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ESTIMATION OF GENETIC PARAMETERS AND GENETIC TREND FOR KLEIBER RATIO IN BARKI SHEEP

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SUMMARY

The present study was carried out to estimate genetic parameters and genetic trendforKleiber ratios (average daily gain from birth to weaning (3 month)/ metabolic weight (KR1), from weaning to 6 months old/ metabolic weight (KR2) and from 6 months to 9 months old/ metabolic weight (KR3)) in Barki sheep. Records of 1176 lambs of both sexes, progenies of 83 sires and 690 dams were used. Data were collected during 1997 to 2004 from the Barki sheep flock raised at the Desert Research Centre, Maryout Research Station, near Alexandria, Egypt. This flock was raised under a semi-intensive production system. The statistical analysis was carried out using restricted maximum likelihood methods. The model included sex, year of birth and dam's age as fixed effects in addition to animal, sires and dams as random effects. All these fixed effects were significant for all the studied traits. The heritability (h^2) estimates for KR1, KR2 and KR3 were 0.15, 0.14, and 0.08, respectively. Genetic correlations were found to be high and significant for all traits under study. The results suggest that genetic improvement of efficiency of feed utilisation in Barki sheep through selection program based on Kleiber ratio is not expected to be efficient due to low heritability of the trait.

Keywords: Barki lambs, kleiber ratio, Direct heritability and Genetic trend

INTRODUCTION

Barki sheep are raised under ~~a~~ pastoral production system in the north western desert of Egypt with population of 493,000 (11% of total Egyptian sheep population), and known to be well adapted to harsh desert conditions (MALR, 2014). A strategy to increase the efficiency of sheep production in conventional system as well as intensive systems is the selection of animals on the basis of efficiency of feed utilization. Since individual sheep differ in their ability to utilize feed efficiently, selecting the most efficient animals, those with lower maintenance requirements, results in a significantly lower production cost (Ghafouri-Kesbi *et al*., 2011). Direct selection for lower maintenance requirements is difficult. However, measures of feed efficiency could be used to achieve this goal (Arthur *et al*., 2001).

Kleiber ratio is defined as: growth rate divided by body mass$^{0.75}$ (metabolic weight). It has been recommended as an indirect selection for feed conversion (Kleiber, 1947; and Köster *et al.,* 1994). Previous results showed that a part of variation among animals concerning the KR is weakly heritable (h^2= 0.01-0.15). Furthermore, there is a positive genetic correlation of KR, with traits related to growth (Abegaz, 2005; and Ghafouri-Kesbi *et al*., 2011). Although, genetic parameters for Kleiber ratio have been estimated for some breeds of sheep (Mohammadi*et al*., 2010, Savar-Sofla*et al*. 2011, and Mokhtari*et al*., 2012), information on genetic parameters for Kleiber ratio in Barki sheep is not available. Therefore, the aim of this research was to investigate genetic parameters and genetic trend for Kleiber ratio in Barki sheep in Egypt.

MATERIALS AND METHODS

Source of data:

Live body weight records of Barki lambs were collected from 1997 to 2004. Data were collected from Barki sheep flock, belonged to the Desert Research Center at Maryout Research Station, 35 km west of Alexandria. The animals of this flock were raised under a semi-intensive production system. Animals were allowed to pasture on residual of plants and crops or Egyptian clover in winter and the green maize in summer for 5 hours daily. A complementary ration was added to feed animals at the end of afternoon to ensure covering their daily requirements

Mating season took place in September, and lambing started in February each year. Ewes were often first mated at approximately 16-18 months of age. Mating groups of 20-25 ewes with one ram that was randomly chosen, were assigned during the mating season. At birth, lambs were ear-tagged and kept with their mothers and weighed within 24 hours after birth and at biweekly intervals thereafter until weaning. The lambs were weaned at 3 months. Detailed feeding and flock management was described by El-Wakil *et al.* (2009).

