GENETIC AND PHENOTYPIC PARAMETERS OF MILK YIELD AND REPRODUCTIVE PERFORMANCE IN THE FIRST THREE LACTATIONS OF EGYPTIAN BUFFALO

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SUMMARY

The objective of this work was to investigate early selection based on the first lactation to improve milk yield in the first three lactations. A total of 1911 lactation records each for milk yield, lactation length, age at first calving and average interval between successive calvings, representing 637 buffalo cows, daughters of 123 sires and 519 dams, were analyzed by fitting a multiple-trait animal model using REML procedure. The model included herd and year-season of birth as fixed effects and animal as random effect. The results revealed that the fixed effect of herd contributed significantly to variation in all studied traits except for age at first calving, while year-season of birth significantly affected milk per day/lactation, first lactation length, age at first calving and average interval between successive calvings. Heritability estimates for milk yield, cumulative milk yield, milk per day/lactation and first lactation length varied from 0.13 to 0.27. Heritability estimates for age at first calving and average interval between successive calvings were 0.11 and 0.07, respectively. Genetic and phenotypic correlations were high and positive for milk yield, cumulative milk yield, milk per day/lactation and first lactation length. While, it was moderate to low for these traits with both age at first calving and average interval between successive calvings. Results indicated that early genetic selection of milk yield for the first three lactations based on the first one is possible through a selection scheme in the Egyptian buffalo.

Keywords: Improve milk yield, a multiple-trait animal model, a selection scheme

INTRODUCTION

Through last decades, selection for high milk yield has been associated with detrimental effects on reproductive efficiency (Dematawewa and Berger, 1998 and Catillo *et al*., 2002), occurrence of mastitis (Schutz, 1994) and culling rate (Dematawewa and Berger, 1998). Milk yield and functional traits are the most important traits that influence profitability of dairy production (Mark *et al*., 2002 and Haile-Mariam *et al*., 2003). It seems appropriate to continue genetic selection toward higher yields and fertility while maintaining health and survival traits by improving managerial practices (Dematawewa and Berger, 1998).

First lactation yield is the most commonly used trait as a selection criterion for dairy animals. Most buffaloes have low milk yield and short lactation length in their

first lactation (Metry *et al*., 1994), therefore the decision of genetic selection in most cases, is delayed to next lactations. Thus, it would be better to consider other traits based on the performance during first lactation and investigate their association with performance of the second and third lactations. In addition, including productive and reproductive traits in breeding programs would minimize the negative effects of selection for milk production only. Therefore, the present study aimed at studying the relationship between some productive and reproductive traits through the first three lactations in Egyptian buffalo and investigating improvement possibilities.

MATERIALS AND METHODS

Data:

Data were obtained from four experimental herds belonging to the Animal Production Research Institute (APRI), Ministry of Agriculture and Land Reclamation, Egypt.

Records pertained to 1984 - 2004 years of birth and 1987 - 2008 years of the calving. A total of 1911 lactation records for 637 buffalo cows, daughters of 123 sires and 519 dams were used in the study. Buffalo cows were kept under semi-open sheds. Amounts of rations given to animals were determined according to animal body weight and level of milk production. Milking was practiced twice a day at 07.00 am and 04.00 pm throughout the lactation period. The ration was offered twice daily and clean water was available all the time. Buffalo cows were naturally mated in a group-mating system. Rectal palpation was applied to check pregnancy. As a rule, buffalo heifers were to be first mated at 24 months of age or 330 kg of weight which comes first, and milking buffalo cows were to be dried off 2 months before their expected next calving dates. Data in the present study were adjusted for the effect of herd-year-season of calving using additive correction factors for each one of the first three lactations. Abnormal records affected by diseases or by missing birth dates or dry off dates and yields were excluded. After editing, 87% of lactation records were kept in the data file. All known relationships among individuals were considered in the animal model.

Traits definition:

The present study included milk yield and reproductive traits. Milk yield traits studied were 305-day milk yield of the first lactation (MY1, kg), the second lactation (MY2, kg) and the third lactation (MY3, kg), cumulative milk yield of the first two lactations (CMY2, kg), cumulative milk yield of the first three lactations (CMY3, kg), milk per day of the first lactation (MY1/d, kg), milk per day of the first two lactations (MY2/d, kg), milk per day of the first three lactations (MY3/d, kg) and first lactation length (FLL, d). Reproductive traits studied were age at first calving (AFC, mo) and average interval between successive calvings (ACI, d).

