

Effects of Non-Genetic Factors on Daily Milk Yield of Friesian Cows in Mahwa Station (South Burundi)

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Keywords

Friesian cattle – Dairy cow – Milk production – Burundi.

Summary

From 1991 to 2003, 75,650 daily milk records from 111 Friesian cows maintained at Mahwa station in Burundi were used to study the effects of the lactation length, age at calving, year and month of lactation, and parity on daily milk yield (DMY). Data were analyzed by the GLM procedure in SAS. All factors affected DMY significantly ($p < 0.001$). The overall average was 8.71 L/d. The peak milk yield of 11.48 ± 0.20 L/d occurred at the 15th day in milk on the lactation curve. The estimated linear (L/month) and quadratic (L/month²) regression coefficients for age at calving (in months) were -0.26 and 0.0052 in first parity, 0.49 and -0.0056 in second parity, and -0.22 and 0.0013 in third parity and above, respectively. Milk production decreased according to the year of lactation with the highest decrease in 1993. The minimum milk production was observed in 1995 with 6.91 ± 0.17 L/d and the maximum in 1991 with 15.55 ± 0.45 L/d. Milk production was significantly higher in February (9.75 ± 0.13 L/d) in the middle of the rainy season than in September (7.60 ± 0.13 L/d) at the end of the dry season. Least-squares means for DMY for first, second, and third lactations and above were 11.47 ± 0.30 , 5.23 ± 0.09 and 10.11 ± 0.06 L/d, respectively.

INTRODUCTION

In Eastern and Southern Africa, local dairy cattle breeds are predominant in the traditional sector. They are well adapted to tropical environments because of their high degree of heat tolerance, their resistance to tick-borne and other diseases occurring in the tropics, and their low maintenance requirements (18, 25). *Bos taurus* breeds that are predominantly found in temperate countries have a high potential milk production but they are not well adapted to tropical conditions because of their low heat tolerance and low disease resistance (25). Therefore, many African countries have introduced exotic cattle, mostly Friesian, Ayrshire, Jersey, Guernsey and Sahiwal cows (18).

Friesian is a common breed worldwide because of its high milk production. Most Friesian cows are bred in temperate countries of Europe, and in Canada and the United States of America (11). They are known for their fast growth, early maturity, high milk yield and long productive life. They were therefore imported into tropical and subtropical countries either to be maintained as purebred or to improve the indigenous cattle breeds (1). Productive and reproductive performances of purebred Friesians in the tropics are usually lower than those maintained in temperate climates and depend upon ecological and socioeconomic factors (8, 11). In Kenya, many large and medium-scale farms own purebred Friesians and their average milk production increased from 3577 kg/cow in 1985 to 5056 kg/cow in 1997. This increase was due to improved management techniques (19).

In Burundi, Ankole is the most common local breed. It has a low milk production but it is well adapted to the hard conditions of smallholders. The low productivity of these indigenous cows cannot meet Burundians' needs in milk. Moreover, the population

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increase makes it difficult to find natural pastures to rear cows. The number of cattlehead thus decreased from 675,000 in 1970 to 430,607 in 1990. In 1996, PNUD (21) estimated at 248,500 t the Burundian deficit in dairy products. In an attempt to improve the situation, the Ministry of Agriculture and the Institut des sciences agronomiques du Burundi (ISABU) established public farms where local cows were crossbred with exotic breeds. The importation of pure Friesians in Mahwa station dates back to 1991 and 1992, when 75 and 80 pregnant heifers, respectively, were imported from Zimbabwe. The adaptability and productivity of Friesian cows were studied under modern farming conditions, either as a pure breed or after crossing them with local breeds, before releasing them to smallholders. The aim of this study was to assess the effects of the lactation length, age at calving, parity, and year and month of lactation on daily milk yield (DMY) of Friesian cows maintained at Mahwa station.

MATERIALS AND METHODS

Site

The study was carried out at the Mahwa station of ISABU. The station was built in 1954 by the Burundian Ministry of Agriculture to improve the milk production of local cattle by crossbreeding them with exotic breeds and by introducing European dairy breeds (3). It is located in Bututsi's natural region at 1850 m of altitude, 3°47' S lat. and 30° E long., on an area of 850 ha. The weather is characterized by a rainy season from October to May and a dry period from June to September. A short dry season of two weeks is also regularly observed between January and February. Total annual rainfall ranges from 1400 to 1700 mm (20). The mean temperature oscillates between 17.6 and 17.8°C with maxima at 23.5 to 24.8°C, and minima at 8.9 to 10.3°C (23). At the time of the study, there were 182 cows at the station, with 4 purebred Sahiwal, 88 crossbred Sahiwal-Ankole, 47 crossbred Ayrshire-Sahiwal-Ankole, 39 purebred Friesian and 4 crossbred Montbéliarde-Sahiwal-Ankole. This station was trypanosome free because tsetse flies could not survive at the high altitude and moderate temperatures of the station.

