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Seasonal variation of milk persistency of Kenana × Friesian crossbred dairy cows under confinement feeding in a hot environment

A. L. Abate, M. Atta* and R. N. Anthony

Department of Animal Production, College of Natural Resources and Environmental Studies, University of Juba, P.O. Box 321/1 Khartoum, **Sudan**.
***Corresponding author**

The present data were extracted from the records of Kenana x Friesian crossbred dairy cows managed under confinement in Kafuri Dairy Farm in the outskirts of Khartoum. The objective was to examine the seasonal variation of milk persistency and establish the relationship between milk yield and persistency. The monthly milk yield records of 3 successive lactations of 19 cows ranging in parity from 1 to 8 during the period 2005 – 2007 were used to calculate milk production traits viz.: milk yield per lactation, lactation length, peak yield, and persistency index. The lactation curve parameters were estimated according to the formula: $y_n = an^b \times e^{-cn}$, where: y = weekly milk yield (kg), n = time post calving in weeks, a, b and c are constants and e is the base of natural logarithm. Analysis of covariance was used to examine the significance of effects of year (2005, 2006 and 2007) and season of calving (dry summer, wet summer and winter) taking the parity order of the cow as a covariate. Repeatability (r) of the studied traits was estimated by intra-cow correlation. The results showed that season of calving had no significant effect on all of the studied traits, whereas, the year of calving had no significant effect on only the lactation curve parameters. Persistency correlated negatively with the lactation period, peak yield and constants b and c and positively with week of peak. The study concluded that these crossbred (Kenana × Friesian) cows have moderately repeatable milk persistency. The effects of factors such as calving year and calving season must be taken into consideration when evaluating the production of such cows. The positive phenotypic correlation of lactation yield with peak yield and persistency suggests that one of those traits could be used as a selection criterion to improve all three traits.

Key words: crossbred dairy cows, milk yield, lactation curve, persistency measures.

The indigenous cattle in the tropics are known for their tolerance to hot environments but they generally exhibit low productive and reproductive performance (Ageeb and Hiller 1991). Kenana and Butana cattle are considered the main local dairy breeds in the Sudan. Under improved feeding and management these two breeds yield about 1600 litters per lactation (Osman and Russell 1974). Many attempts have been made to improve the genetic potential of these animals for milk production. Crossing between exotic and indigenous breeds has been practiced in the Sudan since 1925 with Shorthorn compared to crossing with Friesian which was only introduced in 1960 (Medani, 1996). Friesian crossbreds were noted to be the most suitable for their good adaptability to the tropical environment in addition to their high yielding capacity.

Following the typical lactation curve crossbred cows should increase milk yield in early lactation until peak yield and thereafter steadily decrease yield for the remainder of lactation (Wood, 1967). The steady decline in milk yield after peak leads to reduced productivity and efficiency through the remainder of lactation (Knight and Wilde 1993). Clearly there are great benefits to be gained by maintaining milk production at high level for extended periods that is by improving lactation persistency. Improved persistency of lactation can contribute to reducing the cost of the production system because lactation persistency is associated with feeding and health costs, reproductive performance, resistance to disease and the return from milk considering a 305-day production cycle (Solkner and Fuchs 1987). It may be desirable to select for increased persistency without increasing peak yield because the latter subjects the cow to undesirable stress, health and fertility problems (Bar-Anan and Ron 1985). The same authors also reported that persistency could be a marker of adaptability of an animal to lactation stress, perhaps through factors associated with appetite and fertility. Tekerli *et al.* (2000) noted that for cows with flatter lactation curves, the incidence of metabolic and reproductive disorders that originate from the physiological stress of high milk yield would be lower, and the proportion of roughage in the ration could be increased, thus reducing production costs. Knowledge of the probable shape of the lactation curve makes feeding trials more efficient because differences between treatments are more easily detected when the animals are grouped according to the expected curve shape. Probably the best known mathematical model of the lactation curve was proposed by Wood (1967): $y_n = an^b e^{-cn}$, where y_n is milk yield on day n, a is a scaling factor to represent yield at the beginning of lactation, and b and c are factors associated with the inclining and declining slopes of the lactation curve. Tekerli *et al.* (2000) added that the important features of the lactation curve are the maximum yield and persistency (the extent to which the peak yield is maintained).

