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Quantitative Genetic Analysis and Evaluation for Early Growth Performance in Saudi Camels

Al-Sobayil[1], K. A. , Khalil[1], M. H., Al-Jobeile[1], H. S., Mohamed[2], K. M. and Salal, S.A.[2]

[1]Department of Animal Production & Breeding, College of Agriculture & Veterinary Medicine, Al-Qassim University, Buriedah P.O.Box 1482, Saudi Arabia.

[2]Range and Animal Development Research Center (RADRC), Al Jouf, Saudi Arabia.

Abstract: A 383 progeny records for Saudi camels were genetically analysed and evaluated for growth performance of body weights at birth and bimonthly thereafter up to 12 months of age and weight gains at 2-month intervals. Data were analyzed using **DFREML** procedure to estimate direct additive effects (i.e. direct heritabilites), maternal common environment and residual variance. Breeding values of camels in this population were predicted for growth traits using an animal model.

Phenotypic variations for most growth traits in Saudi camels were moderate or slightly high; ranging from 7.0 to 35.2%. Direct heritabilities ($\mathbf{h^2_a}$) for body weights and gains were moderate or slightly high and ranging from 0.24 to 0.40. Ratios of maternal common environment for these traits were mostly moderate and ranging from 0.10 to 0.30. The ranges in breeding values for growth traits of animals genetically evaluated (with and without records) were moderate or high. The ranges were 25.3, 39.6, 61.0, 70.1, 83.7, 104.3, 109.6, 111.0, 102.1, 96.7, 81.0, 115.1, and 96.7 kg for body weight at 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 months of age, respectively. While, the ranges in estimates of breeding values for daily gains in weights were 0.270, 0.348, 0.371, 0.471, 0.491,

0.542, and 0.638 kg at intervals of 0-2, 2-4, 4-6, 6-8, 8-10, 10-12, and 0-12 months of age, respectively. Accuracies of breeding values recorded for growth traits were moderate; ranging from 0.46 to 0.75. For list of all the camels with and without records, the additive selection responses per generation **(SR_A)** predicted were moderate or high and nearly similar at different stages of growth (0-12 months); ranging from 5.7 to 12.2 % relative to the actual means of the traits.

Keywords: Saudi camels, Growth, Heritabilities, Maternal environment, Genetic evaluation, Animal model.

Introduction

The estimates of genetic parameters available for growth performance in camels aree very few; based on small number of records and applying old methodology (Wilson et al 1990; Wilson, 1991&1998; Hermas, 1998b). Although 70% of the world camel population is found in the Arabian countries as reported by FAO (Ramet, 2001), growth performances in native camels' breeds were not genetically evaluated using updated methodologies (e.g. **MTDFREML**, **GSAMP**, **PEST**, … etc). In an attempt to evaluate these camels, the objectives of the present study were: (1) to characterize growth performance of a herd of Saudi camels, (2) to estimate heritabilities, maternal common environment, and error variances for these traits using an animal model, and (3) to predict the breeding values for camels with records and their sires and dams (parents without records) in this population.

Materials and Methods

Animals and management:

One-pedigreed Saudi camel population was genetically analysed and evaluated. Animals used in this study were collected from the camel herd, Range and Animal Development Research Center, Al-Jouf region which located in the northwestern part of Saudi Arabia. All the animals were treated and medicated similarly and they were reared under the same managerial and climatic conditions. Details of management and feeding of the herd were described by Khalil et al (2005). Records were collected over 12 years from the period from 1993 to 2004. Pedigrees for all calves were registered in special records.

Data and models of analysis:

Data for body weights at birth and bimonthly thereafter up to 12 months of age were collected and weight gains at 2-months interval were computed. The distribution of data collected is presented in Table 1. Data were analyzed using a single-trait animal model as (Boldman *et al*, 1995):