Animal and herd management

Animal management had been intensive from the date of importation of Friesian cows (1991-1992) until October 1993, when the Civil War started in Burundi. Thereafter, animal management deteriorated and dairy cattle were managed semi-intensively with grass in the morning (8 h am to 14 h pm) and a forage complement distributed in the pen in the afternoon. For each liter of milk produced, lactating cows were supplemented with 0.25 kg of a concentrate composed of 20% palm tree oilcake, 35% rice bran, 35% corn maize, 10% soya flour, and 4% minerals. The forage complement and concentrate mix were distributed according to their availability. Cows were milked twice a day and production was recorded every day.

Daily milk yields were collected from 1991 to 2003 on 111 Friesian lactating cows for a total of 87,779 records. Data included the animal's identity, birth and calving dates, lactation number, year and month of lactation (at the time of observation), lactation length, and quantity of milk produced. Only lactation lengths of 100 to 305 days were considered in the analyses because lactation lasting less than 100 days were associated with diseases. A total of 8196 DMYS were discarded; they concerned in particular lactation lengths over 305 days. Cows in first parity aged from 20 to 81 months, those in second parity from 25 to 100 months, and those in third parity and above from 55 to 160 months. When the age at

calving was missing, the mean age of cows with the same parity was used. After editing, 76,650 DMYS were retained for analysis.

Data analysis

Data were analyzed by a linear model including the test-day in the lactation (1 to 305 days), parity ($n = 3$), age at calving nested within parity (23 to 122 months), year of lactation (1991 to 2003), month of lactation ($n = 12$), and interaction effect between year and month of lactation. Data were analyzed by the GLM procedure of SAS with the following linear model:

$$Y_{ijklmn} = \mu + A_i + F_m + \beta_1 B(F_m) + \beta_2 B^2(F_m) + C_k + D_l + CD_{kl} + e_{ijklmn}$$

where Y_{ijklmn} was a single DMYS on the n^{th} animal, μ the overall mean, A_i the effect of i^{th} day in milk ($i = 1, 2 \dots 305$), F_m the effect of m^{th} parity ($m = 1, 2, 3$), $B(F_m)$ the covariate effect of age at calving (in months) nested within m^{th} parity, $B^2(F_m)$ the covariate effect of squared age at calving (in months²) nested within m^{th} parity, β_1 and β_2 the linear and quadratic regression coefficients, C_k the effect of k^{th} year of lactation ($k = 1, 2 \dots 13$), D_l the effect of the first month of lactation ($l = 1, 2 \dots 12$), CD_{kl} the interaction effect between year and month of lactation, e_{ijklmn} the residual random effect associated with Y_{ijklmn} observation. Results were given as least-squares means (LSMs) of DMYS plus/minus standard errors. Only significant differences ($P < 0.001$) were reported.

RESULTS

The overall mean DMYS was 8.71 L/d. The model explained 54.53% of the variability observed in DMYS (Table I). All explanatory variables significantly influenced DMYS. The lactation shape was typical and followed the theoretical curve as described by Wood (26), and Dhanoa et al. (9). Milk yields increased quickly from 5.24 ± 0.21 L/d on the first day in milk to a peak of 11.48 ± 0.20 L/d at day 15 in milk. High DMYS (> 11.20 L/d) persisted from days 11 to 50 in milk and thereafter. DMYS decreased gradually and reached 6.47 ± 0.25 L/d at the end of the lactation (Figure 1).

Table I

Analysis of variance of daily milk yield of Friesian cows reared at Mahwa station. All effects influenced the yields significantly ($p < 0.001$)

Explanatory variables	Degree of freedom	Sequential sum of squares	Partial sum of squares
Parity	2	91,504	8,658
Age at calving within parity (month)	3	13,927	10,047
Age ² at calving within parity (month ²)	3	11,215	11,308
Lactation year	12	203,433	190,080
Lactation month	11	119,195	20,699
Interaction lactation year*month	119	136,397	136,397
Days in milk	304	137,364	137,364

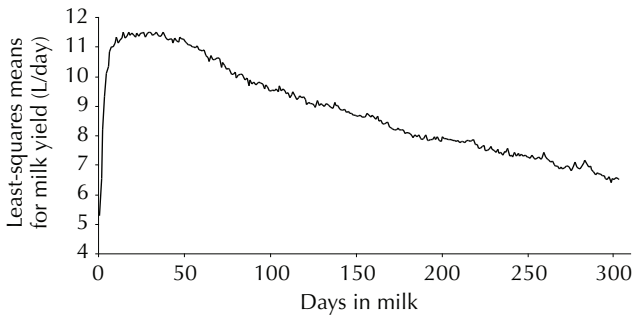


Figure 1: Least-squares means of daily milk yield during the lactation (305 days in milk) of Friesian cows maintained in Mahwa station.