Boster and Boster (1984) have summarized the various ways of measuring persistency while the major factors that influence lactation persistency are known to include month of calving, parity order and sire progeny group. Effects of season of calving on persistency have been attributed primarily to seasonal differences in pasture availability and quality (Auran 1973). Environmental effects due to temperature and photoperiod are generally small in temperate environments (Wood 1970b) but can be important in warmer subtropical areas.

The objectives of the present study are to examine the seasonal variation of milk persistency of Kenana × Friesian crossbred dairy cows and the relationship between milk yield and persistency.

MATERIALS AND METHODS

The data used in this study were extracted from the records of Kafuri Dairy Farm located in Khartoum North on approximately 5 acres of land on the eastern bank of the Blue Nile. The dairy herd in the farm consists of crossbred Kenana × Friesian cows fed on a concentrate ration of wheat bran, beans crust, cotton seeds cake, crushed sorghum grains, molasses and salt given twice daily at 08:00 and 12:00 hrs at the rate of 9 kg of feed cow^{-1} day^{-1}. *Sorghum bicolor* and *Medicago sativa*, which are grown in the farm, were offered as green fodder. The fodder was given directly after the concentrate ration in amounts of 25 – 30 kg $cow^{-1}day^{-1}$. All animals were housed in open pens and in groups according to their production level, age and physiological status. Only natural mating was practiced. The cows were allowed to be served after two months post calving. Breeding bulls were selected from progenies of the highest yielding dams in the herd. Animals were usually vaccinated against the major infectious livestock diseases in the Sudan particularly Hemorrhagic Septicemia, Anthrax and Contagious Bovine Pleuropneumonia**.** Furthermore, monthly tests for mastitis, theileriosis, and routine spraying with acaricide against external parasites were carried out.

The data used in this study were the monthly milk yield records of 3 successive lactations of 19 cows of different parity orders (during the period 2005 – 2007). The data were the productive traits and lactation curve components. The productive traits included: milk yield per lactation (kg), lactation length (days), peak yield (kg wk^{-1}), persistency index according to the formula (given on next page).

The coefficient of variation (CV %) of monthly milk yield was also used to describe persistency (Tekerli et al. 2000). The lactation curve components were estimated according to Wood (1967) regression formula using *STATISTICA* computer software as described by StatSoft (2001). The formula was: $y_n = an^{b} \times e^{-cn}$, where: y = weekly milk yield (kg), n = Independent factor (time post calving in weeks), a, b and c are constants, e = the base of natural logarithm. From this equation, week of peak yield (b/c), persistency of the lactation curve peak in weeks (-(b+1)×ln c, where ln c is the antilog of the constant c, were calculated (Tekerli *et al.* 2000).

The data of the productive traits and lactation curve components were classified into 3 year groups according to year of calving (2005, 2006 and 2007). The data were also arranged into three seasonal groups: dry summer (March to June), wet summer (July to October) and winter (November to February) seasons calvers. Means, standard deviations and coefficients

$$\text{persistency index}(\%) = \frac{\text{milk yield per lactation (kg)}}{\text{weekly peak yield (kg/week)} \times \text{lactation period (weeks)}} \times 100$$

Table: 1. Description of lactation performance and lactation curve components

Traits	Valid N	Mean	SD	CV	r	SE of r
Milk yield, kg	57	2847.25	632.885	22.2	0.32	0.152
Lactation period, mo	57	9.56	1.018	10.6	0.43	0.144
Peak yield, kg wk^{-1}	57	413.88	117.660	28.4	0.38	0.148
Persistency, %	57	74.16	12.919	17.4	0.28	0.153
CV of milk yield, %	57	31.27	11.802	37.7	0.23	0.153
a	57	148.12	131.453	88.7	0.32	0.152
b	57	0.77	0.581	75.7	0.27	0.153
c	57	0.05	0.036	69.8	0.30	0.152
Week of peak	57	15.60	7.401	47.5	-0.07	0.125
Persistency of peak, wks	57	5.37	0.757	14.1	-0.16	0.108

SD = standard deviation;
r = repeatability;
SE = standard error and
a, *b* and *c* are lactation curve constants

of variation for the milking traits and lactation curve components were calculated by *STATISTICA* computer programme. Analysis of covariance was used (StatSoft 2001) to examine the significance of effects of year and season of calving taking the parity order of the cow as a covariate. Repeatability of the studied traits was estimated by intra-cow correlation (components of variance analysis) from the three years records.

