Describing the lactation process in Ayrshire and Holstein Friesian cattle in Kenya using a mechanistic lactation function

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Introduction

Modelling of lactation curves offer a summary of longitudinal milk yield patterns by which accurate predictions of daily and total lactation milk yield would be made (Sherchand *et al.* 1995; Olori *et al.* 1999; Quinn *et al.* 2005). Accurate modelling of lactation curve parameters is important in management of lactating cows (Rekik *et al.* 2003; Silvestre *et al.* 2006). A number of mathematical functions have been developed to describe the lactation curve of dairy cows (e.g. Wood 1967; Ali and Schaeffer 1987; Wilmink 1987; Dijkstra *et al.* 1997; Pollott 2000). However only a few of them have parameters that may have physiological interpretation. Dijkstra et al. (1997) described lactation as a physiological process involving population, proliferation and death of mammary cells and their activities during pregnancy and lactation. Lactation of Ayrshire (A) and Holstein Friesian (HF) cows has not been described ascribing physiological interpretation to the lactation patterns within the Kenyan dairy systems. The objective of this paper is to describe lactation process of Ayrshire and Holstein Friesian cows ascribing physiological interpretation to the lactation patterns.

Material and methods

Data. Data for this study were obtained from the dairy cattle database at the national animal evaluation organisation- Livestock Recording Centre (LRC) in Naivasha, Kenya. The data consisted of monthly test day (TD) milk yield records from parity one to three of Holstein Friesian and Ayrshire cows that calve down between 1990 and 2006.

Data were edited for consistency of date of calving and date of first test day, and drying date. Animals with less than 5 test days per lactation and lactation following abortion were excluded from the study. In case where the first test day was taken earlier than the 5th day post partum, the record was discarded and the subsequent record taken as test day one. For double sampling in a month, one of the records was deleted such that only one record per month was used. Most cows lactated year round and sometimes beyond, therefore lactation length greater than the standard 305 days in milk (DIM) was considered. The entire lactation

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length spanning 360DIM was clustered into twelve test days as follows: TD1=5-30DIM, TD2=31-60DIM, TD3=61-90DIM, TD4=91-120DIM…TD12=331-360DIM. The summary statistics of milk yield and structure of the data are presented in Table 1.

Table 1: Structure and summary statistics of the data on test day milk yield (in kg)

Breed	Parity No.	No of animals	No. of records	Mean TD milk yield	Std Dev	Minimum	Maximum
Ayrshire	1	882	8491	9.14±0.05	4.51	0.10	40.00
	2	352	6242	10.20±0.06	5.02	0.50	44.00
	3	254	5141	11.00±0.07	5.29	0.50	38.60
Holstein	1	3745	36554	14.45±0.03	6.27	0.18	50.00
	2	1136	27772	16.30±0.05	7.64	0.20	50.00
	3	594	20943	16.90±0.06	8.21	0.10	50.00

Statistical analysis. Test day milk yield data from the individual lactation of the two breeds was fitted on the mechanistic lactation function described by Dijkstra et al. (1997). Parameters of the function were estimated using non linear procedures of SAS (SAS, 2003). A Marquardt algorithm computational strategy was used to search for the 'best fit' solution for the curve, which was assumed when the difference between error sums of squares in successive iterations was less than 10–6.

Results and discussion

The mechanistic function fitted the lactation data well. This is depicted by the high estimates of adjusted R^2 (Table 2). In Ayrshire, the estimates increased with increase in parity from 0.825 in parity 1 to 0.841 in parity 3 implying achievement better fit in later parities than in earlier parities. A reversed trend was observed in the Holstein Friesian where the adjusted R^2 value declined with increase in parity number. However the function fitted the Holstein Friesian data better compared to the Ayrshire.

Table 2: Fit of the Dijkstra's function to test day milk yield data and the lactation parameters of the function

Breed	Parity	Adjusted R^2	Lactation curve parameters			
			a	*b*	*c*	*d*
Ayrshire	1	0.825	8.716 (0.49)	0.027 (0.01)	0.073 (0.02)	0.002 (0.00)
	2	0.835	11.544 (0.37)	0.009 (0.00)	0.032 (0.01)	0.002 (0.00)
	3	0.841	12.616 (0.37)	0.007 (0.00)	0.022 (0.01)	0.003 (0.00)
Holstein	1	0.855	11.631 (0.41)	0.039 (0.01)	0.084 (0.01)	0.001 (0.00)
	2	0.851	14.594 (0.52)	0.041 (0.01)	0.086 (0.01)	0.002 (0.00)
	3	0.851	15.598 (0.52)	0.037 (0.01)	0.071 (0.01)	0.003 (0.00)

