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GENETIC EVALUATION FOR FRIESIAN CATTLE IN EGYPT USING SINGLE-TRAIT ANIMAL MODEL

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ABSTRACT

A total number of 1011 first lactation records of Friesian cows daughters of 705 dams and 103 sires for a period of 19 years raised at Agricultural Research Station, Sakha, Kafr El-Sheikh Province, belonging to Animal Production Research Institute, Ministry of Agriculture, Egypt were used to evaluate the genetic parameters of total milk yield (TMY), 305-day milk yield (305-dMY), lactation period (LP), age at first calving (AFC), number of service per conception (NOS), calf birth weight (BW) and calf weaning weight (WW) as well as estimating breeding values (BV) of animals using single-trait animal model. Data were analyzed using Multi-trait Derivative Free Restricted Maximum Likelihood (MTDFREML) Program to calculate the genetic parameters and BV. Statistical Analysis System (SAS) was utilizing to investigate the effect of fixed effects on these traits using mixed model procedure. Means (± SD) of TMY, 305-dMY, LP, AFC, NOS, BW and WW were 2653±1191, 2338±864 kg, 332±107 days, 31.8±5.8 months, 2.25±1.80, 29±4.26 and 95±10.5 kg, respectively. Heritability estimates (h^2) for the same traits were 0.07, 0.27, 0.12, 0.04, 0.25, 0.19 and 0.06, respectively. The range of BV for all animals was -2.64 to 2.95, -3.43 to 5.62 kg, -3.41 to 6.44 days, -4.01 to 7.94 months, -2.77 to 3.34, and -2.12 to 1.62 kg, respectively. Spearman rank correlations and Pearson correlations between estimated breeding values of all animals in pedigree (cows, dams and sires) provided by the genetic analysis ranged between 0.19–0.99. Rank correlations of animals between traits were the lowest for reproduction traits. It could be concluded that improving the environment conditions will improve these traits. Also, with the moderate h^2 and the wide range in BV between animals regarding to 305-dMY and AFC will help in improving these traits genetically.

INTRODUCTION

In Egypt the dairy sector contributes about 30% of the total value of agricultural production. There is a great gap between the production and consumption regarding the animal protein requirements for the Egyptian people. Milk yield of the native Baladi cows is low, about 800 kg per lactation, and is used mainly for nursing the calf. The most important method to fill this gap is to increase the productivity of local and imported Dairy cattle by selection and continuous genetic improvement using the recent and computerized methods used in the developed countries. Friesian cattle play a great role in dairy industry because of its high productivity of milk compared with the local cattle. The genetic parameters for a trait are essential in animal breeding. Genetic parameters are also needed to predict breeding values to be used in the ranking and selection of superior animals for breeding. Consequently, estimation of genetic parameters for productive and reproductive traits and breeding values of Friesian cattle in Egypt are required for the genetic improvement programs of these cattle.

One of the most important practices in animal breeding strategies is to find more accurate and practical models for estimating genetic and environmental parameters. Misztal *et al* (1993) reported that for improving the accuracy of its genetic evaluations, the Holstein Association of America has changed from a sire model to an animal model. Animal models are more suitable than sire models because of considering all pedigree relationships rather than only sire lines. Accordingly, The main objective of the this study was to estimate the heritabilities and breeding values of some productive (total milk yield, 305-day milk yield and lactation period), reproductive (number of service per conception and age at first calving) and growth (birth weight and weaning weight) traits by using single-trait animal model analysis for a governmental herd of Friesian cow in Egypt.

MATERIALS AND METHODS

Data and management

Data on 305-day milk yield (305-dMY), lactation period (LP), number of services per conception (NOS), age at first calving (AFC), birth weight of calf (BW) and weaning weight of calf (WW) from 1011 first lactation records of Friesian cows daughters of 705 dams and 103 sires for a period of 19 years (1977 to 1995) belonging to Sakha Animal Production Research Station, Animal Production Research Institute, Ministry of Agriculture situated at Kafrelsheikh Governorate in the northern part of Nile Delta of Egypt were used to estimate genetic parameters and breeding values. Single-trait heritability animal models were used to estimate parameters based on restricted maximum likelihood methodology.

