Quantitative Genetic Analysis and Evaluation for Lactation Traits in Saudi Camels

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Abstract: A 269 lactation records for Saudi she-camels were genetically analysed and evaluated for lactation traits of milk yield of the first three months of lactation (3MMY), annual milk yield (AMY), total milk yield (TMY), length of lactation period (LP), monthly milk yield (MMY), and daily milk yield (DMY). Data were analyzed using **DFREML** procedure to estimate direct additive effects (i.e. direct heritabilites), permanent environment and random errors. Breeding values of camels with and without records in this population were predicted for lactation traits using an animal model.

Phenotypic variations for most lactation traits in Saudi camels were moderate; ranging from 12.2 to 31.2%. Direct heritabilities (h^2_a) obtained for lactation traits were moderate and ranging from 0.08 to 0.25. Ratios of permanent environment for these traits were also moderate and ranging from 0.20 to 0.28. The ranges in breeding values for the animals with and without records genetically evaluated were moderate or high. These ranges were 166.8 kg, 1312 kg, 1436 kg, 282 day, 121.2 kg, and 3.044 kg for 3MMY, AMY, TMY, LP, MMY, and DMY, respectively. Accuracies of breeding values recorded for lactation traits were high and ranging from 0.42 to 0.76. The percentages of animals that have positive estimates of breeding values for 3MMY, AMY, TMY, LP, MMY, and DMY were 57.9, 57.3, 54.3, 56.3, 56.4, and 53.3%, respectively. The rates of selection

responses predicted were moderate or high where the rates were ranging from 3.1 to 9.6 % relative to the actual means of the traits.

Keywords: Saudi camels, Lactation, Heritabilities, Permanent environment, Genetic evaluation, Animal model.

Introduction

The Arab World has more than 12 million camels, which is about 70% of the world camel population (Ramet, 2001; FAO's paper). But, the share of camels in meat and milk production in our Arabian countries is still very low (Hermas, 1998). This is because the camel was ignored as an animal genetic resource and no genetic improvement was practiced to increase his productive potentiality. The published works concerning estimation of genetic parameters and evaluation for lactation traits in camels using updated methodologies (e.g. **MTDFREML**, **GSAMP**, **PEST**, … etc) are very limited, since most of these estimates were based on small number of records and applying old methodology (Wilson et al 1990; Hermas, 1998). Genetic improvement for milk production traits in camels could be achieved through selection and it necessitates identifying the elite she-camels and superior sires through the evaluation of animals to be selected. Evaluation of animals using animal models are nowadays utilized in many countries all-over the world for various domestic species such as cattle and sheep, although, surprisingly, this method was almost completely ignored in camel evaluation systems.

In Saudi Arabia and during the last two decades, a common trend has been raised for establishing large-scale commercial herds of dairy and meat camels in order to increase the national milk and meat production from camels. Since that time and until now, few attempts have screened some of the genetic aspects of productive efficiency of Saudi breeds in such herds. In an attempt to evaluate these camels since the native camels' breeds were not genetically evaluated, the objectives of

the present study were: (1) to characterize a Saudi herd of camels for lactational performance in terms of first 3-month milk yield, annual milk yield, total milk yield, length of lactation period, monthly milk yield, and daily milk yield (2) to estimate the effects of direct additive genetic (i.e. heritabilities), permanent maternal environment, and error for these lactation traits of this herd using an animal model, and (3) to predict the breeding values for animals of this Saudi population (i.e. she-camels with records and their parents of sires and dams without records).

Materials and Methods

Animals:

One-pedigreed Saudi camel population was genetically analysed and evaluated. Animals used in this study were collected from the camel herd of Range and Animal Development Research Center, Al-Jouf region which located in the northwestern part of Saudi Arabia. Records were collected over 20 years from the period from 1985 to 2004.

Management and feeding:

All the animals were treated and medicated similarly and they were reared under the same managerial and climatic conditions.

Camels in Al Jouf region is usually sexually active in the colder months of the year (October till March). Natural mating was applied for all she-camels and delivery season occurs from November till April.

Hand milking was performed for lactating she-camels twice/day and the amount of milk yield was calculated individually for each animal and recorded in special records. During the last three years, milking machines were used for milking.

All the animals were fed *ad libitum*. Camels under investigation were fed the available roughage and concentrate pellets. Whole dates and bran were also offered irregularly. During the spring season, green fodders were available in the

range and were allowed for the animals with concentrate supplementation.

Data collected:

All the abnormal records and those of the aborted she-camels and records without pedigree and breeding dates were excluded from the present study. A total number of 269 complete lactation for 161 she-camels fathered by eight sires and mothered by 33 dams were used. Lactation traits of milk yield of the first three months of lactation (3MMY), annual milk yield (AMY), total milk yield (TMY), length of lactation period (LP), monthly milk yield (MMY), and daily milk yield (DMY) were analysed.

