Egyptian Journal of Rabbit Science, 33(1): 17-34 (2023)

GENETIC PARAMETERS OF SOME DOE REPRODUCTIVE CHARACTERISTICS, DOE BODY CONDITION SCORE AND WEIGHT IN RABBITS

E. M. Abdel-Kafy; Fatma M. Behiry*; Hoda M.A. Shabaan and Shereen S. Ghoneim
Animal and Poultry Production Research Institute, (APRI), Agricultural Research Center, Giza, Egypt
**Corresponding author: fatma.behiry@arc.sci.eg*

ABSTRACT: *A total of 2600 records for 218 doe rabbits were used to estimate genetic parameters for some doe reproductive traits (Fertility, FER; and the total number of services each conception, NSC) and doe body condition traits at mating (body weight, BW; and doe body condition score, BCS). By measuring the genetic correlations between these traits, the influence of doe body condition traits during mating on these reproductive traits was assessed. The distribution and plotting of all traits in the data were performed to describe them at the farm level. The medium doe body condition score showed the highest number of fertile does. Fertility failure is more due to obese body than poor body condition. The medium doe body condition score showed the highest number of does used the lowest NSC (one service). The medium BCS is the ideal one. Heritability of traits under study is low to moderate. Heritability estimates were 0.03, 0.02, 0.21, and 0.20 for FER, NSC, BCS, and BW respectively. The performance of female rabbits can be improved by including the doe's body condition score and weight when mating in the breeding program. The direct response to selection will be sensible. Genetic correlations among the doe body condition score (BCS) and traits under study (FER, NSC, and BW) were positive.*

The genetic improvement through selection to medium doe body condition score leads to improvement in fertility and the total number of services each conception which emphasizes the importance of interring doe body condition score in breeding programs.

Keywords: body score; fertility; heritability; correlation

INTRODUCTION

The genetic capacity and nutrition level are frequently set as invariants in the commercial production of rabbit meat, but the important reproductive effort of females fluctuates, affecting the female reproductive performance (Cervera *et al.*, 1993). Reproduction is a complicated process that involves numerous systems, and the profitability of rabbit farming is influenced by a variety of factors. According to Savietto *et al.* (2015), nutritional status, nutritional composition, and genetic potential all have an impact on reproductive effort (*i.e.*, the size of the litter being raised and the interval between successive propagation cycles) in rabbit females.

In rabbits, the doe body condition score (BCS) also affects reproductive performance, and females with a medium body condition have greater longevity (Cardinali *et al*., 2008). Different variables influence fertility as BCS, housing, feeding, reproductive rhythm, and genetic potential, according to Broom (1986). At the start of mating, determination of the doe's body condition score and live weight have a big impact on fertility (Hatcher *et al.*, 2007). Some studies suggest that the doe body condition score affects fertility (Davoud *et al.*, 2012). The highest genetic correlation between fertility and indirect measurements of bodily energy, such as body condition scoring, was demonstrated by Banos and Coffey (2009) compared to direct measurements of bodily energy.

Body condition scoring can be utilized as a management criterion because it is a reliable measure of female health (Rosell and De La Fuente, 2008 and Bezdíček *et al*., 2020). The majority of researchers have found that BCS is a practical tool for managing animals as a stand-in for evaluating energy balance and disease risk variables (Nazhat *et al.*, 2021). In the field of practice, such as before the beginning of a new cycle, as a justification for culling, and also in the field of research, the doe body condition score (BCS) of rabbit does is taken into consideration (Cardinali *et al.*, 2007).

Categorical variables are used to measure a number of interested traits relevant to animal breeding. It is not ideal to analyze such variables using a linear methodology because it contradicts numerous of the assumptions of the linear model. A lot of satisfactory methods rely on the threshold model concept. More recently, Gibbs sampling (GS) has been extended to Bayesian inference in the threshold model for binary and categorical data have developed statistical treatment of the threshold model for the animal model (Sorensen *et al.*, 1995 and Luo *et al.*, 2001). It has been suggested to use nonlinear methods for the analyses of discrete traits in animal breeding to be able to produce more accurate estimations of genetic parameters and better predictors of the genetic quality of potential selection candidates (Templeman, 1993). Although some studies have looked at the connection between body reserves at parturition and fertility (Romero *et al*., 2011), to the best of our knowledge, no studies have looked at the genetic factors affecting doe body condition score and weight at the age of mating in rabbits.

