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ESTIMATION OF GENETIC PARAMETERS FOR LITTER TRAITS IN GABALI RABBITS RAISED IN THE NORTH-WESTERN COAST OF EGYPT USING MULTI-TRAIT ANIMAL MODEL

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The experimental work of this study was carried out at Maryout experimental station, Desert Research Centre, Ministry of Agriculture and Land Reclamation, Egypt. Data of 428 litters from 145 does fathered by 20 sires and mothered by 61 dams were collected on Gabali rabbits during the period from 2003 to 2007. Genetic parameters estimated for litter traits (litter size at birth, LSB, 21 days, LS21, and at weaning at 28 day, LSW, litter weight at birth, LWB, 21 days, LW21 and at litter weight at weaning, LWW). Multi-trait animal model was used to estimate heritability, repeatability, and permanent environmental effect as well as to estimate genetic (r_g), permanent environmental (r_{pe}), environmental (r_e) and phenotypic (r_p) correlations between the studied traits. Actual means of Gabali rabbits were 5.74, 3.75 and 3.51 young for LSB, LS21 and LSW, respectively, while, they were 318, 1205 and 1655 g for LWB, LW21 and LWW, respectively. Litter traits in Gabali rabbits tended to be lowly, moderately or highly heritable and repeatable. Heritability (or repeatability) estimates for LSB, LS21 and LSW were 0.30 (0.70), 0.41 (0.41) and 0.18 (0.19), respectively, while, for LWB, LW21 and LWW were 0.34 (0.80), 0.00 (0.00) and 0.22 (0.22), respectively. Proportion of permanent environmental variance for doe performance was low for most studied traits, except for LSB and LWB. Estimates of r_g were positive between all the correlated traits and high in values (0.98, 1.0 and 0.97) between LSB and LWB, LS21 and LW21 and LSW and LWW, respectively. Estimates of r_{pe} between LSB and each of LWB, LSW and LWW were 0.99, -0.69 and 0.32, respectively. Estimates of r_e were 0.88 and 0.90 between LSB and LSW and between LS21 and LW21, respectively. Estimates of r_p, between litter traits were positive and moderately high in magnitude, except between LSB and LWW, LWB and LSW.

Keywords: Correlations, Gabali rabbits, litter traits, heritability, repeatability, permanent environmental effect.

Litter traits are usually regarded as the best estimates of number and weight of young produced by the doe rabbit since they constitute functions of all pre-weaning

effects. Litter weight at weaning, as a composite trait, reflects the contribution of fertility, maternal behavior, milk production, pre-weaning growth and survival (Lukefahr *et al*., 1990). Gabali rabbits as a local breed living in north Sinai is well adapted to the Egyptian conditions. This breed is characterized by high total milk yield (3497 g), milk composition of protein (9.84%), fat (25%) and total solids (39.93%), mineral content of milk (phosphorus, 25 ppm, potassium, 101.81 ppm, calcium, 2024.6 ppm, magnesium, 558 ppm) and litter size at weaning (5.35 young) and litter weight weaning (1868 g) comparable to V line rabbis in Egypt as reported by Iraqi et al (2007). From earlier researches it could be stated that Gabali rabbits did not get enough study to be acquainted with its genetic aspects completely. The genetic parameters are very important in the progress of genetic improvement of different breeds and in designing its breeding programs that allow the genetic evaluation of such a breed and study its genetic properties. Multi-trait animal model is the best method today used to in evaluation of its breeding programs and facilates obtaining good estimates of variance components (Baselga et al., 1992 and Iraqi et al., 2006)

The main objectives of the present study are to quantify litter traits [litter size at birth (LSB), litter size at 21 days (LS21), litter size at weaning (LSW), litter weight at birth (LWB), litter weight at 21 days (LW21) and litter weight at weaning (LWW)] in Gabali rabbits, and to evaluate the components of direct additive genetic and permanent environmental variances, heritability and repeatability for the previous traits.

MATERIALS AND METHODS

Breeding animals:

This study was carried out at Maryout experimental station, Desert Research Centre, Ministry of Agriculture and Land Reclamation, Egypt, for four consecutive years during the period from September 2003 to April 2007. Breeding animals of Gabali rabbits were bought from Bedouins living in north Sinai who used to capture these animals, domesticate and raise them for their own food.