Cows were artificially inseminated at random. Heifers were serviced for the first time when reached 18 months of age or 350 kg live body weight which come first. Cows were usually served two months postpartum. Pregnancy was detected by rectal palpation 60 days after last mating. The cows were loosely housed in open sheds system. Cows were kept under similar system of feeding and management practiced on the farm applied by Animal Production Research Institute, Ministry of Agriculture. All cows were fed on good quality concentrate ration. During winter and spring months (from December to May), animals were supplied with Egyptian clover (*Trifolium alexandrinum*), while during summer and autumn (from June to November), animals were fed on dry ration, mainly either Egyptian cover hay or green sweet sorghum. Also, rice straw was available around the year. Feeds were supplied to cows according to their live body weight, milk production and pregnancy status. Portable water and mineral mixture were available freely. Cows were machines milked twice daily in a parallel. Cows were usually dry off about two months before the expected calving date.

Friesian calves were allowed to suckle their dam's colostrums for the first three days after birth, thereafter they were artificially reared on natural milk twice daily on the age basis till weaning at the age of 15 wk. An amount of 500 kg of natural milk was available for each calf during the suckling period. Beside milk, green fodder was given to the calves *ad libitum* according to the schedule applied under the feeding and management system of Animal Production Research Institute, Egypt. Green fodder in winter was Egyptian clover (*Trifolium alexandrinum*) and green maize or elephant grass were offered in summer. The calf meal (concentrates) and hay were offered to calves from the beginning of the third week of age according to their live body weight. Calves were weighed for the first time within 24 hours from birth and also at weaning at 15 weeks of age.

Genetic Evaluation

Genetic parameters included heritability, phenotypic and genetic correlations and breeding values for evaluated traits were estimated under a single-trait model, with fixed effects of year of calving/birth and season of calving/birth. Age at first calving, body weight at calving, sex of calf and/or total milk yield were used as covariates with a random animal effect. Fixed effects in the model varied depending on the individual trait. A list of dependent variables (studied traits) and independent variables (additive genetic, fixed effects and covariates) used in the statistical models for single-trait analysis is given in Table 1.

Table 1: A list of dependent variables (studied traits) and independent variables (additive genetic, fixed effects and covariates) used in the statistical models for single-trait analysis.

Trait	Additive Genetic effect	Fixed effect			Covariates		
		Year	Season	Sex	LWC	TMY	AFC
TMY	x	x	x		x		x
305-dMY	x	x	x		x		x
LP	x	x	x		x		x
NOS	x	x	x		x	x	
AFC	x	x	x				
BW	x	x	x	x	x		
WW	x	x*	x	x	x		

TMY = total milk yield, 305-dMY= 305-day milk yield, LP = lactation period, NOS = number of services per conception, AFC = age at first calving, BW = birth weight, WW = weaning weight, Yr = year of calving, Sea = season of calving/birth, Sex = sex of calf, LWC = live weight of cow/dam at calving and AFC = age at first calving. *1982-1995 only

Statistical Analysis System (SAS, 2004) was utilizing to investigate the effect of fixed effects on these traits using mixed model procedure. The statistical analyses were performed using Multivariate Derivative Free Restricted Maximum Likelihood (MTDFREML) program of Boldman *et al*. (1995) to estimate the genetic parameters and breeding values. Models used for single-trait evaluation wasas follows:

$$Y_{ijkl} = \mu + A_i + Yj + S_k + ßx + e_{ijkl}$$

Where, Y is an observation of the studied trait, μ is overall mean, A_i is the random additive genetic effect of i^{th} animal, Y_j is the fixed effect of I^{th} year of calving (k= 1, 2, 3,…. 19) 1=1977, 2 = 1978….. 19=1995, S_l is the fixed effect of l^{th} season of calving/birth (l= 1, 2, 3, and 4) 1=Winter….. 4= Autumn, ß is the regression coefficient which is different according to the analyzed trait

(x) as given in Table 1, and e_{ijklm} is measurement error. Initial analyses of each trait were conducted using a single trait animal model. Sex of the calf was added as fixed effect in case of both BW and WW analyses. Year of calving in case of WW were from 1982 to 1995. The vector presentation of this model is:

$$Y = Xb + Zu + e$$

Where: Y = observations vector of records, β = the vector of fixed effects, a = the vector of direct genetic effects and e = the vector of residual effects. X and Z are incidence matrices relating records to fixed and direct genetic, respectively. Estimates of additive direct heritability (h^2a) were calculated as follows:

$$h^2a = \sigma^2a / (\sigma^2a + \sigma^2e)$$

Where: σ^2a is the additive direct genetic variance, σ^2e is the random residual effect associated with each observation.