Estimates of lactation curve parameters are presented in Table 2. Estimates of parameter *a* increased with parity in both breeds. Within respective parities between the breeds, higher estimates were observed in the Holstein Friesian compared to the Ayrshire. This parameter represents initial milk production as a product of the number of secretory cells and their secretory activity at the beginning of the lactation (Dijkstra *et al.* 1997). This therefore indicates that initial milk production increases with increasing parity implying that the number of secretory cells and secretory activities were relatively higher in later lactations than in early lactations. Between breeds, the Holstein Friesian had higher secretory activities at the beginning of lactation than Ayrshire. This is supported by the curves of predicted milk yield in Figure 1.

The rate of cell proliferation from time of parturition denoted by parameter *b* was positive implying an inclining slope of the curve. This parameter declined with parity indicating that milk production in the subsequent parities was more, a function of the activity of the pool of secretory cells at the beginning of the individual lactation than the cell proliferation in the previous lactation. The high rate of cell proliferation in Holstein Friesian relative to the Ayrshire indicated the breed's ability to attain higher peak than the Ayrshire. The estimates of parameter depicting the rate of cell death (*d*) depicted marginal increase with parity. However with decay parameter estimates (*c*) that declined with parity, a picture of more persistent lactation in parity one relative to lactations two and three is portrayed. This scenario was also observed in evaluation of lactation curves of dairy cattle in Mexico (Val-Arreola *et al.* 2004).

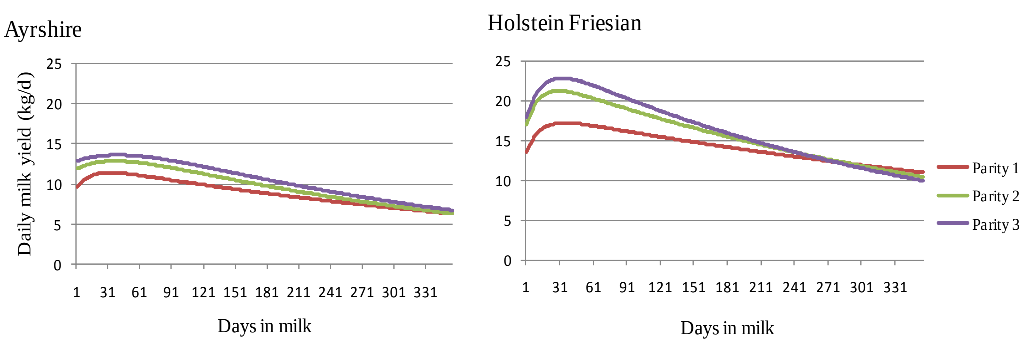

Figure 1. Predicted lactation curves for the first three parities in the Ayrshire and Holstein Friesian cows

Figure 1 presents lactation curves for predicted test day milk yield in Ayrshire and Holstein Friesian. In both breeds, milk yield increased from parturition to reach peak production before dropping thereafter. These shapes depict the standard lactation curve that has been reported in other studies (Sherchand *et al.* 1995; Olori *et al.* 1999; Quinn *et al.* 2005). The breeds exhibited more persistent lactation in parity one relative to parity two and three. This indicates a reduction in the rate of proliferation of differentiated cells in later parities since the rate of cell death is considered fairly constant between parities (Dijkstra *et al.* 1997). Ayrshire had a moderate peak but more persistent lactation curve relative to the Holstein Friesian. In addition, Ayrshire cows tended to attain peak later and gradually compared to the Holstein Friesian. These differences have a great implication in management of the cows during early lactation. Generally, during early lactation cows tend to have depressed feed intake. With high nutrient requirements due to rapidly increasing milk yield that result in peak milk production within the first month of lactation as observed in the Holstein Friesian, these animals are prone to lactation diseases and consequently require critical management during early lactation stages. Ayrshire cattle depict good lactation characteristics (gradual increase to peak production and gradual decline) that make it a desirable breed of choice in medium to smallholder production systems with constraining production resources.

Conclusion

Mechanistic model of Dijkstra described the lactation of Ayrshire and Holstein Friesian well. Milk yield is a function of secretory cell population and cell activity. High activity during early lactation should be complemented with good nutrition management to avoid physiological conditions associated with high milk yielding cows. In this regard Holstein Friesian require more vigilant management compared to Ayrshire hence it is more suited for high input production systems while Ayrshire would thrive well in low to medium input systems. Secretory cell population and activity varies between lactations and between breeds although they follow the shape pattern. Consequently, evaluation of milk production performance in dairy cows should be parity and breed specific if high accuracy is to be achieved.

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