Breeding plan and management:

At the beginning of experiment, females were classified into 3 or 4 doe groups depending upon the available numbers. For each group of does, a buck from the same breed was assigned for mating them at random to avoid full-sib, half-sib and parent-offspring matings. Breeding does and bucks were individually housed in wire cages with standard dimensions arranged in one-tire batteries allocated in rows along the rabbitry with passages suitable for service. At sexual maturity, each doe was transferred to the cage of the assigned buck to be mated and returned back to her own cage. Ten days after mating does were palpated to detect pregnancy and those failed to conceive were returned to their assigned bucks to be re-mated. All does were re-mated after kindling from the assigned bucks. On the 25th days of pregnancy, nest boxes were supplied with some rice straw to help the does in preparing a warm comfortable nest to receive the kindled bunnies of their litters. Within 12 hours after

kindling, litters were checked, recorded and thereafter examined every morning to get rid of the dead individuals from the nest. At the 28th day post-kindling (four weeks) of age, young rabbits were sexed, ear tagged, separated from their dam and transferred to standard progeny wired cages in groups of 3-4 young per cage. Rabbits were fed on a standard pelleted ration (containing 16.3% crude protein, 13.2% crude fibers, 2.5 either extract, 0.6 minerals mixture, 67.4% soluble carbohydrates and 2600 k cal / kg) offered *ad libitum*.

Data and statistical analysis:

Data on 428 litters born to 145 does fathered by 20 sires and mothered by 61 dams were collected during the study. Traits of litter size at birth (LSB), litter size at 21 days (LS21), litter size at weaning (LSW), litter weight at birth (LWB), litter weight at 21 days (LW21) and litter weight at weaning (LWW) at 28 days post-kindling were recorded. Multi-trait animal model was used to analyses the data according to MTDFREML program (Boldman *et al*., 1995). Variance and covariance obtained by REML method of VARCOMP procedure (SAS, 1996) were used as starting values (guessed values) for the estimation of variance and co-variance components. The following animal model was used:

$$y = \boldsymbol{Xb} + \boldsymbol{Z_a u_a} + \boldsymbol{Z}_{pe}\,\boldsymbol{u}_{pe} + \boldsymbol{e}$$

Where:

- $\mathbf{y}$ = Vector of observation for the i th trait,
- $\boldsymbol{b}$ = Vector of fixed effects (e.g. parity, 7 levels, and year-season combination, 16 levels) for the i th trait;
- $\boldsymbol{u_a}$ = Vector of random animal effect for the i th trait,
- $\boldsymbol{u}_{pe}$ = Vector of random permanent environmental effect for the i th trait,
- $\boldsymbol{e}$ = Vector of random residual effect for i th trait;
- X, Z_a and Z_{pe} are incidence matrices relating records to fixed, animal and permanent environmental effects, respectively.

Heritability (h^2) and repeatability (t) estimates were computed based on the following equations:

$$\mathbf{h^2} = \sigma_a^2 / (\sigma_a^2 + \sigma_{pe}^2 + \sigma_e^2) \text{ and}$$

$$\mathbf{t} = (\sigma_a^2 + \sigma_{pe}^2) / (\sigma_a^2 + \sigma_{pe}^2 + \sigma_e^2).$$

where**:**

- σ_a^2 = Additive genetic variance;
- σ_{pe}^2 = Permanent environmental variance;
- σ_e^2 = The random residual effect associated with each observation.

RESULTS AND DISCUSSION

Means and coefficient of variations:

Actual means and their standard deviations (SD) for pre-weaning litter traits in Gabali rabbits are presented in Table 1. Means of LSB, LS21 and LSW were

Table 1. Actual means and standard deviations (SD), percentages of variation (CV %) for litter traits in Gabali rabbits.

Traits		No.	Mean	SD	CV%
Litter size:					
Litter size at birth	(LSB)	428	5.74	1.24	21.51
Litter size at 21 days	(LS21)	406	3.75	0.90	24.09
Litter size at weaning	(LSW)	398	3.31	0.73	22.13
Litter weight:					
Litter weight at birth	(LWB)	428	318	62.32	19.59
Litter weight at 21 days	(LW21)	406	1205	276.73	22.96
Litter weight at weaning	(LWW)	398	1655	363.83	21.98

5.74, 3.75 and 3.31 young. Similar means (5.3 young for LSB) reported by Nayera *et al*. (1999). While it is lower than means reported by Khalil (1996); Afifi (1997); Abd El-Aziz (1998); Iraqi *et al*. (2006) and Iraqi *et al.* (2007) which ranged from 6 to 7.2, 4.4 to 4.9 and 4.0 to 5.4 young for LSB, LS21 and LSW traits, respectively in Gabali rabbits. Lower means of litter traits in the present study may be due to a wide environmental conditions reared the wild Gabali rabbits (El-Zanfaly, 1996).