Mixed-model equations (MME) in the analyses were solved iteratively. Based on the variance of the log-likelihood function values, the convergence criterion was 1×10^{-9}. In addition, several restarts were necessary until changes in the log-likelihood function values (-2log L) were less than 1×10^{-5}. Restarts were performed for all analyses, using the final results of the previous analysis, in order to locate the global maximum for the log likelihoods. Starting values for variance components for single-trait analyses were obtained from literature. Best linear unbiased prediction (BLUP) of estimated breeding values (EBVs) was obtained by back-solution using the MTDFREML program for all animals in the pedigree file for single-trait animal model analysis. Spearman rank correlations and Pearson correlation coefficients among EBVs for traits studied obtained from single-trait analysis were estimated using SPSS (1999) program. Data structure used in the statistical analyses is listed in Table 2.

Table 2: Data structure used in the statistical analyses

Data set description	TMY	305-dMY	LP	NOS	AFC	BW	WW
Total number of records	1011	1011	1011	1011	1011	1011	1011
Total number of valid records	953	528	940	902	1011	915	451
Total number of records with missing values	58	483	71	109	----	96	560
Number of animals with valid records	953	528	940	902	1011	915	451
Number of animal in A^{-1}	1804	1804	1804	1804	1804	1804	1804
Order of MME	1831	1831	1831	1831	1831	1831	1826

TMY = total milk yield, 305-dMY= 305-day milk yield, LP = lactation period, NOS = number of services per conception, AFC = age at first calving, BW = birth weight, WW = weaning weight.

RESULTS AND DISCUSSION

Descriptive statistics

Overall means, standard deviations (SD), minimum and maximum for six traits under investigation are shown in Table 3. The overall means (± standard deviations) of TMY, 305-dMY, LP, NOS, AFC, BW and WW were

2655±1190, 2737±25.6 kg, 334±112 day, 2.28±1.86 service, 31.8±5.84 months, 29.0±4.25 and 95.6±9.40 kg, respectively. Generally, the overall means of the studied traits are in the range of the same traits obtained on Friesian cows in Egypt reported in the literature. For example, the mean of 305-dMY reported in the present study (2737 kg) was in close agreement with that (2722 kg) obtained by El-Sheikh (1995) working with another set of Friesian cows at the same farm (Sakha Station). Lower values of 305-dMY than that reported in the present study were found by Ashmawy and Khalil (1990) (4295 kg), Shalaby *et al*. (2001) (2995 kg), Atil and Khattab (2005a) (4642 kg). Shalaby (2005) (5546 kg) working on Friesian cows in a commercial herd in Egypt and El-Awady and Oudah (2009) (3639 kg). Lower values of 305-dMY than that reported in the present study was reported by Abdel-Glil (1996) (2461 kg).

Regarding the reproductive performance reported in the present study (NOS and AFC), Hammoud *et al* (2010) working on governmental Friesian cattle in Egypt belonging to Faculty of Agriculture, Alexandria University. They found that the overall least squares means (± standard error) of NOS and AFC were 2.1 ± 0.1 service and 30.7 ± 0.1 months, respectively which is nearly similar to those reported in the present study. Similar estimate of NSC (2.0 services) was reported by Kassab and Salem (1993). High NOS results from either failure to conceive at a given service and/or failure to maintain pregnancy thus requiring repeated service (Hammoud *et al*., 2010). Result of Hammoud *et al*. (2010) on Friesian cattle in a governmental herd in Egypt concerning AFC (30.7 months) was in agreement with those reported in the present study (31.8 months). On the other hand, AFC reported here is higher than that reported by Shalaby (2005) (27.7 months) working on Friesian cattle in a commercial herd in Egypt reflecting the good management in the commercial farms comparing with governmental farms.