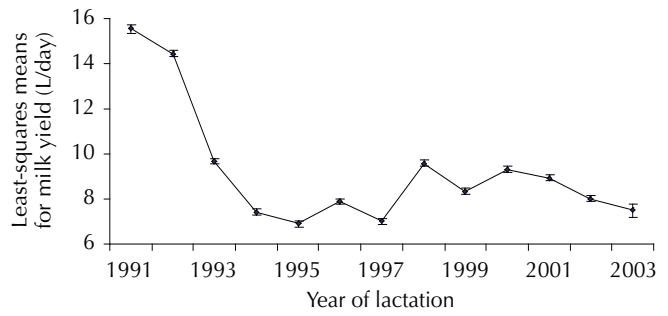


Figure 3: Evolution of least-squares means of daily milk yield through different years of Friesian cows' lactation in Mahwa station.

The mean age at calving in the first, second, and third and more parity were 35.4, 52.7 and 98.4 months, respectively. The estimated linear (L/month) and quadratic (L/month²) regression coefficients for age at calving were -0.26 and 0.0052 in the first parity, 0.49 and -0.0056 in the second one, and -0.22 and 0.0013 in the third one and above, respectively. LSMs of DMY increased with the calving age in the first parity. In the second parity, the trend was curvilinear with maximum production at the age at calving of 44 months. In the third parity, a little decrease was observed from the 56th to 86th months. Milk production slowly increased thereafter. The trends for each parity are given in Figure 2, as $\hat{y} = \hat{a}_i + b_1 B(F_m) + b_2 B^2(F_m)$, where \hat{a}_i is the LSM for each parity ($i = 1, 2, 3$), and b_1 and b_2 are the estimated regression coefficients.

A high variability was observed between yearly DMY with a major drop from 1992 to 1993. After 1993, milk production stayed below the yields observed in 1991 and 1992 (15.55 ± 0.45 and 14.44 ± 0.13 L/d). The minimum LSM for DMY was observed in 1995 with 6.91 ± 0.17 L/d. A little increase in DMY was observed from 1997 to 1998 (9.59 ± 0.19 L/d). Thereafter, it decreased and reached a second minimum in 2003 (7.51 ± 0.40 L/d) (Figure 3).

LSMs for monthly DMY were also variable. The minimum was observed in September (7.60 ± 0.13 L/d), i.e. at the end of the dry season. The maximum LSM for DMY was observed in February (9.75 ± 0.13 L/d) in the middle of the rainy season. A relative high milk production was maintained from January to May when the rainy season ended (Figure 4). LSMs for DMY for the first, second, and third and more lactations were 11.47 ± 0.30 , 5.23 ± 0.09 and 10.11 ± 0.06 L/d, respectively.

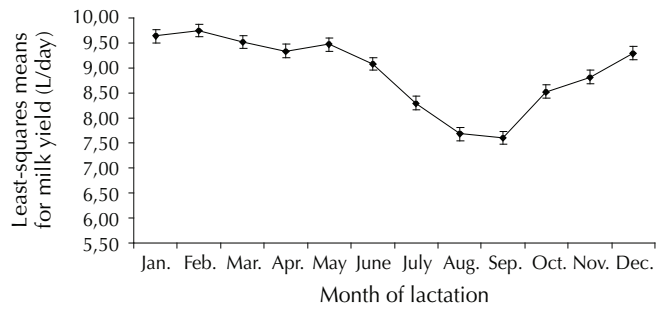


Figure 4: Evolution of least-squares means of daily milk yield according to the month of lactation of Friesian cows maintained in Mahwa station.