Statistical analysis:

Genetic parameters were estimated by the Restricted Maximum Likelihood (REML) procedure, using the software VCE 4.0 (Groeneveld and García Cortés, 1998), fitting a multiple-trait animal model and incorporating all available pedigree information. The following multiple-trait animal model was used:

$Y_{ijkl} = \mu + A_i + H_j + YS_k + e_{ijkl}$

Where Y_{ijkl} is the milk yield trait or reproductive trait, μ is the overall mean, A_i is the additive genetic random effect of buffalo, assumed to be NID (0, σ^2_a), H_j is the fixed effect of jth herd, (i=1,..,4), YS_k is the fixed effect of kth year-season of birth, (K=42 levels, representing 21 years and two seasons per year) and e_{ijkl} is the residual random error term assumed to be NID (0, σ^2_e). Each year was divided into two seasons: hot (April through September) and mild for the rest of months. Phenotypic parameters were estimated by the GLM procedures of SAS (SAS, 2000).

RESULTS AND DISCUSSION

Simple statistics; means, standard deviations (SD), minimums (Min.), maximums (Max.) and coefficients of variation (CV%) for milk yield and reproductive traits are shown in Table 1. Lactations yield of milk increased with lactation order in a linear pattern. The estimates were comparable with those reported by Mourad *et al.* (1991), being 1185, 1562 and 1638 kg for milk yield of the first three lactations, respectively.

Table 1. Means, standard deviations (SD), minimums (Min.), maximums (Max.) and coefficients of variation (CV %) of studied traits

Trait[*]			Range		
	Mean	SD	Min.	Max.	CV %
MY1, kg	1175	422	504	3310	36
MY2, kg	1552	514	502	3259	33
MY3, kg	1635	549	505	3440	34
CMY2, kg	2726	780	1006	6064	29
CMY3, kg	4361	1125	1511	8776	26
MY1/d, kg	5.8	1.4	2.8	9.7	24
MY2/d, kg	6.5	1.3	3.1	11.3	20
MY3/d, kg	7.0	1.2	3.2	12.5	18
FLL, d	203	44	152	305	22
AFC, mo	39	7	28	70	17
ACI ,d	463	75	339	798	16

[*]MY1: milk yield of 1st lactation; MY2: milk yield of 2nd lactation; MY3: milk yield of the 3rd lactation, CMY2: cumulative milk yield of the first two lactations; CMY3: cumulative milk yield of the first three lactations MY1/d: milk per day of the first lactation; MY2/d: milk per day of the first two lactations and MY3/d: milk per day of the first three lactations; FLL: First lactation length; AFC: Age at first calving and ACI: average interval between successive calvings.

Milk yield of the first lactation was the lowest, comparable estimate (1245 kg), was obtained by Ahmad *et al.* (2009) for Nili-Ravi buffalo. Afzal *et al.* (2007) analyzing data of Nili-Ravi found that milk yield was lower in the first lactation than the yield in 2nd, 3rd and 4th lactations. Pervious studies on different populations of buffalo showed that the average 305-d milk yield ranged from 1588 to 2812 kg (Yadav *et al.*, 2002; Afzal *et al.*, 2007 and Khan *et al.*, 2008) in the first three lactations. These higher estimates could be due to good managerial practices, as well as to the results of the selection program for milk production carried out in the

countries (India and Pakistan) for decades. Therefore, much attention should be paid for improving managerial practices.

Also, milk per day/lactation, gradually increased when more lactations were included. Estimates of milk per day of all lactations were close to those reported by El-Bramony *et al*. (2004a) for Egyptian buffalo. Results in Table 1 show that cumulative milk yield (CMY2 and CMY3, kg) tended to increase as lactation order increased averaging 2726 and 4361 kg for the two traits, respectively. As expected, first lactation length averaged 203d (Table1) with range of 152 to 305-d. The mean FLL is within the estimates obtained by Ahmad *et al*. (2009) and Afzal *et al*. (2007) which ranged between 182 and 278d for Nili-Ravi buffalo. Lactation length across lactations averaged 209d (Aziz *et al*., 2001) for Egyptian buffalo.