$$\boldsymbol{Y = Xb + Z_aU_a + Z_cU_c + e}$$

Where: $\boldsymbol{Y}$ = vector of growth observation; $\boldsymbol{X}$= incidence matrix of fixed effects; $\boldsymbol{b}$ = vector of fixed effects including sex, parity and year-season of birth; $\boldsymbol{Z_a}$ and $\boldsymbol{Z_c}$ = incidence matrices respective to random direct additive effects and common maternal effects; $\boldsymbol{U_a}$ and $\boldsymbol{U_c}$= vectors of animal random effects and random common maternal effects, respectively; $\boldsymbol{e}$ = vector of random errors. Inbreeding coefficients for progeny, sires and dams were calculated using program of Boldman et al. (1995). 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). The animal model was used to estimate the proportions of direct additive genetic effects (representing heritability, $\mathbf{h^2_a}$), common maternal effects $\mathbf{(c^2)}$, and error $\mathbf{(e^2)}$. Direct heritabilities $\boldsymbol{(h^2_a)}$ were computed as:

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

Where σ^2_a = direct additive genetic variance, σ^2_c = common maternal effects variance, and σ^2_e = error variance.

Table 1. Structure of the data analyzed

Item	**Number**
Number of sires	12
Number of dams	119
Number of progeny	383
Total number of animals in the pedigree file	514

Estimation of breeding values

Solutions for equations of animals with and without records were computed from the pedigree file. A diagonal element (d_t) and an adjusted right-hand side (^y_t) were accumulated with each record in pedigree file for the t^{th} animal. The breeding values (PBV) were predicted using Kennedy's formula (Kennedy, 1989) as: PBV = [$^y_t/d_t$]; where $^y_t/d_t$ = breeding values of the animals. Khalil et al (2005) described how to estimate the accuracy and standard error (SE) of predicted breeding value for each animal.

Results and Discussion

Means and variations:

To characterize phenotypically the Saudi herd of camels in the present study, means, standard deviations and ranges in variations for growth traits (body weights and gains at different ages) are presented in Table 2. In general, means of this population were fall within the range of those estimates obtained in most of the Arabian studies (Hermas et al, 1991; Ismail and Al-Mutairi, 1991; Wardeh et al, 1991; Hermas, 1998a&b).

Table 2. Actual means, standard deviations (SD), and ranges for early growth performance in Saudi camels

Growth trait		Mean	SD	Minimum	Maximum	CV%
Month	Symbol					
Body weight (kg):						
0	W0	37.3	3.7	22	50	10.0
1	W1	46.3	6.9	24	65	14.9
2	W2	60.4	8.3	39	80	13.8
3	W3	75.5	9.2	54	98	12.2
4	W4	91.5	10.6	65	121	11.6
5	W5	109.5	12.3	76	143	12.3
6	W6	127.2	14.2	92	172	11.1
7	W7	144.5	15.3	102	190	10.6
8	W8	161.6	15.2	108	200	9.4
9	W9	177.3	16.3	126	214	9.2
10	W10	190.4	15.5	125	228	8.1
11	W11	203.8	15.3	136	232	7.5
12	W12	217.1	15.1	152	243	7.0
Daily gain in weight (kg/d):						
0-2	DG2	0.409	0.141	0.036	0.857	34.7
2-4	DG4	0.554	0.151	0.232	1.071	27.2
4-6	DG6	0.638	0.187	0.286	1.500	29.3
6-8	DG8	0.611	0.183	0.071	1.000	30.0
8-10	DG10	0.513	0.181	0.089	1.054	35.2
10-12	DG12	0.476	0.153	0.054	1.339	32.2
0-12	DG012	0.534	0.144	0.363	0.622	27.0

CV = Coefficient of variation.

Percentages of variations (Table 2) for body weight traits were moderate and ranging from 7.0 to 14.9%, while these variations were high for daily gains in weights (27.0-35.2%). Literatures suggest that phenotypic variations among breeds in growth traits are of considerable importance in selection programs (Beniwal and Chaudary, 1983; Morton, 1984; Hermas et al, 1991; Ismail and Al-Mutairi, 1991; Wardeh et al, 1991; Hermas, 1998a).

Genetic analysis for growth traits:

Proportions of direct additive effects (heritabilities, $\mathbf{h^2_a}$), common maternal effects ($\mathbf{c^2}$) and error ($\mathbf{e^2}$) associated with their standard errors (**SE**) for body weights and gains at different ages in Saudi camels are presented in Table 3.