Concerning growth traits, the overall mean (± standard deviation) of BW (29.0±4.25 kg) and WW (95.6±9.40 kg) reported in the present study were also fall within the range of those estimates reported in most studies carried out on the Friesian calves under Egyptian conditions ranged between 25.9 to 37.3 kg for BW and between 76.2 to 98.0 kg for WW (Oudah, 2002). The previous author (Oudah, 2002) working on another set of Friesian calves in Egypt found that the means for BW and WW were 31.5±4.46 and 96.6±9.25 kg, respectively. Atil *et al*. (2005) using Friesian calves also in Egypt found that means of BW and WW were 31.8±4.58 and 97.2±10.3 kg, respectively. The coefficient of variations (CV %) of BW (14.6%) and WW (9.83%) obtained in the present study were in close agreement with the findings of Oudah (2002) being 14.2 and 9.58% and Atil *et al*. (2005) being 14.4 and 10.5% for BW and WW, respectively. The present results (Table 3) revealed that some of the productive and reproductive had high coefficients of variation ranged from 9.83% (for WW) to 82.0% for NOS. Such large coefficients of variation are indicative leaders for opportunities for improvement in these traits. The differences between our findings and other investigators may be related to genetic differences between breeds, climatic conditions, differences in statistical models, managerial practices and/or feeding system that would affect live body weights.

Table 3: Mean, standard deviation (SD), coefficient of variation (CV%), minimum and maximum for studied traits

Trait	Mean	SD	C.V (%)	Min.	Max.
Productive trait					
Total milk yield (kg)	2655	1190	44.9	4180	7755
305-day milk yield (kg)	2737	702	25.6	1051	5431
Lactation period (day)	334	112	33.5	100	925
Reproductive trait					
No. of services per conception	2.28	1.86	82.0	1.00	10.0
Age at first calving (month)	31.8	5.84	18.4	20.0	64.5
Growth traits					
Birth weight of calf (kg)	29.0	4.25	14.6	19.0	46.0
Weaning weight of calf (kg)	95.6	9.40	9.83	62.0	118

Heritability

Heritability estimates and their standard errors for studied traits obtained from single-trait genetic analysis during the first lactation of Friesian cows are shown in Table 4. Heritability estimates for single-trait analysis were 0.27, 0.12, 0.04, 0.25, 0.19 and 0.06 for 305-dMY, LP, NOS, AFC, BW and WW, respectively. Similar findings have also been reported by Costa *et al*. (2000), Kadarmideen *et al*. (2003) and Shalaby (2005).

Table 4: Estimates of variance components and heritability (±standard error) for studied traits derived by the single-trait animal model

Trait	Genetic variance	Environmental variance	Phenotypic variance	Heritability (± SE)
Productive trait				
TMY	7.41	106.0	113.4	0.07±0.065
305-dMY	8.39	22.6	31.0	0.27±0.154
LP	14.0	104.9	118.9	0.12±0.072
Reproductive trait				
NOS	0.115	2.64	2.75	0.04±0.064
AFC	7.86	23.4	31.2	0.25±0.097
Growth traits				
BW	2.72	11.7	14.4	0.19±0.085
WW	4.87	81.6	86.4	0.06±0.104

TMY=Total milk yield, 305-dMY=305-day milk yield, LP=lactation period, NOS=number of services per conception, AFC=age at first calving, BW=birth weight, WW=weaning weight, heritability = genetic variance/phenotypic variance.

The moderate h^2 of 305-dMY obtained from single-trait analysis (0.27) fall within the range of estimates reported by different authors working on Friesian cattle in Egypt (e.g. Abdel-Glil, 1996; Badawy and Oudah, 1999: Khattab *et al*., 2000: El-Arian *et al*., 2003: Atil and Khattab (2005a) and (2005b): Shalaby, 2005 and El-Awady and Oudah, 2009) ranged from 0.12 to 0.52. Single-trait analysis of the data gave an estimate of 0.25±0.097 for the h^2 of AFC. The h^2 reported here fall within the range of some reported estimates by different authors ranged from 0.05 (Seykora and McDaniel, 1983) to 0.75 (Atil and Khattab, 2005a). Shalaby (2005) found that h^2 of AFC from single- and two-trait animal model analyses were 0.19±0.075 and 0.18±0.056, respectively. The moderate h^2 reported here for 305-dMY and AFC, are enough to allow genetic improvement in these traits which could be achieved through selection.

