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Estimation of Genetic, Phenotypic and Environmental Parameters of Morphometric Traits in Sudanese Rabbit

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ABSTRACT
This experiment aimed at the estimation of the genetic parameters for morphometric traits of the Sudanese Local rabbits. Traits studied were: Body Weight (BWT), Ear Length (EL), Fore Limb (FL), Hind Limb (HL), Body Length (BL), height at wither (HTW), Nose to Shoulder (NS), Thigh Girth (TG), Tail Length (TL), abdominal circumference (ABC) and Heart Girth (HG). Data on 74 full pedigreed rabbits at 3 and 5 month of age were used to estimate the heritabilities, genetic, phenotypic and environmental correlation coefficients for these morphometric traits. Heritabilities and various correlation coefficients at 3 month were inestimable for EL. Heritabilties were estimated from sire component of variances. Heritabilities for other traits at this age were moderate to high (0.211-0.570) except for HG (0.130). The genetic correlations among traits studied were generally positive and high. On the other hand, heritability estimates at 5 month of age for all the traits studied were moderate to high (0.223-0.521). The genetic correlation coefficients at 5 month of age of heart girth with all traits studied except ear length (non estimable) and body length (moderate) were high. Whereas, the estimations of the genetic correlation coefficients for body weight with ear length, height at wither, nose to shoulder and tail length was low and negative. It is concluded that linear trait can be used, as alternative guide for body weight, in selection programs aiming at local rabbit improvement.

Key words: Abdomen, ear, heritability, heart girth, tail

INTRODUCTION
Estimation of genetic parameters for productive and reproductive traits is very vital to the use of manmade selection which will lead to maximum genetic improvement when suitable breeding programs are used. Heritability estimates are useful information for predicting potential response to or progress from selection. When choosing a selection method for production traits interrelationship among traits must be considered (Adeleke *et al.*, 2011). Heritability, which is a function of the various variance components, it reflect the genetic nature of a traits and is vital for genetic assessment and selection programs (El-Raffa, 2005). Among the pre-requisites for genetic improvement for important economic traits in animal breeding is the knowledge of genetic parameters such as heritabilities (Akanno and Ibe, 2005). To establish or evaluate a sound breeding

program, accurate knowledge of both environmental and genetic parameters is required. Genetic parameters were estimated for morphometric traits in plants and animals by many researchers. Maniee *et al.* (2009), Lariviere *et al.* (2009), Ahmed *et al.* (2004) and Oni *et al.* (2007) reported that values of heritability estimates and correlation coefficients of production traits ranged from moderate to high. This range of estimates suggests that production traits are largely affected by genetic additive variance (Rahman *et al.*, 2007). Adeyinka *et al.* (2006) found heritability estimates for linear measurements were low in Naked Neck fowl breed.

Estimates of genetic correlations between rabbit body weights and morphometric traits are scarce in available scientific literature all around the world (Akanno and Ibe, 2005). Moreover, rabbit producers and breeders are interested in the relationship that exists between body weight and linear traits because this information would tell something about rabbit feed efficiency and production performance (Okoro *et al.*, 2010).

Improvement of rabbit genetically is a vital scope on the way to increase their contribution to the much needed animal protein in developing countries (Okoro *et al.*, 2010). In the Sudan intensive rabbit farming system as pertained in Europe and some African countries such as Ghana has not yet been developed which might attributed to the availability of other cheaper sources of meat and/or consumer preference. However, the rabbit contributes to the budget of those who keep them through the sale of live rabbits in the market. The main feed offered to local rabbits in Sudan is berseem (*Medicago sativa*), supplemented with human food remains (Elamin, 1979). This is not the suitable diet for high levels of production and much scientific work is needed to formulate suitable diets from local available cheap feed stuffs. The major breed is the Baladi (local type) which has small body weight and production potential. Rabbits could be of particular importance in large towns and in areas that were known to be infested with Tsetse fly transmitted diseases, as an alternative source of protein (Elamin, 1979). Rabbit raising in Sudan is not a widespread practice compared to other animal species, either on a small (at family level) or large scale (large farms). Very few rabbit breeders are in business in Sudan and are confined only to the households. The small size of Sudan local rabbits, their heat tolerance and negligible mortality may point to successful environmental adaptation. Rabbits in Sudan are characterized by different colors, sizes, yield and adaptability (Ahmed, 1998). These rabbit in Sudan had not been yet fully characterized although some studies were conducted by Elamin *et al.* (2011a, 2012) and El-Rahman *et al.* (2012). The aim of the present study was to estimate the genetic parameters of morphometric traits in Sudan local rabbits.

