U. of K. J. Vet. Med. Anim. Prod., Vol.10, Issue 1&2 (2019) page 281 - 289
ISSN: 243456

UNIVERSITY OF KHARTOUM
Journal of Veterinary Medicine
and Animal Production

Analysis of the Production Performance of Holstein-Friesian Cattle in Sudan

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Abstract

This research was conducted to investigate the effect of genetic and non-genetic factors on productive traits in Holstein-Friesian cattle at Dairy Land Farm in Khartoum state (Sudan). The data set used covered the period of eighteen years (1984-2002). It comprised 47 sires and 720 cows with 2400 records extending from first to fifth lactation. The data were statistically analyzed using Harvey's least- squares computer program (1990). The least squares mean of lactation milk yield (LMY), daily milk yield (DMY), lifetime production (LTP), dry period (DP) and lactation length(LL) were 3055 kg, 11 kg, 8069 kg, 130 days and 290 days, respectively. The sires had a highly significant (P< 0.001) effect on LMY, LTP (P< 0.01) and LL (P< 0.05). Year of birth had a significant (P< 0.05) influence on LTP. The calving year-season and parity had a highly significant (P< 0.001) effect on LMY, DMY, LL and DP (P< 0.01, P< 0.05, respectively). The linear regression on lactation length had a highly significant (P< 0.001) effect on LMY and DP. In addition, the linear regression on dry period and milk yield had a highly significant (P< 0.001) effect on LL. The heritability of studied productive traits were low, this is probably a result of the artificial selection of the herds under study. The genetic correlations were 0.27± 0.35 between DP and LTP, 0.87± 0.16 between LMY and LL and -0.20± 0.42between LMY and DP while phenotypic correlations between the same traits were 0.28, 0.61and 0.02, respectively and the environmental correlations were 0.28, 0.58and 0.05, respectively). The study concluded that the performance of pure Holstein-Friesians was well below their performance in temperate regions, which probably reflects differences in the environment and levels of management. Taking into account the higher cost of management crossbreeding rather than pure breeding may be a more viable option.

Key words: Holstein-Friesian, milk yield, production, heritability, correlation

المستخلص

تم إجراءهذاالبحث بغرض دراسة أثرالعوامل الوراثية وغيرالوراثية على الصفات الإنتاجية في أبقار هولشتاين-فريزيان في مزرعة ديري لاند بولاية الخرطوم (السودان). غطت مجموعةالبيانات المستخدمة فترة ثمانية عشرعاما (1984-2002). كانت البيانات تتألف من 47 طلوقة و 720 بقرة لديها 2400 سجل تمتد من فترة الحلب الأولى إلى الخامسة. تم تحليل البيانات إحصائيًا باستخدام برنامج هارفي لأدنى المربعات (1990). كانت متوسطات أدنى المربعات لإنتاج اللبن في فترة الحلب (LMY) ، وإنتاج اللبن اليومي (DMY) والإنتاج مدى الحياة (LTP)، وفترةالجفاف (DP) وطول فترة الحلب (LL)، 3055 كجم، و11 كجم، و8069 كجم، و130 يومًا و 290 يوما، على التوالي. كان للطلائق تأثيرعالي المعنوية (P <0.001) علىLMY و (P <0.01) على LTP و(P <0.05) على LL. كان لسنة الميلاد تأثير معنوي (P <0.05) على LTP. وكان لفصل- سنة الولادة وترتيب الولادة تأثير معنوي (P <0.001) و (P <0.01) و (<0.05)

)على LMY وDMY وLL وDP ،على التوالي. كان للانحدارالخطي على طول فترة الحلب تأثيرعالي المعنوية (P
<0.001) على LMY و DP. بالإضافة إلى ذلك، كان للانحدار الخطي على فترة الجفاف وإنتاج اللبن تأثير معنوي (P
<0.001) على LL. وكانت وراثة الصفات الإنتاجية المدروسة منخفضة، وربما يكون هذا نتيجة الانتخاب الاصطناعي للقطعان قيد الدراسة. كانت معاملات الارتباط الوراثية 0.27 ± 0.35 بين DP و LTP، 0.87 0.16 ± بين LMY و LL و -0.20 ± 0.42 بين LMY و DP بينما كانت معاملات الارتباط المظهرية بين الصفات نفسها 0.28 و 0.61 و 0.02 ، على التوالي ومعاملات الارتباط البيئية 0.28 ، 0.58 و 0.05 ، على التوالي. وخلصت الدراسة إلى أن أداء الهولشتاين فريزيان النقي كان أقل بكثير من أدائها في المناطق المعتدلة، وهذا قد يكون ناتجا عن الاختلافات في البيئة ومستويات الإدارة. وعند الأخذ في الاعتبار تكلفة الرعاية الأكبر قد تكون التربية الخلطية بدلا عن النقية هي البديل الأمثل.