Therefore, the main goals of this research was to study the effect of non-genetic factors on body condition traits and some reproductive traits in the present study, evaluate the variance components and genetic parameters for doe body condition score, weight at mating, and some reproductive traits (fertility and number of services each conception) in Baladi Black (BB) rabbits, as well as their genetic correlations, using the Gibbs sampling (GS) methodology and the linear-threshold and threshold-threshold animal models. In addition, determining the ideal doe body condition score in rabbits and studying the possibility of using it in the genetic improvement breeding and selection programs of Baladi Black (BB) rabbits.

MATERIALS AND METHODS

1. *Animals*

At the Sakha Research Station, Kafr El-Sheikh Governorate, Egypt, on the farm run by the Animal Production Research Institute, Agriculture Research Center, rabbits were raised.

This study was conducted for three sequential years with a total of 2600 records on 218 rabbit does of Baladi Black (BB) rabbits. The rabbits were kept in individual wire cages that were 60x50x35 cm and had automatic water nipple drinkers and feeders. The rabbits were kept in the same settings and were given access to a concentrated commercial pelleted meal that included 14.8% crude fiber and 17% crude protein. Rabbits always had access to pure, fresh water through nipples. Initially, does were subdivided at random into families with each family consisting of 4 males and 10 to 12 females. The selected buck was assigned at random to avoid mating with parent-sib and full or half–sib mating. Starting at six months of age does were meted naturally. Each doe was palpated after 10 days from mating to verify pregnancy or not.

2. *Studied traits*

The traits recorded on does of rabbits were fertility (FER), the total number of services each conception (NSC), doe body condition score (BCS) and weight at mating (BW). On the day of mating, the does body condition score (BCS) and weight (BW) were recorded.

To assess the doe body score, which was classified into obese, medium, and poor categories, the flank and rump regions were manually palpated (Bonanno *et al.,* 2005). The method for determining the doe body condition score focuses on hand palpation for vertebras bones protuberance, volumes of muscles over and around the vertebrae in the flank, and manual feeling for bone prominence and muscle richness in the rump. At mating age, the flank and rump areas were measured and have taken three degrees; the first measurement is obese, the second is medium, and the third is poor. Then the body is given a category of “1” if the flank is obese and the rump is obese, a category of “2” if the flank is medium and the rump is medium, and a category of “3” if the flank is poor. A score of "1" indicates excessive fat body, a "2" indicates a medium body, and a "3" indicates a poor body condition.

Fertility was indicated by "1" for a non-pregnant state or "2" for a pregnant state, when mating was successful or unsuccessful. The total number of services each conception for each female is expressed as the total number of mating for fertilizing and recorded. The total number of mating times for fertilization is used to represent the total number of services each female received per conception. Does live body weights were taken at mating in grams using a digital scale.

3. *Statistical analysis*

Options of SAS used to make all simple statistics to obtain the distribution of traits under study in data, determine distribution for fertility (FER) and a number of services each conception (NSC) by doe body condition score (BCS), determine the effect of non-genetic aspects on traits, and test its significance by ANOVA procedure using the fixed model. The model used to test the significance of fixed effects is:

$$Y_{ijk}= \mu+ YS_i + P_j+ (YS\times P)_{ij} +E_{ijk}$$

where, Y_{ijk} = the observation on the ijkth trait, μ= the overall mean, YS_i = the fixed effect of ith year-season of mating (i= 1…12 levels obtained from 3 years and 4 seasons), P_j = the fixed effect of jth parity order of females (k= 1-4 parities), $(YS\times P)_{ij}$ = the effect of interaction between year-season and parity order and E_{ijk} = a random error of each observation. Variance components, genetic parameters, and genetic correlations for traits under study were estimated via bi-variate threshold-linear and threshold-threshold animal model using the Gibbs program of the statistical program package BLUPF90 (Misztal *et al.*, 2016) which uses a Bayesian approach. Doe body condition score (BCS), fertility (FER), and the total number of services each conception (NSC) were modeled as categorical or threshold traits, while body weight at mating (BW) was a linear trait. A bi-variate analysis for traits under study FER, NSC, BCS, and BW using the threshold-threshold model for combinations of two threshold traits (BCS and FER, BCS and NSC, FER and NSC) and combinations of threshold-linear model for one trait is the threshold and the other is linear (BCS and BW, FER and BW, NSC and BW) was used to obtain variance components, genetic parameters, and genetic correlations. 100,000 samples were used to determine the posterior means and standard deviations for variance components, heritability, and genetic correlations after 10,000 Gibbs samples were eliminated as burn-in. A visual examination of the plot of realizations for specific covariance components was used to track the convergence of the Gibbs samples. The model used in the analysis was:

$$Y = X b + Z u + e,$$

Where, Y = vector of observations for the ith trait, b = vector of fixed effects (parity order of females, 4 levels; and doe mating year-season combination, 12 levels) u = vector of random animal effects for the ith trait, e = vector of random residual effects for the ith trait, and X and Z are incidence matrices relating records of the ith trait to the fixed and animal effects, respectively. Estimation of heritability for direct (h^2_d) effects was estimated as:

$$h^2_d = \sigma^2 a / \sigma^2 p \text{ and } \sigma^2 p = \sigma^2 a + \sigma^2 e$$

Where, σ^2_p, σ^2_a, and σ^2_e are total or phenotypic, direct additive genetic and residual variances, respectively. A general formula used to calculate genetic correlations (r_G) among different traits as:

$$r_G xy = \text{cov}\ (xy)_{ij} / \sqrt{X_{ij}}\ \sqrt{Y_{ij}}$$

where, Cov $(xy)_{ij}$ = the additive genetic (a) co-variances between the first and second trait, X_{ij}= the additive genetic (a) variance of the first trait, and Y_{ij} = the additive genetic (a) variance of the second trait.

RESULTS AND DISCUSSION

The structure of the data used in this investigation is shown in Table 1.

Table 1. The structure of the data**.**

Number of records	2600
Number of does	218
Number of sires	35
Number of dams	104
Total number of animals in the pedigree file	357

Description of traits

The variability (CV %) for traits was moderate to high (Table 2). Traits means values fall within the levels of the literature's indicated ranges. Variation in FER, BW, BCS, and NSC in rabbit females could be attributed to their genetic potential (i.e. selection criteria), their reproductive effort, including the size of the litter being raised and the time between subsequent cycles of reproduction, as well as the caliber and nutritional value of their diet (Pascual *et al.*, 2013; Savietto *et al*., 2015). Does' body condition score (BCS) variation may be ascribed to variations in the fat deposition, which is largely accumulated in their abdomen cavities and along their backs, according to dairy cows (Bewley and Schutz, 2008).

Table 2. The means for the variables FER, BW, BCS, and NSC as well as their minimums (MIN), maximums (MAX), standard deviations (SD), and variation coefficients (CV%).

Variable	Mean	MIN	MAX	SD	CV%
FER	1.57	1.00	2.00	0.49	31.21
NSC	1.79	1.00	3.00	0.79	44.13
BCS	1.91	1.00	3.00	0.58	30.37
BW	3138	1850	4600	577.6	18.41

N= 2600 records, FER= Fertility, NSC = Total number of services each conception, BCS =Doe body condition score, and BW = Mating body weight**.**

The pregnant does were 65.77% of the 2600 records (Table 3). In addition, 55.35% of the does had medium doe body condition score and 39.12% used one time as a number of services each conception.

Table 3. Distribution and percent for fertility (FER), the total number of services each conception (NSC) and doe body condition scores (BCS).

Traits levels	FER		NSC			BCS		
	Non-pregnant	**Pregnant**	**One**	**Two**	**Three**	**Obese**	**Medium**	**Poor**
distribution	890	1710	1017	920	663	677	1439	484
Percent	34.23	65.77	39.12	35.38	25.50	26.04	55.35	18.61

Distribution for fertility, the total number of services each conception, doe body condition score, and body weight in the data is depicted in Figures 1, 2, 3, and 4.