Studied traits:

Kleiber ratios were calculated as KR1=ADG1/WW$^{0.75}$, KR2=ADG2/W6$^{0.75}$ and KR3=ADG3/W9$^{0.75}$ where, ADG = Average daily gain, W$^{0.75}$ = metabolic weight, KR1 (from birth to weaning), KR2 (from weaning to 6 months old) and KR3 (from 6 months to 9 months old). Records of 1176 lambs descended from 83 rams and 690 ewes were included in the analysis. The characteristics of the data structure for KR1, KR2 and KR3 are shown in Table (1).

Table 1. Characteristics of the data structure

	KR1	KR2	KR3
No. of Records	1176	980	783
No. of male	580	471	351
No. of female	596	509	432
Mean	16.7	8.12	4.74
Standard deviation	1.94	1.39	1.61
Coefficient of variation %	11.64	17.08	33.96

KR1, KR2, KR3 = Kleiber ratio

Statistical analysis:

Data were analyzed by the General Linear Model via the Statistical Analysis System (SAS, 2002), to estimate effect of ram, ewe within ram, year of birth, sex of lamb on growth criteria: KR1, KR2 and KR3. A statistical model used to analyze these data was written as:

$Y_{ijklm} = \mu + S_i + D_j + Y_k + G_l + \beta_{(age\ of\ dam)\ ijklm} + e_{ijklm}$

where:

Y1 = the observed records on the criterion (LBW)

μ = the overall mean

S_i = the random effect of i^{th} ram, i= 1,., ??,

D_j = the random effect of j^{th} ewe within ram, j= 1,.,??

Y_k = the fixed effect of k^{th} year of birth, k = 1,.,8

G_l = the fixed effect of l^{th} sex of lamb, l = 1, 2

β_{agew} = the linear regression coefficient of KR on age at dam as a covariate

$e_{ijklmno}$ = residual random error.

Estimation of variance components, genetic parameters and estimated breeding values (EBV) via BLUP (Best Linear Unbiased Prediction) were carried out by derivative-free REML with a simplex algorithm using the Multiple Trait Derivative-Free Restricted Maximum Likelihood [MTDFREML] (Boldman *et al*., 1995). Models in matrix notation were as follow:

$$Y = X\beta + Z_a a + e$$

Where:

Y = vector of observations (KR1, KR2. KR3),

X = incidence matrix for fixed effects and covariates

ß = vector of fixed effects and covariates (i. e. fixed effect = year of birth, and sex of lamb; covariate = age of dam)

Z = incidence matrix for random effects

a = vector of random effects (additive genetic effect)

e = vector of residual effects (0, I σ^2_e).

Genetic trends based regressing the means of predicted breeding values on year of birth were achieved. Genetic trend analyses were performed with the regression procedure of the SAS.

RESULTS AND DISCUSSION

Means, standard deviations and coefficients of variation for investigated trait are presented in Table (1). Kleiber ratio means of KR1, KR2, and KR3 were 16.7, 8.12, and 4.74, respectively. However, the results obtained by Ghafouri-Kesbi (2013) in Iranan Mehraban sheep were 19.6, 12.2 and 7.8, respectively; but Abegaz*et al*. (2005) have reporter that KR1, KR2 were 15.3 and 4.4, respectively in Horro sheep. KR1 means were estimated as, 20.3, 18.5, 14.4 and 22.4 for Shal sheep (Mohamadi *et al*., 2013), Arman sheep (Moktari *et al*., 2013), Arabi Sheep (Roshanfekr 2014) and Romney sheep (Faid-Allah *et al*., 2016) respectively. These differences in results may be due to differences in animal weights, breed and management.

Estimates of least squares means and SE for the studied traits are shown in Table 2. All these variables were significant (P≤0.05) for all studied traits. Also, the model included the animal, sire and dam as random effects were fitted for each trait.