الكلمات المفتاحية: هولشتاين-فريزيان، انتاج اللبن،

Introduction

Recent decades have shown a rapid increase in the demand for milk and milk products in the Sudan. Despite the huge numbers of cattle in Sudan (About 38.325million heads in 2001 according to Abdel Rahman, 2007) the traditional cattle production sector does not meet the increasing milk demand of urban areas, probably, due to the low productivity of indigenous cattle breeds that bred in the sector. The main reasons of low productivity of cattle are; poor genetic potential, poor management, low inputs and diseases. Attempts to increase production were made by adopting crossbreeding and importation of pure Holstein Friesians. Exotic breeds require adequate health care, especially against endemic parasites and diseases and need special housing facilities.

Various environmental and genetic factors influence performance traits of dairy cattle. The present study aimed to investigate the environmental and genetic factors influencing the productivity of Holstein Friesian cattle maintained under the subtropical conditions of Sudan. Together with possible future studies on the economics of production from exotic breeds the results of this investigation will be important for planning management and improvement of livestock.

Materials and Methods

This study was conducted on records from the farm of the Arab Company for Agricultural Production and Processing (ACAPP) located 40 km south of Khartoum at El-Baqueir. The farm was established in1984.It was started by importing 1000 heifers-in-calf in two batches (500 heads each) in 1984 and 1985 from West Germany. El-Baqueir area has a semi-arid climate with mean annual rainfall of 167 mm. The wet season extends from July to September with about 70% of the total annual rainfall in this period. Temperature in the area is high with an annual mean average of 30.7 º C and extremes of over 45 ºC.

Each 500 cows were kept in a cow sub-unit of a single steel frame building of 6900 m^2. The building contained 10 cow pens, milking parlour, holding areas and milk storage and cooling facilities. The animals were fed on green or dry roughages (mainly sorghum hybrid) and a concentrate mix (generally consisted of oil seed cakes, wheat bran, sorghum grain, molasses, sorghum gluten, salt and lime). There were fluctuations in the quantity and quality of both roughage and concentrate rations from year to year and from season to season.

Artificial insemination using imported semen of proven bulls was used. All animals in the farm were regularly vaccinated against endemic diseases such as rinderpest, anthrax and foot and mouth disease. Spraying with acaricides for the control of ticks was done twice monthly.

Data collection and manipulation:

The data in this study covered a period of eighteen years (1984-2002). The number of cows studied was 720 pure Holstein-Friesians and their records were 2400 extending from first to fifth lactation, and the number of sires was 47. The data were statistically analyzed using Harvey's least-squares computer program (1990). Productive traits including lactation milk yield (LMY), daily milk yield (DMY), lactation length (LL), dry period(DP) and lifetime production(LTP) were studied.

The following statistical models were applied:

Model (1):

Analysis of lactation milk yield and daily milk yield:

$Y_{ijk} = \mu + S_i + P_j + C_k + b1x1 + E_{ijk}$....................... (1)

Where:

Y_{ijk}= the ijk th observation on the trait in question.

μ= the overall mean.

S_i= the effect of ith sire.

P_j= the effect of jth parity number (j=1-5).

Ck= the effect of kth year-season of calving (k=1-9).

b1= linear regression coefficient of the trait in question on lactation length.

x1= the deviation of lactation length from its overall mean.

Eijk= the residual error.

Model (2):

Analysis of lactation length:

$Y_{ijk} = \mu + S_i + P_j + C_k + b1x1 + b2x2 + E_{ijk}$................... (2)

Where:

b1= linear regression coefficient of the trait in question on dry period.

x1= the deviation of dry period from its overall mean.

b2= linear regression coefficient of the trait in question on milk yield.

x2= the deviation of milk yield from its overall mean.

The rest of the terms are as in model 1 above.