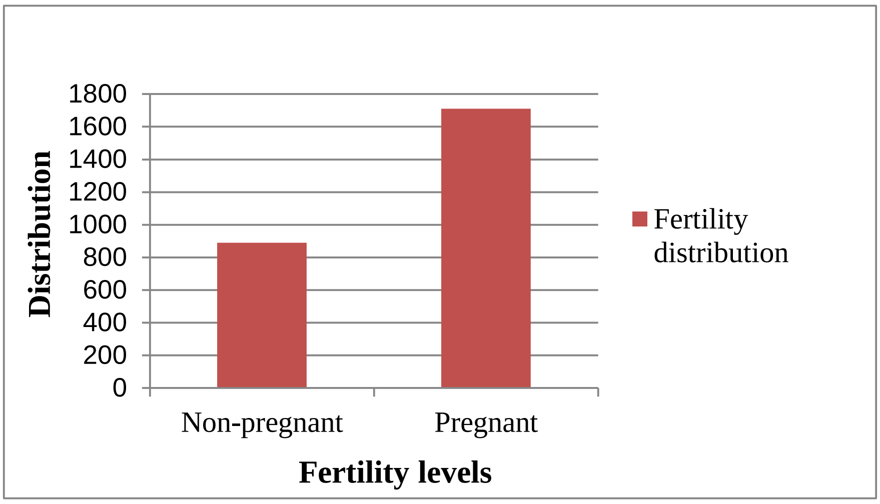

Fig.1. Fertility distribution

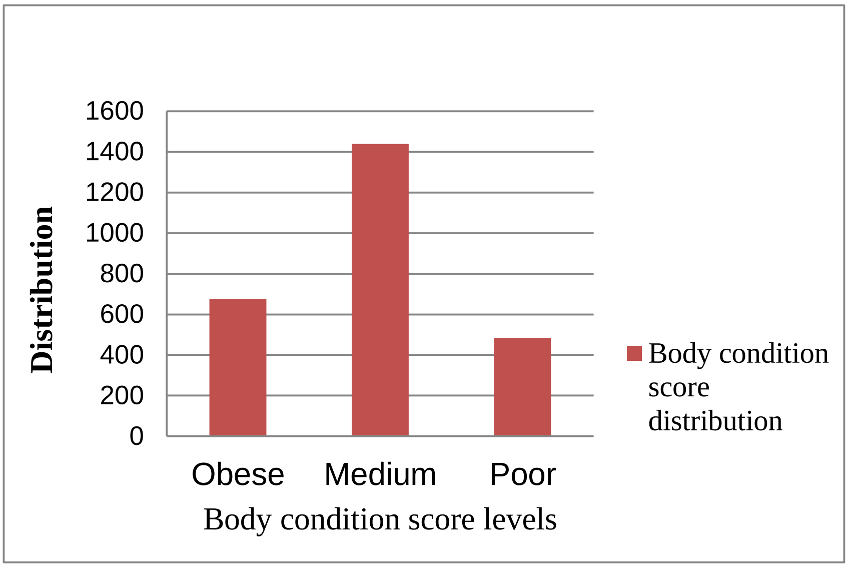

Fig.2. Doe body condition score distribution

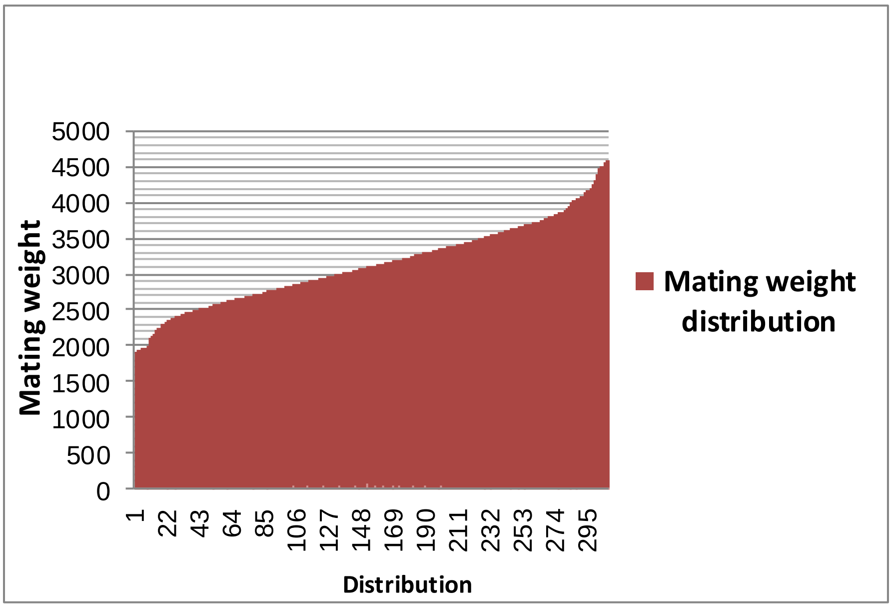

Fig.3. Body weight distribution

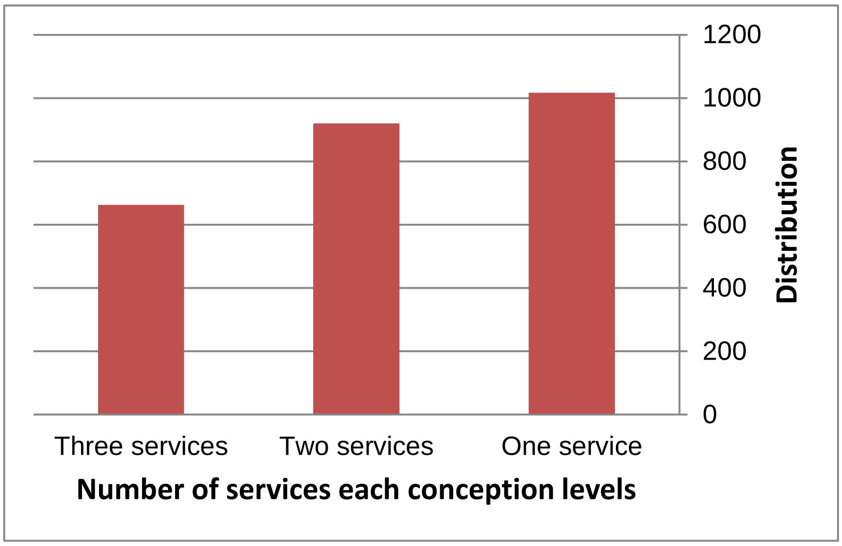

Fig.4. Number of service each conception distribution

Distribution for fertility (FER) and the total number of services each conception (NSC) according to doe body condition score (BCS) showed in Tables 4 and 5 and in figures 5 and 6. The medium doe body condition score showed the highest number of fertile does (table 4, fig.5). This outcome is consistent with the findings of Bonanno et al. (2008), who detected that a medium doe body condition score produced the maximum fertility. This finding highlights the detrimental impact on fertility of low or excessive body fat. Also, our results support the hypothesis that failures in fertility may be