Saudi camels recorded moderate or slightly high direct heritabilities ($\mathbf{h^2_a}$) for most growth traits (Table 3). This may be due to that Saudi camels were not imposed to selection programs. Hermas (1998b) reported similar results for the Libyan camels. Heritabilities for body weights and gains were similar and moderate and indicating that improvement of growth performance could be possibly achieved through selection. In this respect, heritabilities for body weight traits ranged from 0.24 to 0.37 (averaged 0.31), while they ranged from 0.25 to 0.40 (averaged 0.32) for gains in weight. The respective standard errors for heritabilities were reliable in most cases since they ranged from 0.04 to 0.14 (averaged 0.09).

The proportions of variance of common maternal effects **($\mathbf{c^2}$)** for body weights and gains at different ages in Saudi camels were moderate or high and ranging from 0.10 to 0.30 (Table 3). The proportions of $\mathbf{c^2}$ were high at the early ages and decreased thereafter with advancing of age (Table 3). This indicates that weights of camels in the present study were subjected to high variabilities due to the common maternal effects. This trend might be to some extent to the consequence of the genetic variation in some characters of the dam such as mothering or maternal ability (Mrode, 1996). However, the estimates of common maternal effects included in the present study could be accounted for common maternal environmental variation, non-additive genetic variation, and any sire **x** dam interaction.

Table 3. Proportions of direct additive effects (direct heritabilities, h^2_a), common maternal effects (C^2) and error (e^2) for growth performance in Saudi camels

Growth trait[+]	h^2_a±SE	C^2±SE	e^2±SE
Body weight:			
W0	0.24±0.04	0.22±0.04	0.54±0.04
W1	0.28±0.06	0.18±0.05	0.54±0.06
W2	0.27±0.07	0.23±0.07	0.50±0.07
W3	0.32±0.09	0.20±0.07	0.48±0.07
W4	0.23±0.08	0.20±0.07	0.57±0.07
W5	0.35±0.07	0.20±0.06	0.35±0.05
W6	0.35±0.12	0.15±0.06	0.50±0.12
W7	0.37±0.10	0.20±0.05	0.43±0.09
W8	0.31±0.11	0.10±0.05	0.59±0.08
W9	0.26±0.09	0.20±0.05	0.54±0.08
W10	0.27±0.10	0.18±0.07	0.55±0.07
W11	0.36±0.09	0.14±0.07	0.58±0.05
W12	0.36±0.12	0.11±0.06	0.53±0.12
Daily gain in weight:			
DG2	0.28±0.07	0.27±0.05	0.45±0.07
DG4	0.32±0.07	0.26±0.07	0.42±0.10
DG6	0.28±0.12	0.22±0.05	0.50±0.10
DG8	0.25±0.11	0.23±0.04	0.52±0.09
DG10	0.37±0.13	0.30±0.08	0.43±0.07
DG12	0.40±0.14	0.18±0.05	0.42±0.10
DG012	0.37±0.13	0.15±0.08	0.48±0.09

[+] Traits were defined in Table 2.

Opposite to the trend of common maternal effects (Table 3), the proportions of direct genetic effects for most growth traits studied were increased with advancing of age. As stated before, this may be due to that non-additive genetic effects such as common maternal effects were high.

When the animal model was applied, the estimates of e^2 were reduced to be ranging from 0.35 to 0.59 for body weights and from 0.42 to 0.52 for daily gains in weight (Table 3); most estimates were associated with reliable standard errors ranging from 0.04 to 0.12. Using the relationships among animals and the inclusion of common maternal

effects in the animal model lead to these reductions in proportions of error **(e^2).** These reductions in **e^2** for body weights and gains at the early ages were of considerable importance in evaluating such Saudi herd of camels.

Genetic evaluation of animals for growth traits:

Table 4 summarized the minimum and maximum estimates of predicted breeding value (PBV) and their ranges for growth traits of the animals evaluated along with the standard errors (SE) and accuracy of each predictor (r_A). For list of all the animals, the ranges in breeding value estimates of this population were 25.3, 39.6, 61.0, 70.1, 83.7, 104.3, 109.6, 111.0, 102.1, 96.7, 81.0, 115.1, and 96.7 kg for body weight at 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 months of age, respectively. While, the ranges in estimates of breeding value for daily gains in weights were 0.270, 0.348, 0.371, 0.471, 0.491, 0.542, and 0.638 kg at intervals of 0-2, 2-4, 4-6, 6-8, 8-10, 10-12, and 0-12 months of age, respectively. However, the ranges in estimates of breeding value obtained here for growth performance were moderate or high; indicating that improvement of growth performance of Saudi camels could be achieved through selection.