The mean AFC was 39.0 mo. It varied considerably from 39.0 to 53.9 mo as reported in the literature by Gebreel (1996) for Egyptian buffalo and Hussain *et al*. (2006) for Nili-Ravi buffaloes. The mean ACI (463d) was close to the estimate (473d) obtained by Hussain *et al*., (2006) for Nili-Ravi buffaloes. ACI in different populations of buffalo varied between 402 and 652d (Tekerli *et al*., 2001; Aziz *et al*., 2001 and Khan *et al*., 2008). Taneja (1998) explained that longer calving interval associated with high lactation yield and poor reproductive efficiency was due to managerial practices.

Table 2. Analysis of variance of studied traits

Trait[*]	*F*-value and significance	
	herd	Year-season of birth
MY1, kg	5.17**	1.02[NS]
MY2, kg	7.44***	1.02 [NS]
MY3, kg	11.66***	1.04 [NS]
CMY2, kg	9.16***	1.14 [NS]
CMY3, kg	14.06***	1.14 [NS]
MY1/d, kg	12.69***	1.42*
MY2/d, kg	30.23***	1.69*
MY3/d, kg	47.14***	1.43*
FLL, d	33.31***	1.62*
AFC, mo	2.04 [NS]	6.03***
ACI ,d	4.31*	2.83***

[*]See abbreviations in table 1.
***$P<0.0001$; **$P<0.001$;*$P<0.05$ and NS= Non significant ($P\geq0.05$).

Table 2 presents analysis of variance for milk yield and productive traits. The results revealed that the fixed effect of herd contributed significantly to variation in all studied traits except for age at first calving, while year-season of birth significantly affected milk per day/lactation, age at first calving, first lactation length and average interval between successive calvings. Similar results were reported by (Gebreel, 1996 and Badran *et al*., 2002) for Egyptian buffalo, Thevamanoharan *et al*. (2002) and Hussain *et al*. (2006) for Nili-Ravi buffalo.

Heritabilities:

Table 3 shows heritabilities, genetic and phenotypic correlation coefficients for the studied traits. Heritability estimates for milk yield and milk per day/lactation (Table 3) varied from 0.13 to 0.22, with a higher estimate for the first lactation. Previous studies on different buffalo populations (El-Bramony *et al.*, 2004b, Tonhati *et al.*, 2004 and Araujo Neto *et al.*, 2010) reported that milk yield of 305-d ranged between 0.12 and 0.25 in the first three lactations.

Table 3. Estimates of heritabilities (±SE) on diagonal, genetic correlations (above diagonal) and phenotypic correlation coefficients (below diagonal) of studied traits

Trait[*]	MY1	MY2	MY3	CMY2	CMY3	MY1/d	MY2/d	MY3/d	FLL	AFC	ACI
MY1	**0.22** (0.07)	0.88	0.71	0.97	0.90	0.97	0.91	0.85	0.81	0.41	-0.33
MY2	0.38	**0.16** (0.05)	0.96	0.97	0.99	0.50	0.70	0.81	0.91	0.06	-0.13
MY3	0.23	0.44	**0.13** (0.06)	0.82	0.97	0.30	0.50	0.67	0.66	-0.54	-0.27
CMY2	0.79	0.87	0.41	**0.24** (0.09)	0.98	0.76	0.87	0.87	0.92	0.26	-0.20
CMY3	0.66	0.82	0.78	0.90	**0.25** (0.07)	0.56	0.75	0.81	0.88	-0.04	-0.08
MY1/d	0.83	0.30	0.21	0.65	0.55	**0.19** (0.06)	0.79	0.71	0.46	0.38	-0.72
MY2/d	0.64	0.68	0.35	0.80	0.73	0.74	**0.16** (0.06)	0.94	0.67	0.12	-0.56
MY3/d	0.52	0.63	0.64	0.70	0.80	0.62	0.84	**0.19** (0.06)	0.62	-0.05	-0.49
FLL	0.69	0.33	0.21	0.59	0.51	0.33	0.25	0.19	**0.27** (0.08)	0.23	0.29
AFC	0.03	-0.03	0.02	-0.01	0.01	0.03	-0.02	0.02	0.05	**0.11** (0.06)	-0.09
ACI	0.19	0.18	0.10	0.22	0.20	0.13	0.13	0.11	0.20	-0.03	**0.07** (0.05)

[*]See abbreviations in table 1, standard errors of heritability estimates are in parenthesis and standard errors of genetic correlations ranged from 0.11 to 0.42 for the studied traits.