Table 2. Least square means ± standard error for traits

Sub-class	KR1	KR2	KR3
Sex			
Male	16.78±0.07	8.49±0.06	5.32±0.07
Female	16.78±0.07	8.54±0.06	5.23±0.06
Birth year			
1	16.89±0.11 ^{c}	7.86±0.09 ^{b}	4.97±0.10 $^{b\,c}$
2	16.10±0.13 ^{b}	10.35±0.11 ^{f}	6.48±0.12 ^{f}
3	16.12±0.15 ^{b}	8.98±0.13 ^{e}	5.27±0.14 $^{c\,d}$
4	17.01±0.14 ^{c}	8.77±0.12 $^{d\,e}$	4.91±0.13 ^{b}
5	15.15±0.16 ^{a}	8.47±0.13 $^{c\,d}$	5.98±0.14 ^{e}
6	17.27±0.15 ^{c}	7.33±0.13 ^{a}	4.39±0.14 ^{a}
7	17.89±0.16 ^{d}	7.97±0.14 ^{b}	4.81±0.15 ^{b}
8	17.80±0.17 ^{d}	8.14±0.14 ^{c}	5.41±0.15 ^{d}

a,b,c,d are superscripts within a column differ at (*P*<0.05), while e and, f superscript within a column are significant at (*P*<0.01).

Table (3) showed that heritability estimates (h^2) for KR1, KR2 and KR3, were 0.15, 0.14, and 0.08, respectively, which approached the range reported for different breeds of sheep (Mohammadi *et al*., 2010, Ghafouri-Kesbi *et al*., 2011, Savar-Sofla *et al*., 2011, Mokhtari *et al*., 2012). For pre-weaning KR, estimates of h^2ranged from 0.04 in Arman sheep (Mokhtari *et al*., 2012) to 0.15 in Sanjabi sheep (Mohammadi *et al*., 2010). For post-weaning KR, estimates ranged between 0.01 in Moghani sheep (Savar-Sofla *et al*., 2011) to 0.10 in Zandi sheep (Ghafouri-Kesbi *et al*., 2011). Heritability estimates for a trait can differ between sheep breeds and may change slowly over time.

Literature estimates of h^2in sheep revealed that, the Kleiber ratio is a substantially low heritable trait. In goats, reports (0.13-0.35) are a bit higher than in sheep (Van Niekerk *et al*., 1996; and Supakorn and Pralomkarn, 2012). In beef cattle, higher estimates of h^2 for Kleiber ratio have been reported. For example, Köster *et al*. (1994) reported estimates of h^2ranging from 0.22 (KR at 205 days of age) to 0.54 (KR at 365 days of age) in Herford breed. According to current results, pre- and post-weaning Kleiber ratios in Barki sheep are categorized as low heritable traits. Therefore, a low genetic progress would be expected through selection programmes.

If a trait is only 10 % heritable, then 90 % of differences between animals would have been of non-genetic origin. For low heritable traits, where $h^2$is below 0.15, an animal's performance is much less useful for identifying the individuals with the best genes for the trait (Cassel, 2009). For this reason, selection for Kleiber ratio in sheep should be according to estimates of breeding values (Janssens and Vandepitte, 2004).

Table 3. Variance components and heritability estimates for traits studied

Traits	**Variance components**				
	σ^2_a	σ^2_m	σ^2_p	h^2**(SE)**	σ^2_e**(SE)**
KR1	0.464	2.684	3.149	0.15(0.06)	0.85(0.06)
KR2	0.199	1.214	1.414	0.14(0.07)	0.86(0.07)
KR3	0.151	1.838	1.989	0.08(0.08)	0.92(0.08)

σ^2_a= direct additive genetic variance, $\sigma^2_{m=}$ maternal additive genetic variance, σ^2_p= phenotypic variance,h^2= direct heritability, and $\sigma^2_{e=}$ residual variance (SE= stander error)

Table (4) showed that estimates of genetic correlations between traits were found to be highly significant for KR3-KR1 (-0.29) and KR3-KR2 (0.22) and significant for KR1-KR2 (-0.05). The genetic correlation values between traits are not affected by the values of heritability, *i.e.* two traits can have a very high genetic correlation even when the heritability of each is low (Ghafouri-Kesbi. 2013).

The genetic correlations between KR3 & KR2 (0.22) are highly positive, possibly can therefore be used as the selection criteria of lambs with higher biological efficient and good users of feed are highly efficient to enhance the biological efficiency of the animals of the flock. These results are very important because Barki sheep use the pasture to cover maintenance and production. The negative genetic correlation estimates between KR1 and KR3 ensured the importance of neglecting using KR1 to select KR3.