Model (3):

Analysis of dry period

$Y_{ijk} = \mu + S_i + P_j + C_k + b1x1 + b2\ x12 + E_{ijk}$................... (3)

Where:

b2= quadratic regression coefficient of the trait in question on lactation length.

x12= the deviation of lactation length from its overall mean.

The rest of the terms are as in model 1 above.

Model (4):

Analysis of lifetime production:

$Y_{izn} = \mu + S_i + A_z + F_n + b1x1 + E_{izn}$.................... (4)

Y_{izn}= the iznth observation on the trait in question.

A_z= the effect of zth year of birth (m=1-3)

F_n= the effect of nth age at first calving (n=1-4)

b1= linear regression coefficient of the trait in question on total lactation length.

x1= the deviation of total lactation length from its overall mean.

The rest of the terms are as in model (1) above.

Results and Discussion

Lactationmilk yield(LMY):

The overall mean of milk yield per lactation in the present study is 3054.5± 68.2 kg (Table 1). This level of production is close to the productivity of Friesian crossbreds (2500 kg) reported by Ahmed *et al*., 2007), but it is very low compared with the productivity of Friesian cows in temperate regions (about 20,000 kg). In addition, it is high compared with the production of local breeds (2000 kg reported by Osman and Russel (1974). It is close to the findings of Usman et al. (2012) in Pakistan (3438± 887.2kg) and Hammoud *et al*. (2014) in Egypt (3697± 1190 kg). However, it is lower than results obtained by Faid-Allah (2015) in Egypt (6385.0 kg) and Gara *et al*. (2009) in Tunisia (5669.8 kg).

Sires significantly affected the milk yield. Parity had a highly significant effect on this trait. This is similar to the results of Faid-Allah (2015) and Sandhu *et al*. (2011). The results revealed that the maximum milk yield was reached in the second parity followed by a gradual decline. That is probably an indication of poor management and harsh environment, since productivity should increase up to the forth parity and then decrease gradually.

The effect of year-seasons of calving was significant. This is in agreement with the results reported by Faid-Allah (2015). However, it contradicts that obtained by Usman et al. (2012). The variation in milk yield between years and seasons may be due to changes in management, genetic make-up of the herd and environment. Generally, throughout the study years, the milk yield was higher in winter and wet summer than in the dry summer. This may be due to the high environmental temperature during dry summer.

Daily milk yield (DMY):

In the current study the overall mean of daily milk yield was 11.2±0.3 kg (Table 1). This daily mean is similar to estimates reported by Romero *et al*. (1992) (10.8 kg) in Venezuela. But it is lower than the daily mean of imported Friesians reported by Hammoud *et al*. (2014) (13± 1.1 kg) in Egypt. However, it is higher than the finding of Mbap and Ngere (1989) in Nigeria.

The sire, parity number, and calving year-season had highly significant effects on this trait. The daily production of milk increased in the second parity in which the maximum daily yield (12.2±0.3) was achieved, and then decreased gradually. As for calving year-seasons milk production was higher in wet summer and winter than in dry summer. The linear regression on lactation length did not significantly affect daily milk yield.

Lactation length (LL):

The overall mean of lactation length in the present study was 290.3± 3.3 days (Table 1), which is close to the optimal length (305 days) generally agreed upon in the cow's calendar. This result is close to the findings of Sattar et al. (2005) (291.9± 6.6) in Pakistan and Hammoud *et al*. (2014) (310± 15) in Egypt. The sires significantly affected lactation length. This finding is similar to the results of Faid-Allah (2015) in Egypt but it is in disagreement with the results of Usman et al. (2012) in Pakistan. The effect of parity number on this trait was highly significant. This disagrees with the findings reported by Usman et al. (2012) in Pakistan.

Year-seasons of calving had a highly significant influence on lactation length. This result is in agreement with the results of Faid-Allah (2015) in Egypt. The variation in LL reflects the effects of age, nutrition and health status of the animal. The linear regression on milk yield and dry period had a highly significant influence on lactation length.