In this respect, means of LWB, LW21 and LWW were 318, 1205 and 1655 g, respectively. In general, these means were lower than those obtained by Khalil (1996); Afifi (1997); Abd-El Aziz (1998); Nayera *et al*. (1999) and Iraqi *et al.* (2006) working on Gabali rabbits. Percentage of variation (CV %) for pre-weaning litter traits in the present study ranged from 21.5 to 24.1% for litter size traits and from 19.6 to 23.0 % for litter weight ones. These percentages are, in general, within the ranges obtained by the previously by Egyptian studies. CV % slightly increased with advance of age for litter size traits (LSB and LSW) and litter weight traits (LWB and LWW) in Gabali rabbits. This trend is in agreement with that found by Afifi et al (1992), Ahmed (1997) and Hilmy (1998) for these traits (which ranged from 21.2 to 35.8%).

Heritability :

Heritability (h^2) estimates for litter size traits in Gabali rabbits given in Table 2 were moderate and high ranging from 0.18 to 0.41, which tended to increase from birth up to 21 days and decreased thenafter for LSW. Estimates of h^2 fall in the range from 0.001 to 0.568 (Khalil *et al*., 1987; Youssef *et al*., 2003 and Iraqi *et al*., 2006) for litter size traits. High values of heritability for litter size at birth (0.30), at 21 days (0.41) and litter weight at birth (0.34) in the present study may be due to that Gabali rabbits are not subjected to any program of selection in Egypt, therefore direct additive genetic variances for these traits were high. Heritability estimates for litter weight at 21 days were low (0.0001) and moderate for LWW (0.22) (Table 2). Small estimates of heritability for LW21 might be due to the large maternal effect, i.e. increasing non-additive genetic effect (Iraqi *et al*., 2006). Also, Youssef *et al*. (2003) found low and moderate heritability estimates for litter weight traits in Baladi Red (0.13 and 0.22) and in NZW (0.11 and 0.20) rabbits in Egypt. Rastogi *et al*. (2000)

Table 2. Ratios of variance components for direct additive genetic effect (heritability, h^2), permanent environmental effect (σ^2_{Pe}) and error (σ^2_e) to the phenotypic variance and repeatability (t) for litter traits in Gabali rabbits.

Trait+	h^2	σ^2_{pe}	σ^2_e	t
LSB	0.30±0.060	0.40±0.182	0.30±0.177	0.70
LS21	0.41±0.077	0.0001±0.181	0.59±0.192	0.41
LSW	0.18±0.058	0.006±0.215	0.82±0.217	0.19
LWB	0.34±0.060	0.46±0.127	0.21±0.118	0.80
LW21	0.0001±0.021	0.00±0.00	0.99±0.021	0.0001
LWW	0.22±0.060	0.00±0.000	0.78±0.060	0.22

+ Traits as defined in Table 1.

attributed the low heritabilities in litter weight traits to the negative covariance between direct and maternal effects.

Permanent Environmental effect (σ^2_{pe}):

The proportion of permanent environmental variance (σ^2_{pe}) for litter traits in Gabali rabbits showed low and moderate in values for litter size traits (Table 2). In general, the small percentages of σ^2_{pe} may be partially attributed to large temporary environmental variation (including climatic, sanitary, managerial condition…*etc.*) (Moura *et al.,* 1991). Very small magnitudes in permanent environmental effect may be a result of the small number of does used in this study (Youssef *et al*., 2003). Lukefahr and Hamilton (1997) and Sorensen *et al*. (2001) reported the proportion of σ^2_{pe} ranged from 0.0 to 0.22% for litter traits (LSB, LS21 and LSW). Youssef *et al.* (2003) showed low proportions of σ^2_{pe} (5 to 14%) in both Baladi Red and NZW rabbits. Iraqi et al (2006) estimated the proportion of σ^2_{pe} for litter traits as 2.36, 8.88, 4.31 and 18.7% for LSB, LWB, LSW and LWW, respectively. Conversely, Ferraz *et al*. (1992) reported that the proportion of σ^2_{pe} was 49.6 % of total variance for LWW at 28 days. On other hand, higher proportions of σ^2_{pe} at the early ages (at birth) and thereafter decreased with advancing of age till weaning age may be due to variation in uterine capacity of does. Moreover, proportion of σ^2_{pe} was the highest for both LSB and LWB compared to additive genetic variance for the same traits (Table 2). This indicates that the importance of permanent environmental effect on litter weight traits (Ferraz and Eler, 1996).