The breeding value (BV) of a sire and ewe expressed a prediction of its genetic ability, which is very useful in any breeding program. The Kleiber ratios of BV (Table 5) had an indirect indication of the animal's genetic ability for efficiency of feed conversion. Animals with a higher breeding value are more efficient for selection. BV estimates (KR1, KR2 and KR3) in Barki sheep ranged from -0.505 to 0.558 for rams and -1.564 to 1.107 for ewes. These results agreed with those obtained by Faid-Allah *et al.* (2016) in Romney sheep. The negative estimates of the breeding values are appearing because of the absence of selection of animals of both sexes in this flock.

Table 4. Genetic correlation estimates between all traits in Barki sheep

	KR1	KR2	KR3
KR1	1	0.052(*)	-0.294(**)
KR2		1	0.221(**)
KR3			1

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table 5. Breeding values estimates for traits studied

	Traits	Breeding values			
		Minimum	Maximum	Mean	Std
Sire	**KR1**	-0.505	0.558	0.005	0.196
	KR2	-0.284	0.318	-0.024	0.100
	KR3	-0.211	0.293	-0.011	0.071
EWE	**KR1**	-1.564	1.107	-0.001	0.203
	KR2	-0.662	0.743	0.002	0.122
	KR3	-0.324	0.486	0.001	0.071

The genetic trends were calculated by regression of average predicted breeding value for the studied trait of an animal within a year of birth. A negative estimate of the annual rate of genetic response from 4 to 6 years in the Barki sheep for studied KR traits was noticed. It may be due to the absence of genetic improvement strategy in this flock.

From one to eight years onwards, all traits have low BV tends, and the fluctuation in trends indicates bad selection program for this flock for the eight years under study. In case of KR2 and KR3 traits, slight increase in positive genetic trend was noted at the end of the studied years (Graph 1). Similar findings were reported by (Thiruvenkadan *et al.*, 2011) and (Shokrollahi and Baneh, 2012), who mentioned similar results of genetic correlation coefficients and the breeding values of growth rate.