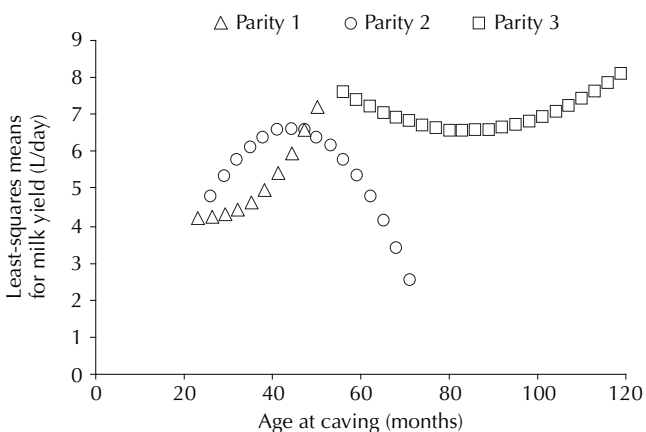


Figure 2: Linear and quadratic effects of age at calving (in months) on daily milk yield in Friesian cows; ordinary least-squares solutions from the model.

■ DISCUSSION

The overall average DMY observed here (8.71 L/d) was higher than the overall average DMY reported by Hatungumukama et al. (12) on Ayrshire crossbred cows (6.11 L/d) kept at the same station. On the other hand, it was lower than the average of 9.99 kg/day obtained by Tadesse and Dessie (25) on Friesian cows in Debre Zeit, a station of Ethiopia. It was also lower than the 11.5 L/d reported by Bayemi et al. (4) in Cameroon, and the 10.1 to 13.9 L/d reported by Combellas et al. (8) for supplemented Friesian cows. In Mahwa station, Friesian cows were not nearly expressing their genetic potential. Low milk production could have been due to the low level of concentrate feeding that forced animals to depend mainly on natural pasture composed of *Eragrostis olivacea*, one of the least-nutritive plants.

The period of peak lactation (15th day in milk) was consistent with that observed by Adeneye and Adebajo (1), who reported a peak during the first month of lactation for British Friesians in Western Nigeria. But the peak was more persistent than noted by the same authors. The peak yield obtained in Mahwa station (11.48 ± 0.20 L/d) was lower and occurred earlier than the peak (18.8 L/d at day 65 in milk) reported by Chagunda et al. (7) in Friesian cows in Southern Malawi.

The mean age at first calving of 35.4 months was higher than that of 25.2 and 30.5 months reported by Ageeb and Hayes (2), and Kabuga and Kwaku Agyemang (14), respectively. The mean age at second calving of 52.7 months was higher than that of 43.2 months observed by Kabuga and Kwaku Agyemang (14). This low precocity might have been related to the extensive farming conditions of the station.

The increase in milk production with the increasing age at calving in parity 1 was consistent with results reported by other authors (15, 16, 22) who found that milk production increased with the calving age in first and second parities. The curvilinear trend in parity 2 disagreed with results found elsewhere (15, 16, 22, 24). The decrease observed after the 44th month of calving age could be associated with the low nutrition and deteriorated animal management in the station since October 1993. The increased trend observed in the third parity was associated with the selection applied in the station where the least productive animals were sold and the most productive ones were kept until old age. The low linear and quadratic coefficients in third parity agreed with Kafidi's results (15).

Changes in management, feeding regime and other environmental factors are usually responsible for the variation of milk production through years (7, 12). Kabuga and Kwaku Agyemang (14) reported that the variation of the chemical composition of forage and concentrate mix explained the variation of Friesian milk production in Kumasi from 1975 to 1981. The 1993 Civil War caused financial problems in Mahwa station. Managerial changes associated with the war probably explained the decline in 1993 and the minimum DMY in 1995. The milk production drop in 1993 was also reported by Hatungumukama et al. (12) on the Ayrshire crossbred cows in the same station. The slight increase observed from 1997 to 1998 could have been due to a little increase in animal feeding. Genetic factors could also explain the low milk yield observed in 2003. During this period, the lactating cows were born at Mahwa station from bulls with a probably low genetic breeding value.

LSMs for DMY also differed with the seasons. Many other authors have reported low DMY during the dry and hot periods (2, 10, 12). In this study, DMY was lowest at the end of the dry season. One of the many constraints on milk production in the tropics is the low availability of natural forage during the dry season. Moreover, high temperatures during the dry season reduce feed intake and milk production (2, 6, 17). Ageeb and Hayes (2) reported that Friesian cows are more sensitive to heat stress than local breeds and their crossbreds.

The highest LSM for milk production observed in parity 1 was in disagreement with results from other authors (5, 10, 12, 13, 25), who observed that milk production increased from parity 1 to 3. This might be explained by the fact that many Friesian cows had their first calf in 1992, under intensive management conditions compared to the deteriorated conditions in 1993, when they were in parity 2. Moreover, LSMs were adjusted for the other effects in the model, including the linear trend in age at calving that was negative. The little improvement in animal feeding associated with security reestablishment in 1998, the selection of more productive cows in the station and the greater feed intake in old cows might have explained the increase from parity 2 to 3, even if production remained lower than in parity 1.