MATERIALS AND METHODS

Location: The experiment was conducted in the rabbit unit of the Faculty of Animal Production, Gezira University, Sudan.

Breeding stock: The foundation stock consisted of 65 female and 25 male mature rabbits brought from five different localities, in central Sudan. This was done so that there was a considerable amount of genetic variation within the animal group. The animals were given prophylactic doses of anthelmintics and antibiotics as injections. The animals were randomly mated in a ratio of one male to every three females to obtain 665 kits in two consecutive generations.

Housing and management: This research is a part of a whole experiment conducted in the rabbit unit of the Faculty of Animal Production, Gezira University, Sudan. The mean high and low temperature and relative humidity during the experimental period were 40 and 17°C and 66 and 34%, respectively.

Table 1: Rabbit experimental ration formula

Ingredients	%	Protein	Total protein	Energy (kcal)	Total energy
Grains	10	8.9	0.89	3663	366.30
Groundnut cake	11	47.4	5.21	3749	412.39
Wheat bran	40	16.0	6.40	2631	1052.40
Groundnut hulls	24	5.3	1.27	1830	439.20
Berseem hay	15	15.2	2.28	1881	282.15
Total			16.05		2552.44

Two animal houses were used. A large one 21 m long, 3 m wide 3 m high at the northern side and 3.67 m at the southern side. Materials used in houses construction were: red bricks, metal poles and corrugated iron sheets. The larger house was divided into three compartments. One of the compartments was used to shelter the growing weaned kits, while the others were divided internally at the sides into cages with metal steal and wire mesh (each cage was 105×79×60 cm). Theses cage were used to house mates (sire and dam) till pregnancy was assured or till kindling. The second house, which was located 20 m apart from the first one, was 6×3×2.25 m made up of the same materials. This house was used to shelter growing kits hence it was divided into 10 cages each (1×1 m) and each litter was housed separately. The house was provided with pots made of clay mud as nests for kindling.

Formulated ration (Table 1) was provided *ad libitum* throughout the experimental period. Green fodder (berseem) was given frequently. Fresh water was also available throughout the day. The International Animal Ethics Committee guideline was followed in the study.

Data collection and statistical analysis: Traits studied were Body Weight (BWT), Ear Length (EL), Fore Limb (FL), Hind Limb (HL), Body Length (BL), height at wither (HTW), Nose to Shoulder (NS), Thigh Girth (TG), Tail Length (TL), abdominal circumference (ABC) and Heart Girth (HG). These measurements were taken using plastic metric tape. Genetic data (composed of 74 and 73 individual produced by 11 sires for 3 and 5 month groups) was used to estimate genetic parameters. Harvey's (10) LSMLMW program (Least Square and Maximum like hood Procedure) was used to estimate variance and covariance components (from sire components) model II:

$$Y_{ijklm} = \mu+S_i+G_k+M_k+e_{ijklm}$$

Y_{ijklm} = The individual observation of the trait Y_{ijklm}
μ = Overall mean for trait Y
S_i = Random effect of the ith sire
G_k = Fixed effect of sex
M_k = Fixed effect of season
e_{ijklm} = The random error associated with the measurement of each