Accuracies (r_A) of minimum and maximum estimates of breeding value recorded for body weights and gains of animals were moderate in most cases (Table 4). The estimates ranged from 0.46 to 0.75 for body weights, while the respective figures for daily gain traits ranged from 0.48 to 0.70 (Table 4).

The percentages of animals with positive estimates of breeding value for growth traits indicate that the present Saudi herd of camels recorded high percentages of animals with positive signs (58 %). High estimates of breeding value with positive signs lead to state that the top animals to be selected all had positive breeding values. Thus, phenotypic selection of animals themselves according to their weights could be more effective method to improve growth traits in camels at an early age under the Saudi conditions.

Table 4. Minimum, maximum and ranges of predicted breeding values (PBV) for growth traits of animals, their standard errors (SE), and accuracy of prediction (r_A) in Saudi camels

Growth trait[+]	Minimum			Maximum			Range
	PBV	SE	r_A	PBV	SE	r_A	
Body weights (kg):							
W0	-12.2	1.70	0.86	13.1	1.10	0.59	25.3
W1	-18.1	8.53	0.51	21.5	8.38	0.54	39.6
W2	-26.7	12.68	0.76	34.3	12.85	0.75	61.0
W3	-31.8	26.48	0.40	38.3	21.68	0.66	70.1
W4	-42.6	12.35	0.44	41.1	21.81	0.48	83.7
W5	-51.2	11.70	0.84	53.1	11.10	0.59	104.3
W6	-48.1	8.53	0.51	61.5	8.38	0.54	109.6
W7	-46.7	12.68	0.76	64.3	12.85	0.75	111.0
W8	-53.8	16.48	0.40	48.3	21.68	0.66	102.1
W9	-42.6	12.35	0.44	54.1	21.81	0.46	96.7
W10	-46.7	12.68	0.76	34.3	12.85	0.75	81.0
W11	-51.8	26.48	0.40	63.3	21.68	0.68	115.1
W12	-42.6	12.35	0.44	54.1	21.81	0.46	96.7
Daily gains in weight (kg):							
DG2	-.112	.036	0.85	.158	0.057	0.53	0.270
DG4	-.148	.070	0.71	.200	0.071	0.70	0.348
DG6	-.150	.124	0.040	.221	.104	0.64	0.371
DG8	-.144	.166	0.045	.327	.165	0.58	0.471
DG10	-.150	.124	0.040	.321	.104	0.64	0.491
DG12	-.164	.166	0.045	.378	.165	0.56	0.542
DG012	-.224	.088	0.045	.414	.165	0.49	0.638

[+] Traits were defined in Table 2.

Number of camels with and without records evaluated was 514.

Predicted additive selection responses per generation (SR_A):

The direct additive selection responses per generation **(SR_A)** for the list of all camels with and without records (Table 5) showed that estimates of **SR_A** in such Saudi her of camels were nearly similar at different stages of growth (0-12 months). The rates of selection responses predicted were moderate or high, ranging from 5.7 to 12.2 % relative to the actual means of the traits.

Table 5. Additive selection responses per generation (SR_A) for growth traits in Saudi camels

Growth trait[+]	SR_A in kg	SR_A (%)[++]
Body weights (grams):		
W0	3.11	8.3
W1	4.21	9.1
W2	4.74	7.8
W3	5.29	5.8
W4	6.18	6.7
W5	7.72	7.1
W6	8.21	6.5
W7	8.74	6.0
W8	9.29	5.7
W9	10.18	5.7
W10	12.74	6.7
W11	13.18	6.5
W12	15.29	7.0
Daily gains in weight (grams):		
DG2	0.036	8.8
DG4	0.051	9.2
DG6	0.050	7.8
DG8	0.065	10.6
DG10	0.056	10.9
DG12	0.058	12.1
DG012	0.065	12.2

[+] Traits were defined in Table 2.