RESULTS AND DISCUSSION

The amount of milk produced (2847 ± 632.885) and the lactation length (9.56 ± 1.018 months = 286.8 days) in the present study (table 1) were comparable to that reported by Ishag (2000) (2417.20 ± 921.00 kg and 291.3 ± 67.2 days, respectively) for 50% crossbred Sudanese Kenana x Friesian cows in the Sudan. Smaller amount of milk produced per lactation were reported for other tropical crossbred cows by Osman and Russell (1974) for 50% Butana × 50% Bos taurus (2417.20 ± 921.00) in the Sudan and by Wollny *et al*. (1998) for Malawi zebu × Friesian (1163.00 ± 999.00) in Malawi. Smaller amount of milk yield was also reported for pure Kenana (1423.58 ± 551.70) (El-Habeeb, 1991) and Butana (1662.57 ± 108.96 of 37.22 % CV) (Musa *et al*., 2005) in the Sudan. The lactation length of the present study (table 1) was longer than that reported for the Sudanese indigenous Kenana cows (224.00 ± 82.00) (Alim 1960) and Butana herd of Atbara Livestock Research Station (268.17 ± 5.56 days of 27.93% CV) (Musa *et al*. 2005)

The coefficient of variation of a trait gives the idea of the level of discrepancy of the tested data (El Khidir, 2009). He added that for animal production studies, presence of high level of discrepancy of a trait among individuals of the population indicated the good chance of improving this trait by selection. In the same context, the results of the present study (table 1) revealed that the persistency of the lactation curve peak yield has small coefficient of variation indicating low level of discrepancies among individuals. These observations are consistent with those of Broster and Broster (1984) who noted that persistency had generally been regarded as a genetic trait. The parameters *b* and *c* of the lactation curve usually describe the shape of the lactation curve since they represent the inclining and declining slopes of the lactation curve. The values of these parameters in the present study (table 1) were higher than those reported by Wood (1980) for Friesian (0.2399 and 0.0371), Shorthorn (0.2289 and 0.0380), Ayrshire (0.2653 and 0.0411), Jersy (0.1865 and 0.0320) and Guernsey (0.1964 and 0.0348) mature cows (parity 4 or more). The values *b* and *c* constants in the current study indicated the steeper shape of lactation curve. Tekerli *et al.* (2000) stated that dairy cows with a flat lactation curve are considered to have more persistent lactations than those with the same lactation yield but a steep lactation curve.

The repeatability coefficients of most of the studied traits (table 1) ranged between moderate and low. Albarrán-Portillo and

Pollott (2007) stated that the traits with low repeatability were influenced more by factors, which vary from lactation to lactation. Gengler (1995) reported repeatability for persistency of milk (0.26) comparable to that of the current study. Similarly, Tekerli *et al.* (2000) noted that repeatability estimates were moderate for peak (0.26) and lactation yields (0.34) and lower (0.06 to 0.20) for other lactation curve traits. Consistently, The present values of repeatability for *a*, *b* and *c* were higher than those reported by Wood (1970a) for British Friesians. The repeatabilities (Table 1) indicated that lactation curve traits were influenced by environmental factors (Tekerli *et al.* 2000).

In the present study (table 2), season of calving had no significant effect on all of the studied traits, whereas, the year of calving had no significant effect on the lactation curve parameters only. Similar observations were reported by Osman (1972). In his study on Sudanese cattle at Ghazala Gawazat, he showed that the year of calving had a significant effect on lactation performance, but season of calving had no effect. Similarly, Tekerli *et al.* (2000) noted that the effect of year was not significant for *a* and *b*, but it was significant for lactation yield. They added that the significant effect of year on milking performance traits may be due to the diverse feeding and management conditions as well as annual climate changes. Similar statement was noted by Musa *et al*., (2005) for data from the Butana herd of Atbara Livestock Research Station for the period 1949 – 1999. It is axiomatic that the total milk yield correlated positively with the lactation period and peak yield which in turn correlated positively with each other (Table 3). It is generally accepted that lactation persistency is lower in higher yielding animals, even if they were well fed, and is negatively associated with peak milk yield (Chase 1993). This explains the present negative correlation of persistency with the lactation period, peak yield and constants *b* and *c*. In addition, Tekerli *et al.* (2000) stated that lower values of CV% of monthly yield indicated greater persistency and this is consistent with the negative correlation between persistency of milk yield and CV% of monthly yield. Consistently, Tekerli *et al.* (2000) reported that the negative correlation between *a* and *b* (table 3) implied that higher initial yield was associated with a lower rate of increase until peak yield. The positive correlations between *b* and *c* indicated that cows that reach the peak more rapidly also have a quicker decline after peak (Batra *et al*. 1987). In the same context, the positive correlation between persistency and week of peak suggested that cows that reach peak yield later during lactation would have higher persistency and flatter lactation curve (Tekerli *et al.* 2000).