The Harvey program computes estimates of heritability and genetic correlation as:

$$h^2 = \frac{4\sigma_s^2}{\sigma_s^2 + \sigma_e^2}$$

$$r_G = \frac{COVes(x, y)}{\sigma_s^2(x)\sigma_s^2(y)}$$

Where:

h^2 = Heritability

r_G = Genetic correlation

σ_s^2 = Sire variance component

σ_e^2 = Error variance component

COVes (x, y) = Sire covariance component between traits x and y

RESULTS AND DISCUSSION

Table 2 shows heritability estimates of linear traits in rabbits at three and five months of age as estimated from sire component of variances. Estimates at three months were found to vary from high (0.570) for TL to low (0.13) for Hg. As for heritability estimate for BWT in this study was 0.21±0.124 and this is near to the result reported by Ferraz and Eler (1994) who found 0.26 under tropical conditions. This is lower than the result reported by Akanno and Ibe (2005) at the same age (0.36±0.35). On the other hand, Janssens and Vandepitte (2004) reported 0.49-0.54 for heritability estimates of BWT in three strains of sheep.

Heritability was non-estimable for EL due to negative variance (Table 2). Whereas, heritability estimate for EL was found to be 0.11±0.24 and 0.11±0.21 as reported by Chineke and Adeyemi (2001) and Akanno and Ibe (2005). Akanno and Ibe (2005) concluded that there is negligible contribution of additive genes to variation of this trait.

Heritability estimates for other linear traits in Table 2, were generally comparable with the results reported by Akanno and Ibe (2005). As for NS and BL estimates are lower than the results reported by Chineke and Adeyemi (2001). Estimates are higher than those reported by Mandal *et al.* (2008).

Estimates at 5 month of age ranged from moderate (0.223) for FL to high (0.521) for TL (Table 2). These findings are comparable with the results obtained by Akanno and Ibe (2005).

The genetic correlations at 3 month were shown in Table 3 (above diagonal). The genetic correlations of BWT with FL, HL, TG, TL, ABC and HG were positive and high, whereas, the

Table 2: Heritability estimates of morphometric traits in local rabbits at 3 and 5 month of age from sire component of variance

	Age group	
Traits	3 month	5 month
BWT	0.207±0.124	0.262±0.130
EL	ne	0.301±0.137
FL	0.546±0.123	0.223±0.128
HL	0.509±0.138	0.505±0.140
BL	0.203±0.124	0.238±0.130
HTW	0.211±0.125	0.276±0.130
NS	0.239±0.129	0.253±0.130
TG	0.343±0.139	0.287±0.140
TL	0.570±0.131	0.521±0.140
ABC	0.360±0.140	0.280±0.135
HG	0.130±0.109	0.231±0.130

BWT: Body weight, EL: Ear length, FL: Fore limb, HL: Hind limb, BL: Body length, HTW: Height at wither. NS: Nose to shoulder, TG: Thigh girth, TL: Tail length, ABC: Abdominal circumference and HG: Heart girth and ne: Non estimable

Table 3: Genetic correlation coefficients among morphometric traits in local rabbits at 3 month of age (above diagonal) and at 5 month of age (below diagonal)