The single trait analysis gave low h^2 for LP (0.12±0.072). El-Arian *et al.* (2003) and Atil and Khattab (2005b) obtained h^2 of 0.07. The h^2 of NOS obtained from single-trait analysis was also low (0.04). Oudah *et al*. (2001) obtained h^2 of 0.11 on Holstein-Friesian. Heritability estimate of BW obtained from single-trait analysis was 0.19±0.085, meanwhile, the heritability estimate of WW was 0.06±0.104. Higher h^2 (± standard error) for BW and WW were obtained by Oudah and Mehrez (2000) being 0.24 to 0.27, Atil *et al*. (2005) working on Friesian cattle in Egypt being 0.28±0.10 and 0.13± 0.09 for the two traits, respectively. Oudah and El-Awady (2006) also, found that h^2 of BW and WW were 0.24±0.08 and 0.28±0.08, respectively. The differences between present results and other investigators may be due to differences in the genotypes, management, and number of records and/or methods of analysis. The low h^2 of some traits studied indicated that the major part of the variation in these traits was environmental and selection may not prove effective in bringing about genetic improvement in these traits. Therefore, better management can play a major role in improving these traits.

Estimated breeding values

Minimum, maximum, standard deviation (SD) and percentage of negative estimates for breeding values obtained from single-trait animal model analysis for different studied traits (n=1804) are presented in Table 5. Regarding the breeding values obtained from single-trait analysis, the ranges of all animals in the pedigree for TMY, 305-dMY, LP, NOS and AFC were 5.59, 9.06 kg, 9.85 day, 0.69 service and 11.9 months, respectively with standard deviation (SD) ranged between 0.07 for NOS and 0.72 for TMY. Generally, the percentages of negative breeding values obtained from single-trait analysis were 53.0, 44.5, 53.7, 50.2 and 56.8% for TMY, 305-dMY, LP, NOS and AFC, respectively. The present results indicated that there was wide range of breeding values for all studied traits, suggests the existence of genetic variation between animal and hence the possibility of sire selection using single-trait traits evaluation for fertility traits with milk yield. Atil and Khattab (2005b) found that the range of cow, sire and dam breeding values of AFC were 17.94, 14.31 and 9.09 month, respectively. Atil and Khattab (2005a) found that the range of sire breeding value for AFC was 14.3 months.

Table 5: Minimum, maximum, standard deviation and negative estimates percentage for breeding values obtained from single-trait animal model analysis for different studied traits (all animals in the pedigree, n=1804).

Trait	Mean	Min	Max	Range	SD	Negative %
			Productive trait			
TMY (kg)	-0.0047	-2.64	2.95	5.59	0.72	53.0
305-dMY (kg)	-0.0209	-3.43	5.62	9.06	1.01	44.5
LP (day)	-0.0019	-3.41	6.44	9.85	1.30	53.7
			Reproductive trait			
NOS (service)	0.0056	-0.25	0.44	0.69	0.07	50.2
AFC (month)	-0.0360	-4.01	7.94	11.9	1.27	56.8
			Growth traits			
BW (kg)	0.0536	-2.77	3.34	6.11	0.68	47.2
WW (kg)	0.0026	-2.12	1.62	3.74	0.38	33.3

Correlations between Estimated breeding values

Spearman rank correlations and Pearson correlations between EBVs obtained from single-trait analysis for all animals in the pedigree are presented in Table 6. Correlations between estimated breeding values of all animals in pedigree (cows, dams and sires) provided by the genetic analysis ranged between 0.19–0.99. Rank correlations of animals between traits were the lowest for reproduction traits. Kadarmideen *et al*. (2003) and Shalaby (2005) obtained similar results.