Table 1. Least square means and standard errors for lactation milk yield (LMY), daily milk yield (DMY), lactation length (LL) and dry period (DP)

Items	N	LMY (kg)	N	DMY (kg)	N	LL (days)	N	DP (days)
Overall mean	1439	3054.5±68.2	1424	11.15±0.25	1041	290.3±3.3	1063	129.8±7.3
Sire		***		***		*		N.S
Parities		***		***		***		*
First	570	3266.5±78.4	569	12.0±0.3	398	298.5±3.9	401	124.7±8.5
Second	395	3346.5±76.1	393	12.2±0.3	330	277.4±3.7	337	111.0±8.1
Third	258	3144.9±81.1	256	11.5±0.3	176	276.5±4.2	180	129.8±9.0
Fourth	144	2693.3±95.2	135	9.9±0.6	90	293.4±5.4	96	138.5±11.0
Fifth	72	2821.6±121.9	71	10.2±0.5	47	305.6±7.4	49	145.0±14.3
Calving year-seasons		***		***		***		**
Winter 1984-1989	425	2844.3±148.1	421	10.4±0.6	338	275.1±10.4	342	148.0±21.1
Dry summer 1984-1989	159	2641.2±151.0	156	9.6±0.6	128	279.2±10.5	132	151.2±21.3
Wet summer 1984-1989	208	2704.6±148.2	202	10.0± 0.6	159	270.7± 10.5	166	167.1±21.3
Winter 1990-1995	156	3545.0±109.1	156	12.8±0.4	95	273.3± 6.9	97	139.8±13.9
Dry summer 1990-1995	132	3150.5±109.4	132	11.4±0.4	83	273.5± 7.1	84	158.8±14.5
Wet summer 1990-1995	245	3392.4±104.5	244	12.2±0.4	173	280.0± 6.5	177	121.1±13.2
Winter 1996-2002	53	3225.1±153.1	53	11.9±0.6	36	310.0± 9.35	35	101.6±19.5
Dry summer 1996-2002	27	2708.8±129.4	26	10.3±0.7	15	354.5±12.5	16	108.1±26.0
Wet summer 1996-2002	34	3279.0±178.0	34	11.8±0.7	14	296.2±13.0	14	72.6±26.6
Linear regression on LL		11.3±0.4***		0.002±0.002N.S				-0.22± 0.06***
Quadratic regression on LL								0.003±0.001***
Linear regression on DP						-0.10±0.02***		
Linear regression on LMY						0.03±0.001***		
Coefficient of variation (%)		27.2		28.0		15.4		57.3

N.S= non-significant*= significant (P< 0.05) **= significant (P< 0.01)***= significant (P< 0.001)

Dry period (DP):
The overall mean of dry period was 129.8± 7.3 days (Table 1), which is much longer than the optimum dry period (60 days). This result is close to that of Hammoud *et al.* (2014) (117± 13 days) in Egypt and Al-Samarai *et al.* (2015) (114.1± 2.0 days) in Yemenbut it is higher than the estimate of Ahmed *et al*. (2007) (84.2± 8.5 days) in Sudan. Sires have no significant effect on dry period. This result disagrees with those of Usman *et al.* (2012) in Pakistan and Al-Samarai *et al.* (2015) in Yemen. The parity number had a significant effect on this trait. Generally, there was an increasing trend in dry period as parities advanced. The variability in DP among parities may be attributed to the level of management, increase in milk yield and poor fertility of cows.
Calving year-seasons had a significant influence on DP. The variation in DP between year-seasons might be due to change in environmental conditions and

management practices. Furthermore, the, shortest dry periods were observed in the wet summer, while the longer periods were in dry summer. This may be due to the high summer temperatures and the tendency to allow cows to continue lactation in wet summer when forage is available and to dry them early in the dry season due to lack of fodders. The linear and quadratic regressions on lactation length had a highly significant influence on dry period in the present study.

Lifetime production (LTP):

The overall mean of lifetime production in this study was 8069.2± 201.5 kg (Table 2). This result appears to be acceptable compared with the other estimates in tropical and subtropical countries. It is close to the findings from Holstein Friesian data of Faid-Allah (2015) (7208.7) in Egypt, but it is lower than the estimate of Gara *et al*. (2009) (19496.3) in Tunisia.

The year of birth had a significant influence on LTP. This result is similar to that of Khattab *et al* (2009) in Egypt who reported significant effect of year of birth on LTP. The variation in life time production of milk between birth years is probably due to genetic and management changes. Age at first calving had no affect life time production in this study although it is generally accepted that when cows started production life earlier they will end up with more lifetime production.