[++] SR_A = The rates of selection responses predicted relative to the actual mean of the trait.

Conclusions

1. The moderate or relatively high estimates of heritability and breeding values obtained for growth traits of the Saudi herd in the present study could be an encouraging factor to impose efficient selection stratification at an early age during the first year of growth to improve growth performance in camels.

2. An animal model including the fixed effects (e.g. year-season, parity, sex) together with the common maternal effects will be recommendable for planning genetic evaluation programs to improve growth performance in Saudi camels at an early age.

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التحليل والتقييم الوراثي الكمي لأداء النمو المبكر في الإبل السعودية

خالد عبد الله السبيل[1]، ماهر حسب النبي خليل[1]، حمد الجبيلي[1]، كامل مصطفى محمد[2]، صلال عيسى صلال[2]

[1] قسم إنتاج الحيوان وتربيته - كلية الزراعة والطب البيطري - جامعة القصيم

بريدة ص ب 1482 – المملكة العربية السعودية

[2]مركز أبحاث تنمية المراعى والثروة الحيوانية بالجوف – سكاكا – ص.ب. 322 - السعودية

الملخص العربي:

استخدمت بيانات 383 من نسل الإبل السعودية لتحليل وتقييم أداء هذه الإبل وراثيا لصفات النمو من الميلاد حتى عمر 12 شهرا والمتمثلة في وزن الجسم الشهري وكذلك الزيادة اليومية في وزن الجسم خلال فترات مختلفة. تم تحليل البيانات باستخدام طريقة DFREML لتقدير قيم المكافئات الوراثية وقيم تباين التأثير البيئي الدائم والخطأ العشوائي. كذلك تم تقدير القيمة الوراثية لصفات النمو لكل حيوان على حدة لهذه العشيرة مستخدما النموذج الوراثي للحيوان. كانت التباينات المظهرية لمعظم صفات النمو متوسطة أو عالية القيمة حيث تراوحت بين 7 إلى 35.2 % . أظهرت نتائج التحليل الوراثي لصفات النمو في الإبل السعودية بأن قيم المكافئات الوراثية لوزن الجسم ومعدلات الزيادة اليومية كانت متوسطة أو عالية نسبيا حيث تراوحت القيم بين 0.24 إلى 0.40 وكانت نسب التباين الأمي لصفات النمو معظمها معتدلة القيمة حيث تراوحت القيم بين 0.10 إلى 0.30. بينت نتائج التقييم الوراثي المتحصل عليها للحيوانات التي لها سجلات والتي بدون سجلات بأن القيم الوراثية (التربوية) كانت متوسطة أو عالية القيمة حيث كان المدى في

هذه القيم هو 25.30 , 39.6 , 61.0 , 70.1 , 83.7 , 104.3 , 109.6 , 111.0 , 102.1 , 96.7 , 81.0 , 115.1 , 96.7 كجم لأوزان الجسم عند عمر الميلاد، 1 ,2 ,3 ,4 ,5 ,6 ,7 ,8 ,9 ,10 ,11 ,12 شهرا على التوالي. في حين كان المدى في القيم الوراثية لمعدلات الزيادة اليومية في وزن الجسم هو 0.270 , 0.348 ، 0.371 ، 0.471 ، 0.491 ، 0.542 ، 0.638 كجم على فترات صفر – 2 , 2 – 4 , 4 – 6 , 6 – 8 , 8 – 10 , 10 – 12 , صفر – 12 شهرا على التوالي . وكانت درجة الثقة من القيم الوراثية التي تم تقديرها للحيوانات لصفات النمو معتدلة حيث تراوحت درجة الثقة بين 0.46 إلى 0.75. كانت الاستجابات الانتخابية والمتنبأ لها لجيل واحد لصفات النمو متوسطة أو عالية لقائمة الحيوانات التي لها سجلات والتي بدون سجلات في هذا القطيع من الإبل السعودية وكانت متشابهة تقريبا عند الأعمار المختلفة من النمو (صفر – 12 شهرا) حيث تراوحت هذه العوائد الانتخابية بين 5.7 إلى 12.2 % منسوبة إلى المتوسطات الحقيقية للصفات.