Trait	BWT	EL	FL	HL	BL	HTW	NS	TG	TL	ABC	HG
BWT	_	ne	0.747±0.216	0.530±0.323	0.261±0.464	0.057±0.503	0.251±0.459	0.851±0.152	0.974±0.117	0.834±0.167	0.955±0.142
EL	-.035±.45	_	ne	ne	ne	ne	ne	ne	ne	ne	ne
FL	0.531±0.390	0499±0.370	_	0.892±0.099	-0.241±0.409	0.192±0.408	-0.207±0.406	0.547±0.280	0.483±0.275	0.473±0.298	0.941±0.230
HL	0.439±0.360	0.335±0.360	0.8210.220	_	-0.698±0.353	-0.363±0.395	-0.6380±.357	0.376±0.334	0.190±0.346	0.305±0.351	0.536±.397
BL	0.815±0.250	0.437±0.400	0.402±0.430	0.763±0.250	_	0.420±0.441	0.969±0.175	-0.028±0.460	0.577±0.307	0.123±0.445	0.283±.531
HTW	-0.125±0.450	-0.009±0.440	-0.105±0.470	-0.724±0.330	-0.169±0.460	_	00.486±0.415	-.0195±0.438	0.026±0.420	0.222±0.430	0.755±.418
NS	-0.198±0.450	0.581±0.320	0.320±0.450	0.101±0.410	0.020±0.470	0.643±0.320	_	0.320±0.402	0.458±0.347	0.320±0.414	0.589±0.447
TG	0.760±0.280	-0.189±0.430	0.307±0.430	0.560±0.310	1.124±0.170	-0.174±0.450	-0.758±0.380	_	0.879±0.126	0.949±0.091	0.880±0.240
TL	-0.024±0.410	0.570±0.290	-0.298±0.410	-0.632±0.290	-0.671±0.330	0.632±0.240	0.431±0.350	-0.253±0.390	_	0.868±0.133	0.795±0.289
ABC	0.478±.373	-0.325±0.427	-0.757±0.390	-0.476±0.360	-0.155±0.454	-0.083±0.457	-0.777±0.392	0.040±0.444	0.294±0.371	_	0.712±.0294
HG	0.551±.35	0.194±0.440	0.321±0.460	0.589±0.310	0.627±0.330	-0.758±0.380	-0.542±0.420	0.881±0.210	-0.205±0.410	0.221±0.440	_

BW: Body weight, EL: Ear length, FL: Fore limb, HL: Hind limb, BL: Body length, HTW: Height at wither. NS: Nose to shoulder, TG: Thigh girth, TL: Tail length, ABC: Abdominal circumference and HG: Heart girth, ne: Non: estimable

Table 4: Phenotypic correlation coefficients among morphometric traits in local rabbits at 3 month of age (above diagonal) and at 5 month of age (below diagonal)

Trait	BWT	EL	FL	HL	BL	HTW	NS	TG	TL	ABC	HG
BWT	_	0.047	0.588	0.414	0.501	0.185	0.270	0.726	0.620	0.688	0.745
EL	0.`128	_	0.046	0.007	-0.020	0.145	-0.045	0.079	0.026	0.080	0.028
FL	0.201	0.280	_	0.733	0.086	0.175	-0.098	0.391	0.427	0.419	0.478
HL	0.238	0.268	0.342	_	-0.129	0.038	-0.212	0.341	0.209	0.236	0.245
BL	0.383	0.170	0.187	0.286	_	0.228	0.510	0.306	0.389	0.252	0.300
HTW	0.159	0.050	-0.127	-0.293	0.021	_	0.171	0.173	0.039	0.194	0.213
NS	0.101	0.382	0.151	0.292	0.255	0.319	_	0.227	0.156	0.021	0.217
TG	0.280	0.026	0.199	0.165	0.368	-0.229	-0.068	_	0.588	0.663	0.524
TL	-0.028	0.293	-0.056	0.299	-0.078	0.200	0.238	-0.041	_	0.538	0.393
ABC	0.253	0-.002	-0.125	-0.092	0.076	-0.313	-0.230	0.235	0.218	_	
HG	0.386	0.212	0.125	0.255	0.387	-0.095	-0.013	0.408	0..018	0.232	_

BWT: Body weight, EL: Ear length, FL: Fore limb, HL: Hind limb, BL: Body length, HTW: height at wither. NS: nose to shoulder, TG: Thigh girth, TL: Tail length, ABC: Abdominal circumference and HG: Heart girth

genetic correlations of BWT with BL and NS were low and positive. The results were in accordance with Janssens and Vandepitte (2004). The genetic correlation of BWT with HTW was low. On the other way, the genetic correlations of EL with all other morphometric traits were non-estimable due to negative covariance. The genetic correlations of HG with the other studied traits were generally high. The genetic correlations among the remaining traits varied from low to high and varied in direction (negative or positive). The correlation of BWT with ABC in this study is similar to that reported by Akanno and Ibe (2005), whereas the correlations of BWT with FL and HL are higher than that reported by Akanno and Ibe (2005) for LL. The genetic correlations of BWT with EL, HTW, NS and TL at 5 month of age were low negative. The correlations of BWT with the other traits were positive and high.