Model of genetic analysis:

Data were analyzed by applying program of Boldman *et al* (1995) and using a single-trait animal model as (in matrix notation):

$$Y = Xb + Z_aU_a + Z_pU_p + e$$

Where: Y = vector of lactation trait; X= incidence matrix of fixed effects; b = vector of fixed effects including parity (3 parities) and year-season of calving (winter or spring); Z_a and Z_p = incidence matrices respective to random direct additive effects and permanent environmental effects, respectively; U_a and U_p= vectors of animal random effects and random permanent environmental effects, respectively; e = vector of random errors.

Pedigree information was used as far as it existed. The relationship coefficient matrix $(\mathbf{A^{-1}})$ among animals was considered in such single-trait animal model (Korhonen, 1996). Program of Boldman *et al* (1995) was adapted to use the sparse matrix package, **SPARSPAK** (George and Ng, 1984). Convergence was assumed when the variance of the log-likelihood values in the simplex reached $<10^{-12}$. Occurrence of local maxima was checked by repeatedly restarting the analyses until the log-likelihood did not change beyond the first decimal. The animal model was used to estimate the proportions of direct additive genetic effects (representing heritability, $\mathbf{h^2_a}$), permanent

environmental effects (p^2), and error (e^2). Direct heritabilities (h^2_a) were computed as:

$$h^2_a = \sigma^2_a / (\sigma^2_a + \sigma^2_p + \sigma^2_e)$$

Where σ^2_a = direct additive genetic variance, σ^2_p = permanent environmental effects variance, and σ^2_e = error variance.

Model of genetic evaluation:

Breeding values (PBV) for she-camels were predicted using their own records. Animals without their own records such as dams and sires were also evaluated. fathered by 8 sires and mothered by 33 dams. Solutions for equations of animals with (161 she-camels) and without records (8 sires and 33 dams) were computed from the pedigree file. A diagonal element (d_t) and an adjusted right-hand side (y_t) were accumulated with each pedigree file record for the tth animal. According to Kennedy (1989), the formula used to predict the breeding values (PBV) was: PBV = [y_t/d_t]; where y_t/d_t = breeding values of the animals. The accuracy of breeding value predicted for each animal was estimated according to Henderson (1975) to be as: $r_A = \sqrt{1 + F_j - d_j \alpha_a}$

Where r_A = the accuracy of predicted breeding value for the ith animal; F_j= inbreeding coefficient of animals; d_j= the jth diagonal element of inverse in the appropriate block coefficient matrix; and $\alpha = \sigma^2_e/\sigma^2_a$. Standard error (SE) of predicted breeding value for each animal was estimated as $SE_{PBV} = d_j \sigma^2_e$ Where d_j and σ^2_e were defined before.

Results and discussion

Means and variations:

Means, standard deviations and ranges in phenotypic variations for lactational performance of Saudi camels are presented in Table 1. These figures in Saudi camels were generally fall within the range of those estimates obtained in most

of the Arabian studies (Ismail and Al-Mutairi, 1991; Wardeh et al, 1991; Hermas, 1998).

Percentages of phenotypic variation for milk traits in Saudi camels were moderate or high; ranging from 12.2 to 31.2 % (Table 1). Literatures suggest that phenotypic variations among breeds in milk traits are of considerable importance (Morton, 1984; Bachmann and Schulthess, 1987; Ismail and Al-Mutairi, 1991; Wardeh et al, 1991; Hermas, 1998). However, camel breeds or individuality probably exist with significantly differences in potentiality of milk production. This potentiality has not been fully exploited because selective pressure of humans on the camel's milk has a minimal trend compared with the other domestic animals (Ramet, 2001; FAO's paper).

Genetic analysis for lactation traits:

Proportions of direct additive effects (heritabilities, h^2_a), permanent environmental effects (c^2) and error (e^2) associated with their standard errors (**SE**) for lactation traits in Saudi camels are presented in Table 2. However, estimates of e^2 for milk traits recorded for Saudi camels were high and ranging from 0.54 to 0.72. But, direct heritabilities (h^2_a) and permanent environmental effects (c^2) for the majority of milk traits were moderate (Table 2); ranging from 0.08 to 0.25 for h^2_a and from 0.16 to 0.23 for c^2. These results indicate that lactation in camels of the present study were subjected to high variabilities due to the permanent environmental effects. This trend may be due to that Saudi camels were not imposed to intensive selection programs. However, the moderate estimates of heritability obtained here indicate that improvement of milk traits could be possibly achieved through selection.