imputable to the high body fat of does than to their poor and bad body condition (Bonanno *et al*., 2008). In addition, major does used the lowest NSC (one time of mating) have the medium doe body condition score (Table 5, Fig. 6). Therefore, the medium doe body condition score was the ideal doe body condition score.

Table 4. Distribution for fertility (FER) by doe body condition score (BCS) in rabbits.

BCS levels / FER levels	Obese	Medium	Poor	Total
Non-pregnant	487	176	227	890
Pregnant	190	1263	257	1710
Total	677	1439	484	2600

Table 5. Distribution for number of services each conception (NSC) by doe body condition score (BCS) in rabbits.

BCS levels / NSC levels	Obese	Medium	Poor	Total
One time	190	709	336	1235
Two times	175	636	97	908
Three times	312	94	51	457
Total	677	1439	484	2600

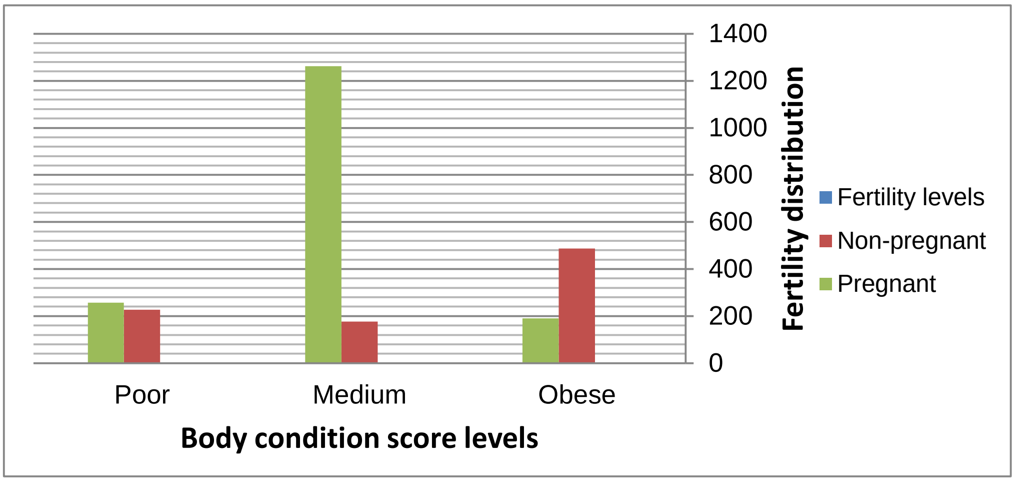

Fig.5. Distribution for fertility (FER) by doe body condition score (BCS) in rabbits.