The study concluded that these crossbred (Kenana × Friesian) cows have moderately repeatable milk persistency. The effects of factors such as farm operation, calving year and calving season must be taken into consideration when evaluating the production of cows. The positive phenotypic correlation of lactation yield with peak yield and persistency suggest that one of those traits could be used as a selection criterion to improve all three traits. However, the negative correlation between peak yield and persistency should be considered at the improvement process.

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Table: 2. Lactation performance traits and lactation curve components of cows calved during different years and seasons

Traits	2005			2006			2007				
	Winter	Dry summer	Wet summer	Winter	Dry summer	Wet summer	Winter	Dry summer	Wet summer	SE	L.S.
No of observations	3	10	6	5	8	6	7	9	3		
Milk yield, kg	3672.2^{a}	3214.8^{ab}	2855.9^{ab}	2673.7^{b}	2783.6^{ab}	2717.7^{b}	2472.6^{b}	2775.5^{ab}	2587.3^{b}	264.25	* year
Lactation period, mo	9.7^{ab}	10.5^{a}	10.3^{a}	9.4^{abc}	9.6^{ab}	9.5^{abc}	8.4^{c}	9.1^{bc}	$9.0b^{c}$	0.37	* year
Peak yield, kg mo^{-1}	564.9^{a}	483.0^{ab}	476.7^{ab}	360.8^{b}	415.4^{ab}	391.4^{b}	334.2^{b}	379.9^{ab}	323.9^{b}	47.51	* year
Persistency, %	67.6^{cd}	66.7^{cd}	57.5^{d}	79.4^{abc}	70.9^{cd}	73.45^{bc}	88.4^{a}	80.8^{abc}	87.3^{ab}	4.37	* year
CV of milk yield, %	37.0^{ab}	34.7^{ab}	43.5^{a}	24.1^{b}	33.2^{ab}	28.1^{b}	23.1^{b}	30.2^{ab}	24.9^{b}	4.77	* year
a	176.5	110.9	212.6	169.1	193.9	140.2	100.2	110.8	197.3	58.86	NS
b	0.678	0.878	1.068	0.493	0.622	0.668	0.702	1.030	0.278	0.254	NS
c	0.037	0.052	0.075	0.035	0.051	0.038	0.038	0.071	0.029	0.015	NS
Week of peak	24.2	15.5	13.6	12.3	13.4	18.6	18.2	16.3	8.4	3.12	NS
Persistency of peak, wks	5.8	5.5	5.4	5.0	4.9	5.7	5.6	5.5	4.6	0.32	NS

L.S. = level of significance
* year = the effect of year of calving is significant (P<0.05)
NS = not significant
Superscripts a, b and c = means on the same row with different superscripts are significantly different (P<0.05)

Table: 3. Correlation coefficients matrix of the lactation performance traits

	total milk yield	lactation period	peak yield	persistency	CV% of yield	a	b	c	week of peak	persistency of peak
Total milk yield	1.00									
Lactation period	0.42*	1.00								
Peak yield	0.76*	0.27*	1.00							
Persistency	-0.09	-0.46*	-0.59*	1.00						
CV% of yield	0.11	0.30*	0.51*	-0.74*	1.00					
a	0.02	0.12	-0.05	-0.04	-0.27*	1.00				
b	-0.01	0.05	0.25	-0.37*	0.72*	-0.70*	1.00			
c	-0.03	0.06	0.22	-0.40*	0.75*	-0.56*	0.93*	1.00		
Week of peak	0.06	0.04	0.03	0.09	-0.03	-0.36*	0.21	-0.09	1.00	
Persistency of peak	-0.01	-0.01	0.14	-0.12	0.29**	-0.57*	0.60*	0.29*	0.82*	1.00

* Marked correlations are significant (P<o.o5)

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