Table 6: Spearman rank correlations (below diagonal) and Pearson correlations (above diagonal) among breeding values of different studied traits obtained from single-trait analysis

Trait	TMY	305dMY	LP	NOS	AFC	BW	WW
TMY		0.44**	0.78**	-0.11**	0.51**	0.19**	0.12**
305-dMY	0.37**		0.51*	0.06**	0.03	0.21**	0.13**
LP	0.74**	0.02		-0.16**	0.01	0.01	0.11**
NOS	-0.08**	0.05*	-0.15**		0.43**	0.05*	-0.05*
AFC	-0.04*	0.01	0.04	0.43**		0.08**	-0.10**
BW	0.16**	0.20**	0.02	0.09**	0.09**		0.65**
WW	0.08**	0.09**	0.03	-0.05*	-0.07**	0.99**	

*** Correlation is significant at the 0.05 level.**
**** Correlation is significant at the 0.01 level.**

CONCLUSION

It could be concluded with the moderate heritability estimates and the wide range in breeding values between animals regarding to 305-dMY and AFC will help in improving these traits genetically.

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التقييم الوراثى لماشية الفريزيان فى مصر باستخدام النموذج الحيوانى أحادى الصفة

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استخدم عدد (1011) سجلا لموسم الحليب الأول لأبقار الفريزيان الناتجة من تزاوج (705) أم و (103) أب خلال تسعة عشر عاما والتابعة لمحطة بحوث الإنتاج الحيوانى بسخا بمحافظة كفر الشيخ – معهد بحوث الإنتاج الحيوانى – وزارة الزراعة وذلك لتقدير المعايير الوراثية لعدد من الصفات الإنتاجية والتناسلية اشتملت على صفات إنتاج اللبن الكلى ، إنتاج اللبن فى (305) يوم ، طول موسم الحليب ، العمر عند أول ولادة ، عدد التلقيحات اللازمة للإخصاب ، وزن العجل عند الميلاد ، وزن العجل عند الفطام، بالإضافة إلى تقدير القيم التربوية لتلك الحيوانات باستخدام النموذج الحيوانى أحادى الصفة. تم تحليل البيانات باستخدام برنامج التحليل الإحصائى (بولدمان ، 1995) لتقدير المعايير الوراثية والقيم التربوية. بينما استخدم برنامج التحليل الإحصائى (ساس ، 2004) لتقدير التأثيرات الثابتة على هذه الصفات. وقد أظهرت النتائج ما يلى:

1. بلغ المتوسط العام (± الانحراف المعيارى للصفة) لكل من إنتاج اللبن الكلى ، إنتاج اللبن فى (305) يوم ، طول موسم الحليب ، العمر عند أول ولادة ، عدد التلقيحات اللازمة للإخصاب ، وزن العجل عند الميلاد ، وزن العجل عند الفطام 2653±1191، 2338±864 كجم ، 332±107 يوم ، 31.8±5.8 شهر ، 2.25±1.80 ، 29±4.26 ، 95±10.5 كجم ، على التوالى.
2. بلغت قيم المكافىء الوراثى للصفات سالفة الذكر 0.07, 0.27, 0.12, 0.04, 0.25, 0.19 , 0.06 ، على التوالى.
3. تراوح الحد الأدنى والحد الأعلى للقيم التربوية للحيوانات تحت الدراسة لنفس الصفات سالفة الذكر ما بين -2.64 إلى 2.95 ، -3.43 إلى 5.62 كجم ، -3.41 إلى 6.44 يوم ، -4.01 إلى 7.94 شهر ، -2.77 إلى 3.34 ، -2.12 إلى 1.62 كجم ، على التوالى.

من هذه الدراسة يمكن استنتاج أنه يمكن تحسين هذه الصفات عن طريق تحسين الظروف البيئية وذلك نظرا لأن العوامل البيئية تلعب دورا كبيرا فى التباين فى هذه الصفات ، كما يمكن أيضا إجراء تحسين وراثى لصفتى إنتاج اللبن فى (305) يوم والعمر عند أول ولادة نظرا لارتفاع قيم المكافىء الوراثى إضافة إلى المدى الواسع للقيم التربوية بين الحيوانات فيما يتعلق بهاتين الصفتين.

قام بتحكيم البحث

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