Genetic evaluation of animals for lactation traits:

The minimum and maximum estimates of predicted breeding value (PBV) for milk traits of the animals and their ranges, standard errors (SE) and accuracy of each predictor (r_A)

are presented in Table 3. The ranges in estimates of breeding values relative to the actual mean of the lactation trait indicate that 3-month milk yield recorded the highest range (71.1%) among all milk traits, i.e. improvement of lactational performance of Saudi camels at an early age could be achieved through selection. For list of all the animals, the ranges in breeding value estimated in this population of camels were moderate or high. These ranges were 166.8 kg, 1312 kg, 1436 kg, 282 day, 121.2 kg, and 3.044 kg for 3MMY, AMY, TMY, LP, MMY, and DMY, respectively. Aboubakar et al (1986) found that the range in breeding value for 305-day milk yield was 504 kg for Holstein cattle in Colombia. In USA, Mexico and Colombia, Aboubakar et al (1987) reported that the ranges in breeding value for 305-day milk yield were 792, 733 and 542 kg, respectively. Rozzi et al (1990) found that ranges in breeding value for milk yield were 156, 544 and 151 kg for Holstien cattle raised in Canada, USA and Italy, respectively. Afifi et al (1992) with Friesian cattle raised in Egypt reported that the ranges in breeding value for 305-day milk yield in the first, second, and third lactation were 552.9, 435.0, and 491.3 kg for 305-day milk yield and 704.5, 736.3 and 587.5 kg for TMY, respectively. With Friesian cattle raised also in Egypt, Sadek et al. (1993) indicate that the range in breeding value was 340 kg, while Afifi et al (1992) found that the ranges in breeding value for lactation period were 46.1, 49.3 and 56.3 days in the first, second and the third lactation, respectively. Gebriel (1996) found that the ranges in breeding value for buffalo cows were 642.9 kg for 305-day milk yield and 85.05 days for lactation period.

Accuracies (r_A) of minimum and maximum estimates of PBV recorded for lactational performance of the animals in the present study were moderate or high (Table 3). These accuracies ranged from 0.42 to 0.76.

Animals with positive breeding values

For 3MMY, AMY, TMY, LP, MMY, and DMY, the percentages of animals (she-camels and their dams and sires) that have positive estimates of breeding values were 57.9, 57.3, 54.3, 56.3, 56.4, and 53.3%, respectively. These percentages indicate that the Saudi herd under investigation recorded high percentages of animals with positive signs for milk traits (averaged 56.1%). High breeding values with positive signs lead to state that the top 56% of the animals to be selected all had positive breeding values. Thus, early selection of she-camels themselves according to their lactational performance during the first three months of lactations (i.e. 3MMY) could be an effective method to improve milk traits in camels under the Saudi conditions. In north and South America, Abubakar et al (1987) noted that 47% of the Holstein sires had positive predicted sire values for 305-day milk yield in both Mexico and Colombia. In the Arabian area, Afifi et al (1992) with Friesian cattle in Egypt found that the positive percentages of breeding values for 305-day milk yield in the first, second and the third lactation were 50.0, 45.6 and 51.0%, respectively, while they were 43.4, 43.2 and 51.0 for total milk yield and 49.1, 47.3 and 46.9% for lactation period. Afifi et al (2002) found that the percentage of the positive breeding values for 305-day milk yield was 53.0% in Holstein cattle raised in Egypt. Gebriel (1996) with the Egyptian buffaloes found that the percentages of positive estimates of buffalo breeding values for 305-day milk yield and lactation period were equal (about 57%).

Predicted additive selection responses per generation (SR$_A$):

For list of all the Saudi camels with and without records in the present herd, the direct additive selection responses per generation **(SR$_A$)** for lactation traits are presented in Table 4. The estimates predicted were nearly similar for different traits of lactation. The rates of selection responses predicted were moderate or high, ranging from 3.1 to 9.6 % relative to the actual means of the traits.

Conclusions

1. Since this is the first attempt to characterize Saudi camels genetically for lactation traits using updated methodology, the moderate or relatively high estimates of heritability and breeding values obtained in the present study could be an encouraging factor for the decision makers to plan a selection policy to improve the lactational performance in Saudi camels at an early stage during the first three months of lactation.
2. An animal model including the fixed effects (e.g. year-season, parity) together with the permanent environmental effects will be recommendable to be applied in a genetic evaluation program to improve the lactaional performance of camels at early stage of lactation (during the first three months of lactation).
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Table 1. Actual means, standard deviations (SD), and ranges for lactation traits in Saudi camels

Lactation trait	Abbreviation	Mean	SD	Minimum	Maximum	CV%
First three months milk yield, kg	3MMY	234.5	62.2	103	493	26.5
Annual milk yield, kg	AMY	1927	483	498	3630	25.1
Total milk yield, kg	TMY	2373	740	524	5428	31.2
Lactation length, day	LP	449	54	390	540	12.2
Monthly milk yield, kg	MMY	157.2	40.1	40.3	301.6	25.2
Daily milk yield, kg	DMY	5.239	1.337	1.344	10.050	25.5

CV = Coefficient of variation.