Heritability estimates for the cumulative milk yield were clearly high ranging from 0.24 to 0.25 (Table 3), indicating that direct selection to improve such traits would be highly efficient. Similar estimates were previously reported on buffalo by (Ramos *et al.*, 2006 and Araujo Neto *et al.*, 2010). Thus, the moderate and high estimates of heritability in the present study can be considered to promote substantial genetic response through selection scheme in Egyptian buffalo.

Estimate of heritability for first lactation length was 0.27 (Table 3). Higher heritability estimate for first lactation length were reported by Sethi and Khatkar (1997; 0.29). However, the estimate of heritability obtained for FLL indicates that this trait could be improved by genetic selection.

Heritability estimates for age at first calving and average interval between successive calvings were 0.11 and 0.07, respectively. Heritability estimates for age at first calving reported by Gebreel, 1996; Tonhati *et al.* 2000 and Araujo Neto *et al.*, 2010 ranged between 0.09 and 0.20. The estimate of heritability for ACI was comparable with estimates of other studies by Aziz *et al.* (2001); Tonhati *et al.* (2000), and Malhado *et al.* (2009) for different populations of buffalo. Thus, low

estimates of heritability for AFC and ACI indicate that a genetic selection for these traits is not expected to have a genetic response through a selection scheme in Egyptian buffalo. It should depend mainly on improving managerial practices.

Phenotypic and genetic correlations:

In general, phenotypic and genetic correlations found in the literature among milk yield across lactations were high and positive (Mourad *et al.*, 1991 and Malhado *et al.*, 2009) for different populations of buffalo. Similarly, phenotypic and genetic associations were high and positive among first lactation length and milk yield as reported by Gebreel (1996); Ahmad *et al.* (2009) and Malhado *et al.* (2009) for different populations of buffalo. While, it was low and negative among age at first calving and milk yield traits (Gebreel, 1996).

Phenotypic and genetic correlations among studied traits are shown in Table 3. Estimates of phenotypic and genetic correlations among milk yield (MY1, MY2 and MY3) and cumulative milk yield (CMY2 and CMY3) were high and positive ranging from 0.23 to 0.90 and from 0.71 to 0.99, respectively, Table 3. These results suggest the possibility of using these traits as selection criteria to improve milk yield. Also, they indicate that selection for any of these traits would result in a correlated positive response in the others.

The results in table 3 show that milk yield of the first lactation had high and positive genetic correlations (0.71 to 0.97) with milk yield, cumulative milk yield, milk per day/lactation and first lactation length. The corresponding phenotypic correlation estimates varied from 0.23 to 0.83. These results suggest that the direct selection of milk yield of first lactation could have a positive correlated response to improve milk yield of second and third lactations. Thus, milk yield of the first lactation might be used as a useful selection trait for improving yield of the first three lactations. The estimates of the present study were comparable with estimates of others studies by (Johari and Bhat, 1979; Sethi and Khatkar, 1997 and Pathodiya and Jain, 2004) for different populations of buffalo.

Genetic correlations between MY1 and each of AFC and ACI were moderate being 0.41 and -0.33, respectively (Table 3). These results indicate that high yielding buffalo cows in their first lactation have also shorter calving interval. Genetic association between MY1 and AFC showed that selection for milk yield might result in an increase of age at first calving.

The present results show that phenotypic (0.62 to 0.84) and genetic (0.71 to 0.94) correlations among milk per day/lactation were high and positive. These estimates generally fall within the range of those obtained by Pathodiya and Jain (2004).

Similarly, first lactation length had positive genetic correlation (0.46 and 0.92) with milk yield, cumulative milk yield and milk per day/lactation, Table 3. The corresponding phenotypic correlation estimates varied from (0.19 to 0.69), respectively. As expected, high yielding buffalo cows usually have longer lactation length. Thus, a favorable correlated response is expected with subsequent lactations 2nd and 3rd when early selection is carried out on the basis of the first lactation length.