■ CONCLUSION

The introduction of Friesian cows in Mahwa station improved milk production. However, this production was lower than those observed by authors who worked on tropical Friesian cows (2, 4, 8, 14, 25); in Mahwa station, Friesian cows could not express their genetic potential because of the low level of feed and sanitary conditions, especially since 1993 when the war started. Therefore, it will be necessary to improve animal feed and health in Mahwa station in order to benefit from genetic selection programs.

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Résumé

Hatungumukama G., Leroy P.L., Detilleux J. Influence des facteurs non génétiques sur la production laitière journalière des vaches Frisonnes à la station de Mahwa (sud du Burundi)

Entre 1991 et 2003, 75 650 données sur la production laitière journalière de vaches Frisonnes de la station de Mahwa ont été collectées pour étudier les effets de la durée de lactation, de l'âge au vêlage, de l'année et du mois de lactation, et de la parité sur cette production. Les données ont été analysées à l'aide d'un modèle linéaire (procédure GLM de SAS). Tous les facteurs ont influencé significativement la production laitière ($P < 0,001$). La moyenne générale a été de 8,71 l/jour. La production laitière a suivi la courbe théorique de lactation avec un pic de lactation de $11,48 \pm 0,20$ l/jour au 15^e jour de lactation. L'âge au vêlage a influencé la production, avec des coefficients de régression linéaire et quadratique de $-0,26$ l/mois et $0,0052$ l/mois² en première parité, de $0,49$ l/mois et $-0,0056$ l/mois² en deuxième parité, et de $-0,22$ l/mois et $0,0013$ l/mois² en troisième (et plus) parité. La production laitière a diminué au cours des années de lactation avec la chute la plus importante en 1993. Elle a atteint un minimum en 1995 avec $6,91 \pm 0,17$ l/jour et un maximum en 1991 avec $15,55 \pm 0,45$ l/jour. Elle a été significativement plus élevée en février ($9,75 \pm 0,13$ l/jour) au milieu de la saison pluvieuse qu'en septembre ($7,60 \pm 0,13$ l/jour) en fin de saison sèche. La moyenne des moindres carrés pour la production laitière journalière a été respectivement de $11,47 \pm 0,30$, $5,23 \pm 0,09$, et $10,11 \pm 0,06$ l/jour en première, deuxième et troisième (et plus) lactation.

Mots-clés : Bovin Frison – Vache laitière – Production laitière – Burundi.

Resumen

Hatungumukama G., Leroy P.L., Detilleux J. Efectos de los factores no genéticos sobre los rendimientos de leche diarios de las vacas lecheras Friesian en la estación de Mahwa (sud Burundi)

Entre 1991 y 2003, los 75 650 records diarios de leche mantenidos para 111 vacas Friesian en la estación de Mahwa en Burundi fueron utilizados para estudiar los efectos de la duración de la lactación, edad al parto, año y mes de lactación y la paridad en los rendimientos diarios de leche (RDL). Los datos fueron analizados mediante el procedimiento de GLM en SAS. Todos los factores afectaron RDL significativamente ($p < 0,001$). El promedio total fue 8,71 l/día. El pico del rendimiento de leche fue de $11,48 \pm 0,20$ l/día, ocurriendo al día 15 de leche en la curva de lactación. Los coeficientes de regresión lineal (l/mes) y cuadrática (l/mes²) para edad al parto (en meses) fueron $-0,26$ y $0,0052$ para el primer parto, $0,49$ y $0,0056$ para el segundo parto y $-0,22$ y $0,0013$ para el tercer parto o más, respectivamente. La producción de leche disminuyó según el año de lactación, con la mayor disminución en 1993. La mínima producción de leche se observó en 1995 con $6,91 \pm 0,17$ l/día y la máxima en 1991 con $15,55 \pm 0,45$ l/día. La producción de leche fue significativamente más alta en febrero ($9,75 \pm 0,13$ l/día) en medio de la estación lluviosa, que en septiembre ($7,60 \pm 0,13$ l/día) al fin de la estación seca. Los cuadrados mínimos para RDL para la primera, segunda y tercera lactación o más fueron de $11,27 \pm 0,30$, $5,23 \pm 0,09$ y $10,11 \pm 0,06$ l/día, respectivamente.

Palabras clave: Ganado bovino Frison – Vaca lechera – Producción lechera – Burundi.