Table 2. Least square means and standard error for lifetime production (LTP)

Item		N	LTP (kg)
Overall mean		544	8069.2±201.5
Birth year			
	1982-1985	230	10474.3±902.4
	1986-1989	83	7327.5±551.6
	1990-1993	231	6405.7±705.2
Age at first calving (Days)			
	700-780	138	8041.8±264.7
	781-825	125	8317.0±265.0
	826-895	136	7884.0±260.8
	896-1200	145	8034.0±251.8
Linear regression on total lactation length			11.07±0.26***
Coefficient of variation (%)			24.9

Heritabilities of production traits:

In this study the heritability of milk yield was 0.04± 0.01 (Table 3). It is lower than estimates obtained by Faid-Allah (2015) in Egypt (0.18) and Toghiani (2012) in Iran (0.26± 0.04). The estimate of heritability of daily milk yield in this study was 0.04± 0.01(Table 3) which is close to the findings obtained by El-Khalil (2001) in Libya (0.06± 0.03). The heritability of lactation length in the present study was 0.02± 0.014 (Table 3). This estimate is lower than the result of Salem *et al*. (2006) (0.07) in Egypt. In this study the heritability of dry period was 0.02± 0.013 (Table 3) which is lower than the findings of Salem *et al*. (2006) (0.05) in Egypt.

The heritability of lifetime production (LTP) in the present study was 0.09± 0.03 (Table 3). This estimate is less than the estimate obtained by Faid-Allah (2015) (0.22) in Egypt. In general, the estimates of heritabilities of productive traits in this study were very low. This is probably a result of the selected nature of the herd under study.

Table 3. Heritability and genetic, phenotypic and environmental correlations of the production traits

Trait	LMY	DMY	LL	DP	LTP	r
LMY		1.19±0.14	0.87±0.16	-0.20± 0.42	Na	r_g
	h^2=0.04±0.01	0.76	0.61	0.02	Na	r_p
		0.73	0.58	0.05	Na	r_e
DMY			Na	-0.33± 0.43	0.62± 0.24	r_g
		h^2=0.04±0.01	0.004	-0.02	0.35	r_p
			Na	0.02	0.33	r_e
LL				-0.01± 0.80	0.85±0.1	r_g
			h^2=0.02±0.01	-0.24	0.89	r_p
				-0.25	0.28	r_e
DP					0.27±0.35	r_g
				h^2=0.02±0.01	0.28	r_p
					0.28	r_e
LTP						r_g
					h^2=0.09±0.03	r_p
						r_e

r_g= genetic correlation r_p= phenotypic correlation re= environmental correlation
h2= heritability (on the main diagonal)

Genetic, phenotypic and environmental correlations:

Generally, the positive genetic correlations between traits indicate that these traits can be improved simultaneously via multi-trait selection breeding programs. Furthermore, the genetic and environmental causes of correlation combine together to give the phenotypic correlation. If both characters have low heritabilities as in the case of the present study, then the phenotypic correlation is determined chiefly by the environmental correlation. Table (3) shows the correlations between productive traits. There are negative phenotypic correlations between dry period (DP) and each of daily milk yield (DMY) and lactation length (LL) (-0.02 and -0.24 respectively). This result indicates that the dry period influences the milk yield through its effect on LL. The phenotypic correlations between LL and both of lactation milk yield (LMY) and DMY are positive (0.62 and 0.004, respectively). Also there are positive phenotypic correlations between DP and LMY (0.02) and between LTP and each of DMY, LL and DP (0.35, 0.89 and 0.28, respectively).

There are negative genetic correlations between DP and each of LMY, DMY and LL (-0.20± 0.42, -0.33± 0.43 and -0.01± 0.80 respectively). There are positive genetic correlations between LMY and both of DMY and LL (1.20± 0.14 and 0.87± 0.16 respectively). There are also positive genetic correlations between LTP and each of DMY, LL and DP (0.62± 0.24, 0.85± 0.1 and 0.27± 0.35, respectively).

Conclusion

The animal's expression of its genetic potential is influenced to a greater or lesser extent by the environmental conditions under which it produces. Under poor environments highly selected breeds such as Friesians cannot realize their genetic potential and adaptation to the local environment is an important component of productivity. In general, the performance of Holstein-Friesian cows in the present study was far below their performance in temperate regions. However, they were of moderate performance compared with the performance of the same breed in other tropical areas. The mean lactation production of Holstein Friesians obtained in the present study were not significantly different from those reported for 50% Friesian under Sudan conditions. Taking into account the higher cost of management for pure Friesians, this means that crossbreeding rather than pure breeding may be a more viable option. This will require more research to determine the optimum level of taurine blood to be used.

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