Phenotpic and genetic correlations found in the literature among AFC and the studied traits were low and negative (Pathodiya and Jain, 2004; Mendoza *et al.*, 2009 and Seno *et al.*, 2010) for different pupulations of buffalo. While results in Table 3 show that estimates of genetic correlations between AFC with the studied traits were

moderate ranging between -0.54 to 0.41, while the corresponding estimates for phenotypic correlation were almost nill (-0.03 to 0.05).

Phenotypic and genetic correlations found in the literature for ACI among studied traits were moderate to low ranging from -0.14 to 0.47 and from -0.22 to 0.09 as reported by Aziz *et al.*, 2001; Ramos *et al.*, 2006 and Mendoza *et al.*, 2009 for different pupulations of buffalo. Similarly, ACI in the present study had negative genetic correlation with milk yield, cumulative milk yield and milk per day/lactation Table 3. While, genetic correlation was low and positive with FLL. The corresponding phenotypic correlation estimates were low ranging between -0.03 and 0.22. Similar estimates were reported by (Aziz *et al.*, 2001) for Egyptian buffalo and by Ramos *et al.* (2006) for Brazil buffalo. The negative genetic correlation suggests that there is a favorable association among lactations yield of milk and calving intervals, thus it is possible to select animals of high breeding values for milk yield and low values for calving intervals.

CONCLUSION

Results indicate that early selection to improve milk yield of the first three lactations based on the first lactation yield is recommended due to (1) its reasonable estimate of heritability (0.22); and (2) its strong genetic correlation with cumulative milk yield of the first three lactations (0.90). The estimates of heritability for AFC and ACI indicate that selection for these traits is not expected to have a genetic response. It should be mainly improved through managerial practices.

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المعايير الوراثية والمظهرية لإنتاج اللبن والأداء التناسلى فى المواسم الثلاثة الأولى للجاموس المصرى

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استهدفت الدراسة بحث إمكانية الإعتماد على بيانات الموسم الأول للإنتخاب الوراثى المبكر لتحسين إنتاج اللبن فى المواسم الثلاثة الأولى. تم إستخدام نموذج الحيوان-متعدد الصفات بطريقة (REML) لعدد ١٩١١ سجلاً لإنتاج اللبن و طول فترة الحليب والعمر عند أول ولادة ومتوسط الفترة بين ولادتين لعدد ٦٣٧ جاموسة نسل ١٢٣ طلوقة و ٥١٩ أم. اشتمل النموذج الإحصائي على التأثيرات الثابتة "القطيع" و"موسم-سنة الميلاد" وإستخدام الحيوان كتأثير عشوائى. وقد أظهرت النتائج تأثيراً معنوياً "للقطيع" على جميع الصفات تحت الدراسة ماعدا العمر عند أول ولادة ، وكان ل "موسم-سنة الميلاد" تأثير معنوي على كل من إنتاج اللبن اليومي في الموسم وفترة الحليب للموسم الأول والعمر عند أول ولادة ومتوسط الفترة بين ولادتين. تراوحت تقديرات المكافئ الوراثى من ٠.١٣ الي ٠.٢٧ لكل من إنتاج اللبن وإنتاج اللبن اليومي فى الموسم وإنتاج اللبن التراكمي وفترة الحليب للموسم الأول. بلغت تقديرات المكافئ الوراثى للعمر عند أول ولادة ومتوسط الفترة بين ولادتين ٠.١١ و ٠.٠٧ على الترتيب. كانت معاملات الإرتباط الوراثي والمظهري مرتفعة وموجبة بين كل من إنتاج اللبن وإنتاج اللبن التراكمي وإنتاج اللبن اليومي فى الموسم وفترة الحليب للموسم الأول. وكانت التقديرات من متوسطة الى منخفضة بين هذة الصفات وكل من العمر عند أول ولادة ومتوسط الفترة بين ولادتين. تشير النتائج الي إمكانية الإعتماد على بيانات الموسم الأول للإنتخاب المبكر لإنتاج اللبن للمواسم الثلاثة الأولى خلال برنامج إنتخابى للجاموس المصري.