Table 3. Minimum, maximum and ranges of predicted breeding values (PBV) for lactation traits of animals, their standard errors (SE), and accuracy of prediction (r_A) in Saudi camels

Lactation trait[+]	Minimum			Maximum			Range	RRM[++]
	PBV	SE	r_A	PBV	SE	r_A		
3MMY, kg	-82.6	12.6	0.76	84.0	14.8	0.74	166.8	71.1
AMY, kg	-452	68.7	0.72	860	72.4	0.68	1312	68.1
TMY, kg	-816	158	0.64	820	142	0.58	1436	60.5
LP, day	-156	36.8	0.46	126	26.4	0.42	282	62.8
MMY, kg	-58.6	4.8	0.62	62.6	6.2	0.56	121.2	77.1
DMY, kg	-1.426	0.345	0.66	1.618	0.265	0.59	3.044	58.1

[+] Traits were defined in Table 1.

[++] RRM= Range in PBV relative to the actual mean of the lactation trait.

Number of camels with and without records evaluated was 202.

Table 4. Additive selection responses per generation (SR$_A$) for lactation traits in Saudi camels

Lactation trait[+]	SR$_A$ in kg	SR$_A$ (%)[++]
3MMY	22.6	9.6
AMY	165.0	8.6
TMY	195	8.2
LP	14.1	3.1
MMY	12.2	7.8
DMY	0.386	7.4

[+] Traits were defined in Table 1.
[++]SR$_A$ = The rates of selection responses predicted relative to the actual mean of the trait.

التحليل والتقييم الوراثي الكمي لصفات الإدرار في الإبل السعودية

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الملخص العربي:

استخدمت بيانـات 269 سجل إدرار لنوق سعودية حلابـة لتحليل وتقييم أداء هذه الإبل وراثيا لصفات الإدرار والمتمثلة في محصول الحليب خلال الثلاثة شهور الأولـى من الإدرار، محصـول الحليـب السنوي، محصـول الحليـب الكلـي، طـول فتـرة الإدرار، محصـول الحليـب الشهري، محصول الحليب اليومي. تم تحليل البيانـات باستخدام طريقـة DFREML لتقدير قيم المكافئات الوراثية وقيم تباين التأثير البيئي الدائم والخطأ العشوائي. تم تقييم الحيوانـات لصفات الإدرار بتقدير القيمة الوراثية (التربوية) لكل حيوان على حدة باستخدام نموذج الحيوان وحيد الصفة. كانت التباينات المظهرية لمعظم صفات الإدرار متوسطة حيث تراوحت القيم بين 12.2 إلى 31.2 %. أظهرت نتائج التحليل الوراثي لصفات الإدرار بـأن قيم المكافئات الوراثيـة لهذه الصفات كانت متوسطة وتراوحت بين 0.08 إلى 0.25 كذلك كانت نسب التأثير البيئي الدائم معتدلة وتراوحت القيم بين 0.20 إلى 0.28. أوضحت نتائج التقييم الوراثي للنوق الحلابـة التي لها سجلات وآبائها وأمهاتها التي ليس لها سجلات بـأن القيم الوراثيـة كانت متوسطة أو عاليـة لصفات الإدرار تحت الدراسة. يتضح ذلك من المدى الواسع في القيم الوراثية المقدرة وهو 166.8 كجـم، 1312 كجـم، 1436 كجـم، 282 يـوم، 121.2 كجـم، 3.044 كجـم لصـفات محصول الحليب خلال الثلاثة شهور الأولـى من الإدرار، محصول الحليب السنوي، محصول الحليب اليومي، محصـول الحليـب الكلـي، طـول فتـرة الإدرار، محصـول الحليـب الشـهري، محصول الحليب اليومي، على التوالي. وكانت درجة الثقة عالية للقيم الوراثية التي تم تقديرها للنوق الحلابة وآبائها وأمهاتها لصفات الإدرار المختلفة حيث تراوحت المعاملات لدرجة الثقة بين 0.42 إلى 0.76. كانت الاستجابات الانتخابية المتنبأ لها لجيل واحد لصفات الإدرار لقائمـة الحيوانات التي لها سجلات والتي بدون سجلات في هذا القطيع من الإبل السعودية متوسطة أو عالية حيث تراوحت هذه الاستجابات بين 3.1 إلى 9.6 % منسوبة إلى المتوسطات الحقيقيـة للصفات.