The phenotypic correlations (Table 4) for BWT with FL, BL, TG, TL, ABC and HG at 3 month of age were high (above 0.50) whereas, the correlations for the same trait with NS, HL were moderate. On the other hand, the correlation of BWT with EL was low. The correlation coefficients among studied morphometric traits rather than BWT ranged from low to high and they were in the negative direction for the correlation of EL with BL and NS and for the correlation of FL with NS (Table 3, above diagonal). High phenotypic correlation between studied morphometric traits agreed with Janssens and Vandepitte (2004) and Oke *et al*. (2004) who found positive, highly significant ($p<0.01$) correlations. The phenotypic correlation of BWT with EL in this study is lower at, both ages, than the result reported by Lukefahr and Ruiz-Feria (2003).

The phenotypic correlations at 5 month of age for BWT with BL, HL, TG, ABC and HG were moderate, whereas, the correlations of the BWT with the remaining morphometric traits were positive and low and the correlation was negative only for the correlation of BWT with TL (Table 3, below diagonal)

The environmental correlations (Table 5 above diagonal) at 3 month of age for BWT with NS, HTW and TL were moderate to low whereas, the correlations of BWT with the remaining traits were all positive and high. The environmental correlations of EL with the other traits were non-estimable at 3 month of age. The correlations among the remaining traits varied from low to high and were all in the positive direction (Table 4 above diagonal). On the other hand, environmental correlations at 5 month among morphometric traits were generally low to moderate and in the

Table 5: Environmental correlation coefficients among morphometric traits in local rabbits at 3 month of age (above diagonal) and at 5 month of age (below diagonal)

Trait	BWT	EL	FL	HL	BL	HTW	NS	TG	TL	ABC	HG
BWT	_	ne	0.560	0.387	0.563	0.219	0.276	0.692	0.189	0.646	0.709
EL	0.191	_	ne	ne	ne	ne	ne	ne	ne	ne	ne
FL	0.096	0.204	_	0.560	0.277	0.184	0.184	0.283	0.357	0.357	0.362
HL	0.130	0.233	0.108	_	0.148	0.148	0.014	0.323	0.232	0.232	0.164
BL	0.240	0.393	0.123	0.036	_	0.178	0.178	0.434	0.434	0.307	0.305
HTW	0.264	0.073	-0.135	0-.038	0.086	_	0.079	0.314	0.052	0.187	0.107
NS	0.204	0.307	0.099	0.420	0.331	0.202	_	0.191	0.191	0-.104	0.139
TG	0.099	0.116	0.163	-0.081	0.101	-0.250	-0.147	_	0.139	0.508	0.447
TL	-0.032	0.117	0.075	0.052	0.262	-0.068	0.136	0.096	_	0.447	0.289
ABC	0.169	0.131	0.086	0.145	0.157	-0.401	-0.032	0.312	0.179	_	0.547
HG	0.333	0.219	0.068	0.087	0.314	0.129	0.156	0.245	0.149	0.236	_

BWT: Body weight, EL: Ear length, FL: Fore limb, HL: hind limb, BL: Body length, HTW: Height at wither. NS: Nose to shoulder, TG: Thigh girth, TL: Tail length, ABC: Abdominal circumference and HG: Heart girth, ne: Non estimable

positive or negative direction (Table 4 below diagonal). These results agreed with and De Oliveira *et al.* (1982), Iraqi (2008) and Elamin *et al.* (2011b) who found positive environmental correlations among body weight at different ages. We concluded that as De Oliveira *et al.* (1982) reported on the basis of environmental correlations among traits environmental conditions affect similarly traits studied.

CONCLUSION

Results obtained in this study indicated that high to moderate heritability estimates for body weight and morphometric traits can be used successfully as guides to selection in programs aiming at improvement of local rabbits in Sudan.

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