactations following abortions, lactation with missing test day yields and lactations with inconsistent dates of birth, calving and drying. Further edits involved removal of records of milk yield sampled earlier than the 5th day post partum in which case the subsequent milk sample was considered to be the first test day sample. Extra milk records where sampling was done more than ones in a month were removed in favour of samples closer to the 14th and 15th days of sampling. A total of 61,240 TD records were available for analysis.

Lactation curve parameters that were used in computation of lactation curve traits were estimated from the TD data using the incomplete gamma function (Wood, 1967).

$$Y_t = at^b e^{-ct} \qquad (1)$$

Where, Y_t is the test day milk yield at DIM t, a, b and c are parameters representing a scaling factor associated with initial milk yield, the pre-peak and post-peak curvatures, respectively. The incomplete gamma function was fitted to the test day data using PROC NLIN of SAS software (SAS, 2004). Lactation curve traits that were computed included total lactation milk yield up to 305 days (TMY) expressed as the area under the lactation curve (referred to as total milk yield in this paper), peak milk yield (MYmax) calculated as $a(b/c)^b e^{-b}$, days at peak milk yield (DIMP) expressed as b/c and persistency (S) expressed as $c^{-(b+1)}$.

The effects of the various factors influencing lactation curve traits were evaluated by fitting a univariate fixed effect model using the general linear model procedure of SAS (SAS, 2004).

$$Y_{ijk}=\mu + Brd + Parity + Cs + HYSc + x_1 CAGE + x_2 (DIM)^2 \qquad (2)$$

where Y_{ijk} is Trait, *Brd* is the effect of the breed of the animal, *Parity* is the effect of the parity/ lactation number, *Cs* is the effect of the shape of the lactation curve, *HYSc* is the effect of the interaction of the herd, year and season of calving while x_1 and x_2 are linear and quadratic covariates of the age of the cow at calving (in months) and DIM when the first test day milk sample was taken, respectively. In the evaluation of factors affecting MYmax, DIMP and S, equation (2) was modified by removing *Cs* from the model. In the analysis of TMY, DIM at first test day sampling fitted in equation (2) as a linear covariate.

Results and Discussion

Levels of significance of various explanatory variables on lactation curve traits are presented in Table 1. The effect of the breed was not significant for DIMP and S. This implies that all breeds exhibited similar lactation curve characteristics which could be attributed to the use of records of animals with only the standard lactation curve in the analyses of these traits. The breed however significantly influenced MYmax, and TMY that could be attributed to the differences in the milk production potential of the animals from different breeds. Although cows of different breeds tended to attain peak milk yield at almost similar times (depicted by insignificant DIMP) and showed non significant differences in persistency, their differences in milk production at peak lactation and during test day sampling is what resulted in the differences in lactation performance depicted by TMY. Significant effects of the breed on TMY were observed in a study of productive and reproductive performance of purebred *Bos taurus* cattle in large scale farms in Kenya (Kahi *et al.*, 2004).

Table 1. Mean squares and levels of significance[d] of variables included in the models for test day milk yield and lactation curve traits

	Traits[f]			
Variable[k]	MYmax	DIMP	S	TMY($\times 10^6$)
Brd	33.87*	1687.86ns	89810ns	9.307***
Parity	1282.77***	22215.61***	17642239***	38.838***
Cs	-	-	-	4.973***
HYSc	89.97***	1961.70***	1824806***	6.073***
DIM	31.24ns	18914.72***	20408195***	3.132*
CAGE	295.82***	1180.67ns	707ns	14.867***
R^2	0.84	0.52	0.49	0.83

[d]*ns=not significant, *=p<0.05, ***=p<0.001, -= Not fitted in the model*

[f]*MYmax=Peak milk yield, DIMP= days in milk at peak milk yield, S= persistency and TMY= Total milk yield through 305 days in milk*

[k]*Brd= Breed, Cs= Shape of the lactation curve, HYSc= Herd year season of calving, DIM= quadratic covariate of days in milk (but fitted as a linear covariate for TMY) when the first test day milk sample was*

taken; CAGE= linear covariate of age at calving (in months)

Parity was significant for all traits implying that lactation characteristics varied between parities which milk production traits implies differences in cow performance between the respective parities. In the evaluation of non genetic effects influencing daily milk yield of Friesian cows in Burundi, a significant effect of parity was attributed to the selection of the of cows based on their lactation performance in the first parity (Hatungumukama *et al.*, 2008). Milk production is a function of udder development which after a period of dormancy after birth is initiated again when a heifer attains puberty and is accelerated during pregnancy (Pollott, 2000). However, first parturition occurs in the process of continuous body and udder development and as a result primiparous cows have limited milk production capacity compared to pluriparous cows. This, combined with cow selection that is also practised in the large scale herds, could be the main basis of observed differences in this study.

Figure 1 shows the different lactation curve shapes of average predicted test day milk yield. From the 6112 lactation curves analysed, 4462 had a standard lactation curve shape while the rest manifested either continuously increasing or continuously decreasing or reverse of the standard curve shapes. The effect of the shape of the lactation curve significantly influenced TMY depicting differences in milk production potential between cows with different lactation curve shapes. For instance, cows with a standard lactation curve recorded low milk yield in test day one than those with a continuously decreasing curve. However, the former proceeds to produce more milk in the following day of test than the latter. Eventually, on the basis of the area under the lactation curves, cows with standard lactation curves would produce more milk at the end of lactation (TMY) relative to their contemporaries with other lactation curve shapes.