Repeatability:

Repeatability estimates for litter traits in Gabali rabbits presented in Table 2 ranged from very low (0.0001 for LW21) to high (0.80 for LWB). Repeatability estimates in the literature (Khalil and Afifi, 1991; Ahmed, 1997; Hilmy, 1998; and

Youssef *et al*., 2003) ranged from 0.01 to 0.25, 0.03 to 0.20, 0.00 to 0.22, 0.01 to 0.23, 0.03 to 0.31 and 0.02 to 0.32 for LSB, LS21, LSW, LWB, LW21 and LWW, respectively. Also, Afifi *et al.* (1992) reported that repeatability estimates for litter weight at various age were relatively higher than that for litter size at the corresponding age. In conclusion, based on the repeatability estimates of 0.70, 0.41 and 0.80 in Gabali for litter size at birth, litter size at 21-days and litter weight at birth, respectively, these traits could be used, as culling criterion to improve doe herd productivity in terms of litter size or weight mass production. Estany *et al*. (1989) considered the litter size at weaning as an economically important composite trait for selection of doe in V line rabbits. Also, Iraqi *et al* (2006) reported that repeatability estimates for litter traits were low or moderate in magnitude being 0.28, 0.10, 0.08 and 0.28 for LSB, LWB, LSW and LWW, respectively, when using multi-trait animal model.

Genetic (r_G), permanent environmental (r_{pe}), environmental (r_e) and phenotypic (r_p) correlations:

Estimates of genetic correlation (r_g) in Table 3 were positive between all correlated traits. It is closely correlated between LSB and LWB (0.98), between LSW and LWW (0.97) and between LS21 and LW21 (1.0). The increase in LSW might be accompanied by an improvement in litter weight traits. The r_g estimates in the present study are in agreement with results of Afifi *et al*. (1992), Hassan (1995), Enab *et al.* (2000) and El-Deghadi (2005) working on different breeds of rabbits. Afifi *et al.* (1992) reported that the genes affecting litter size and litter weight at birth may have effects on the corresponding traits at later ages, thus indicate that selection for litter size at birth would possibly improve litter size and litter weight at weaning as a correlated response.

Estimates of permanent environmental correlations (r_{pe}) in Table 3 were high in magnitude and negative in most correlated traits and ranged from -0.69 to 0.99 between LSB and each of LWB, LSW and LWW, from -0.69 to -0.03 between LWB and each of LSW and LWW. However, estimates of r_{pe} between LSW and LWW and between LS21 and LW21 were 0.32 and -1.0, respectively. El-Deghadi (2005) found that r_{pe} ranged from –0.14 to 0.57 among litter traits in Gabali, NZW rabbits and their crosses.

Estimates of environmental correlation (r_e) presented in Table 3 were positive between all the studied traits. The higher estimates of r_e were 0.90 between LS21 and LW21, 0.88 between LSB and LSW, 0.43 between LSB and LWB. These correlations are fall in the ranges of 0.42 – 0.52, 0.00 – 0.62, -0.11 – 1.12 and 0.89 - 0.90 as obtained by Khalil (1996), Afifi *et al*. (1992) and Hassan (1995).

Estimates of phenotypic correlations ($\mathbf{r_p}$), for litter traits in Table 3 showed that estimates of $\mathbf{r_p}$ among litter traits were positive and moderately high in magnitude, except between LSB and LWW (0.27), LWB and LSW (0.11). Positive and the highest $\mathbf{r_p}$ was obtained between traits of LSB and LSW (0.60) and between LSW and LWW (0.75). The same trends (ranged from 1.0 to 0.83) were shown by Enab *et al*. (2000) and Afifi *et al*. 2001).

Table 3. Estimates of genetic (r_g), permanent environmental (r_{pe}), environmental (r_e) and phenotypic correlations (r_p) for litter traits in Gabali rabbits.

Correlated traits	r_g	r_{pe}	r_E	r_P
Between litter size at birth (LSB) and :				
Litter weight at birth (LWB)	0.98	0.990	0.43	0.51
Litter size at weaning (LSW)	0.40	-0.690	0.88	0.60
Litter weight at weaning (LWW)	0.23	0.100	0.12	0.27
Between litter weight at birth (LWB) and:				
Litter size at weaning (LSW)	0.24	-0.690	0.09	0.11
Litter weight at weaning (LWW)	0.08	-0.033	0.23	0.43
Between litter size at weaning (LSW) and :				
Litter weight at weaning (LWW)	0.97	0.320	0.35	0.75
Between litter size at 21 day (LS21) and :				
Litter weight at 21 days (LW21)	1.00	- 1.000	0.90	-0.05