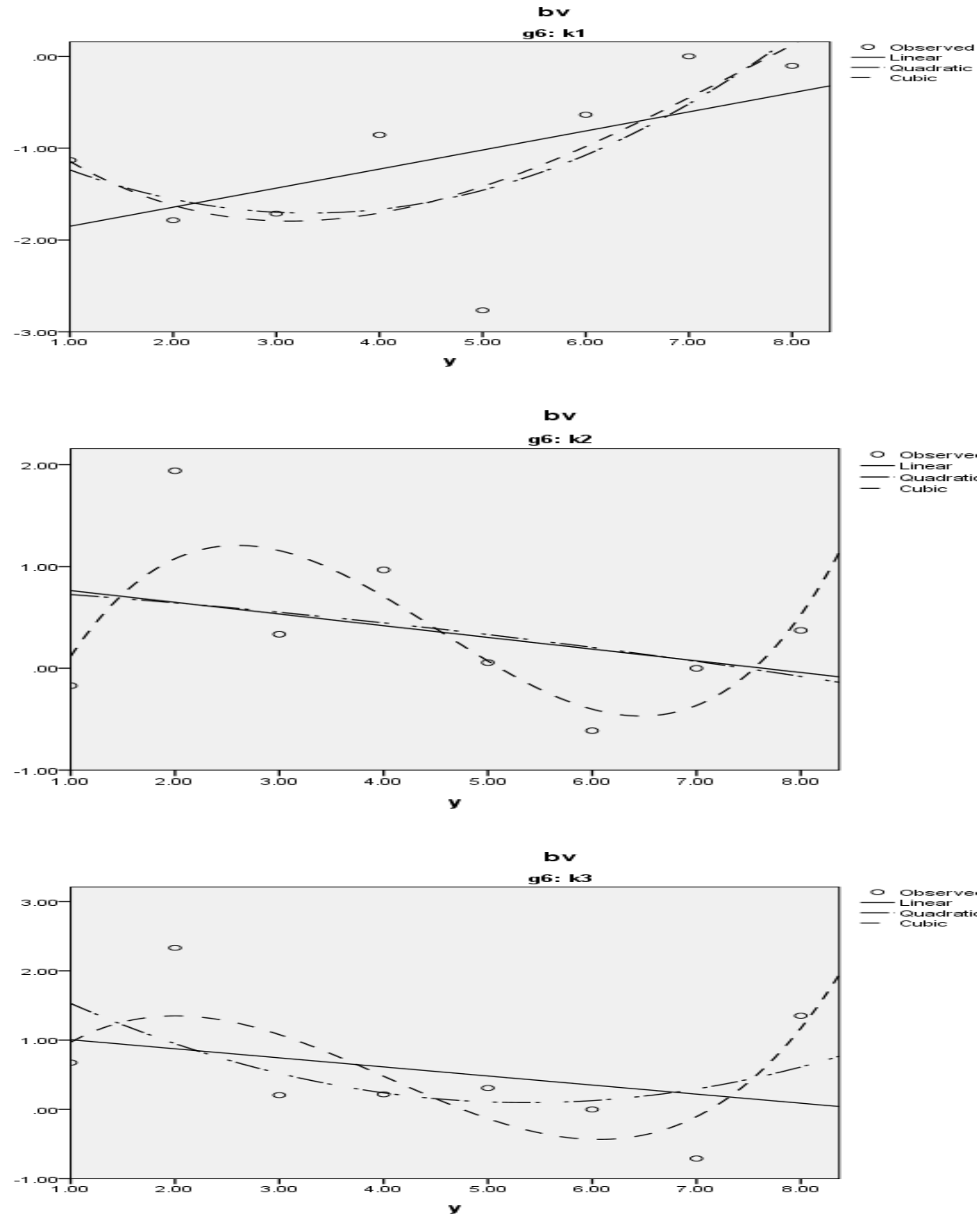

Fig 1: Genetic trends for Kalriber ratios in Barki sheep

CONCLUSION

Estimates of direct heritability and genetic correlations showed that genetic improvement in efficiency of feed utilisation through selection program is not expected to be effective for the studied flock of Barki Sheep.

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تقدير المعايير الوراثية والاتجاه الوراثى لنسبة كليبر فى الأغنام البرقى

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اجريت الدراسة الحالية لتقدير المعالم الوراثية والاتجاه الوراثي لنسبة كليبر (متوسط الزيادة اليومي فى النمو من الولادة إلى الفطام (٣ أشهر) / الوزن التمثيلى (KR1)، ومن الفطام إلى عمر٦ شهور / الوزن التمثيلي (KR2) ومن ٦ أشهر إلى ٩ أشهر من العمر / الوزن التمثيلي (KR3) في الأغنام البرقى. واستخدمت سجلات ١١٧٦ حملان من كلا الجنسين، نتجت من ٨٣ كبش و ٦٩٠ نعجة. تم جمع البيانات خلال الفترة من ١٩٩٧ إلى ٢٠٠٤ من قطيع الأغنام البرقى المربي فى محطة بحوث مريوط التابعة لمركز بحوث الصحراء في الإسكندرية، مصر. حيث تربى هذه القطعان تحت نظام إنتاج شبه مكثف. وتم إجراء التحليل الإحصائي باستخدام restricted maximum likelihood methods. وشمل النموذج الاحصائى الجنس وسنة الميلاد وعمر النعجة كتأثيرات ثابتة بالإضافة إلى النتاج و الكباش والنعاج كتأثيرات عشوائية. وكانت جميع هذه التأثيرات الثابتة معنوية لجميع الصفات المدروسة. وكانت تقديرات المكافئ الوراثى (h^2) لكل من KR1 و KR2 و KR3 هى ٠.١٥ و ٠.١٤ و ٠.٠٨ على التوالي. ودلت النتائج على وجود ارتباطات وراثية عالية ومعنوية لجميع الصفات المدروسة. تميل الدراسة إلى استنتاج أن التحسين الوراثي لكفاءة استخدام الأعلاف في الأغنام البرقى من خلال برنامج الانتخاب القائم على نسبة كليبر ليس من المتوقع أن يكون فعالا بسبب انخفاض المكافئ الوراثى لهذه الصفة.