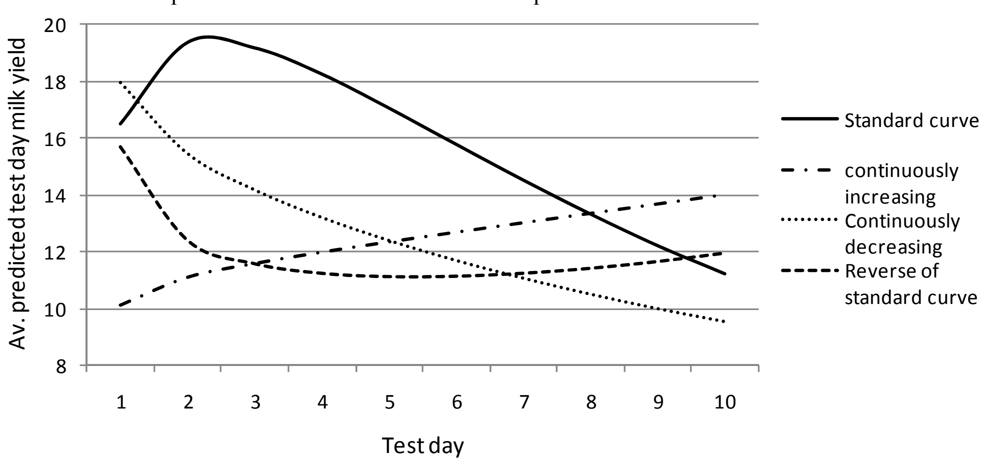

Fig. 1: Different lactation curve shapes of average predicted test day milk yield

HYSc was significant in all traits. The significant influence of HYS points to the importance of management and climatic conditions on milk production. Different herds employed different management strategies to ensure high milk production, which included nutritional and disease management, and selective breeding. This combined with the variation in precipitation over the years resulted in the observed significant effect. Effects of management and climatic conditions have been reported in earlier studies of dairy cattle, although at varying magnitudes (Ilatsia *et al.*, 2007b; Leclerc *et al.*, 2008; Rhone *et al.*, 2008; Tekerli *et al.*, 2000).

The effect of DIM ascribes the observed differences in performance traits to the stage of lactation (Ilatsia *et al.*, 2007b). This effect was significant in all traits except MYmax. Differences in onset of test day sampling have been shown to influence the shape of lactation curve (Silvestre *et al.*, 2006). Consequently, the significant effect could imply differences in curvatures of the lactation curve of the animals. The non significance of this effect implies similarity in milk yield at peak lactation between animals irrespective of the stage of lactation when the first test day was taken. Days in milk at first test day sampling in the current study ranged from 5 to 30 days post partum. Influence of first test day sampling on milk yield at peak lactation is reportedly more pronounced in lactations where sampling was initiated after the first month post partum (Silvestre *et al.*, 2006). Similar observations were made in the study on factors affecting the shape of lactation curves of Holstein cows in Turkey (Tekerli *et al.*, 2000). Age of the cow at calving (CAGE) significantly influenced MYmax and TMY. However the effect was not significant for DIMP and S. The significant effect of CAGE on yield traits i.e. MYmax and TMY could be attributed to the lactation physiology of dairy cows. Milk yield is generally low in young cows due to underdeveloped udders and hence low alveoli activity, however, this improves with the age of an animal as a result of cell proliferation until a later age when the rate of cell death surpasses proliferation leading to a drop again in milk yield (Dijkstra *et al.*, 1997).

The changes in milk yield traits (peak milk yield and total milk yield) with the age of the cow at calving are presented in Figure 2. Average TMY slightly increased with age reaching an asymptote at about 40 months of calving prior to dropping from the 64th month of calving. Average Yldmax increased from 27 months to about 60 months of age and dropped thereafter. There was also more uniform milk yield performance between animals in early and intermediate reproductive ages than in later ages. Therefore, selection decisions would be more precise when based on milk yield records from relatively younger cows than older cows. As the milk yield changes with age, most of the properties of the lactation curvature remain fairly constant thus accounting for the non significant effect of CAGE on the associated traits (DIMP and S).

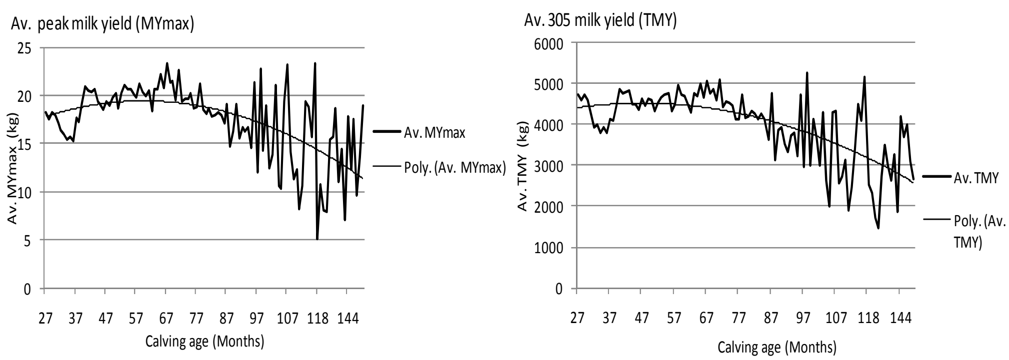

Fig. 2: Changes in milk yield traits (Test day milk yield, Peak milk yield, scaling factor associated with initial milk yield and total milk yield) with the age of the cow at calving

Conclusion

Lactation curve traits were influenced by various factors at varying thresholds. This study confirmed the effect of breed, parity, shape of the lactation curve, interaction of the herd, year and season of sampling and calving, stage of lactation and age of the cow on milk production. These factors should be accounted for in a genetic evaluation process by including them in the model as fixed effects. At farm level, management decisions with such as selection and culling, and feeding should made putting these factors into consideration. In addition, comparison of performance parameters should be based on these causal components in order to achieve more reliable evaluation results.

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