Conclusion:

- Based on the values of heritability for litter size at birth (0.30), at 21-days (0.41) and body weight at birth (0.34) compared to the other studied traits, one would conclude that mass selection of does for litter size at that ages is more effective to improve pre-weaning traits in Gabali rabbits.
- Proportion of σ^2_{pe} was the highest for both LSB and LWB compared to additive genetic variance for the same traits. This indicated the importance of permanent environmental effect on litter size and litter weight traits.
- Based on the repeatability estimates in Gabali rabbits for litter size at birth, litter size at 21-days and litter weight at birth, these traits could be used, as culling criterion to improve doe herd productivity in terms of litter size or weight mass selection.

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تقدير المعايير الوراثية لصفات خلفة البطن فى الأرانب الجبلى المرباة فى الساحل الشمالى الغربى لمصر باستخدام نموذج الحيوان متعدد الصفة

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أجريت هذه التجربه فى محطة تجارب مريوط – مركز بحوث الصحراء بوزارة الزراعة واستصلاح الاراضى – مصر. تم تجميع بيانات ٤٢٨ بطن من ١٤٥ أنثى ناتجة من ٢٠ أب ٦١ أم للأرانب الجبلى خلال الفترة من ٢٠٠٣–٢٠٠٧ . وقد تم تقدير المعاير الوراثية لصفات خلفة البطن (حجم الخلفة عند الولادة ، ٢١يوم ، وعند الفطام ، وزن الخلفة عند الميلاد ، عند ٢١ يوم وعند الفطام) . استخدم نموذج الحيوان متعدد الصفة لتقدير المكافئ الوراثى والمعامل التكرارى و الأثر البيئى الدائم وكذلك تقدير الارتباطات الوراثية والبيئى الدائم والبيئى المظهرى بين الصفات المدروسه .

أظهرت النتائج أن المتوسطات الفعلية للأرانب الجبلى كانت كما يلى ٥.٧٤ ، ٣.٧٥ و٣.٥١ صغير لصفات حجم الخلفة ، عند الميلاد ، ٢١ يوم وعند الفطام –على التوالى . بينما كانت تلك المتوسطات ٣١٨، ١٢٠٥، ١٦٥٥ جرام لصفات وزن الخلفة عند الميلاد ، ٢١يوم ، عند الفطام – على التوالي . تراوحت صفات الخلفة فى أرانب الجبلى من منخفضة و متوسطة الى مرتفعة المكافئ الوراثى و المعامل التكراري. وكانت قيم المكافئ الوراثى (والمعامل التكرارى) ٠.٣٠ (٠.٧٠) ، ٠.٤١ (٠.٤١) ، ٠.١٨ (٠.١٩) لصفات حجم الخلفة عند الميلاد ، ٢١يوم ، وعند الفطام– على التوالى ، بينما كانت ٠.٣٤ (٠.٨٠) ، ٠.٠٠ (٠.٠) ، ٠.٢٢ (٠.٢٢) لصفات وزن الخلفة عند الميلاد ، ٢١يوم ، وعند الفطام – على التوالي .

كانت نسب التباين البيئي الدائم لأداء الأنثى منخفض لمعظم الصفات المدروسة فيما عدا صفات حجم ووزن الخلفة عند الميلاد . وكانت الارتباطات الوراثية موجبة بين كل الصفات المرتبطة ومرتفعة فى قيمتها (٠.٩٨، ٠.٩٧، ١.٠٠) بين حجم ووزن الخلفة عند الميلاد ، وحجم ووزن الخلفة عند ٢١يوم ، وحجم و وزن الخلفة عند الفطام – على التوالي. كانت قيم الارتباط البيئي الدائم بين حجم الخلفة عند الميلاد وكل من وزن الخلفة عند الميلاد وحجم الخلفة عند الفطام ووزن الخلفة عند الفطام ٠.٩٩ ، –٠.٦٩ ، ٠.٣٢ – على التوالى ، بينما كانت قيم الارتباط البيئى ٠.٨٨ ، ٠.٩٩ بين حجم الخلفة عند الميلاد وحجم الخلفة عند الفطام ، وبين حجم الخلفة عند ٢١ يوم ووزن الخلفة عند ٢١ يوم – على التوالى . كما كانت قيم الارتباط المظهرى بين صفات الخلفة موجبة ومتوسطة الارتفاع فيما عدا الارتباط بين حجم الخلفة عند الميلاد ووزن الخلفة عند الفطام ، ووزن الخلفة عند الميلاد وحجم الخلفة عند الفطام .