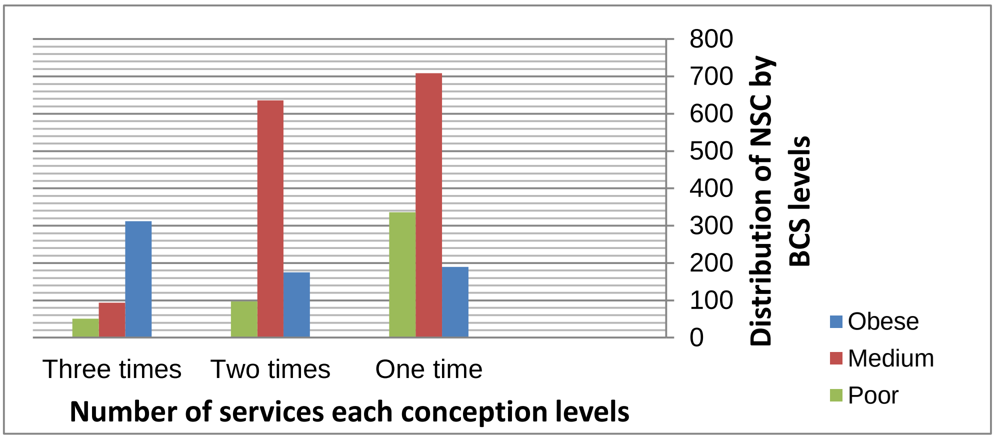

Fig.6. Distribution for number of services each conception (FER) by doe body condition score (BCS) in rabbits.

Non-genetic effects

The effect of year-season combination (YS), parity (P), interaction between parity and year-season (P×YS) on traits studied are displayed in the table 6. All attributes were extremely significant affected by year-season (P< 0.001). Effect of year-season on the reproductive traits of rabbit does may be attributed to their rabbitry environment, nutritional status, and management. Accordingly, the influence of year effect is a major part of the environment must be considered in the analysis of genetic studies. Season and genetic type were mostly cause variance in rabbits' BW and BCS (Fuente De la and Rosell, 2012). Also, the total number of services each conception as a fertility parameter is influenced by the season of the year (Tůma *et al.,* 2010). With different breeds of rabbits; the year of kindling affects NSC significantly as reported by Ahmed (1997) in Californian (CAL) rabbits, Abd El-Aziz (1998) in New Zealand White and Gabali rabbits and their crosses, and Gharib (2004) in Bauscat and Baladi Red rabbits. Year-season had a highly significant (P< 0.001) effect on all traits might be a reflection of the changes in temperature, management, and feed quality. Year-season had an impact on all attributes that was extremely significant (P< 0.001) that might be a reflection of the changes in temperature, management, and feed quality. Parity had a strong significant (P< 0.01) impact on FER and BW while it had no significant effect on BCS and NSC (Table 9). The interaction between parity and year season (P×YS) had no significant on all traits studied.

Table 6. Effects of year-season combination (YS), parity (P), interaction between parity and year- season (P×YS) on traits studied.

Effects / Traits	year-season (YS)		Parity (P)		(P×YS)	
	Value	Prob.	Value	Prob.	Value	Prob.
FER	*** 11.09	<0.0001	** 4.06	0.003	n.s. 1.40	0.07
NSC	*** 3.49	0.0003	n.s. 0.70	0.59	n.s. 0.66	0.93
BCS	*** 6.77	<0.0001	n.s. 0.38	0.82	n.s. 1.08	0.35
BW	*** 8.21	<0.0001	** 3.38	0.01	n.s. 1.20	0.21

FER= fertility, BW = mating body weight, BCS =doe body condition score and NSC =number of service per conception.
* = P <0.05, **=P< 0.01, ***=P< 0.001, and n.s. = Non Significant

Genetic parameters and correlations

Means of the calculated marginal posterior distribution (CMPD), with standard deviation in parenthesis for additive genetic (σ^2_a), phenotypic (σ^2_p), residual (σ^2_e) variances, and heritability (h^2_d) for traits under study are shown in Table (7).

Heritability estimates for traits were low to moderate. Heritability estimates were 0.03, 0.02, 0.21, and 0.20 for FER, NSC, BCS, and BW respectively (Tables 7). These results point to the genetic variation which exists in the doe body condition score and body weight of rabbits at mating. The moderate heritability estimates found in this study for these traits demonstrate the relative significance of additive genetic factors and suggest that genetic improvement of these traits may be achieved by including them in breeding programs, and it would be beneficial to have a response to the selection. These results also show the low genetic variation which exists in fertility and the total number of services each conception. The low heritability estimates for these traits may be a result of the strong environmental influences, which show that environmental variables have a greater impact on certain reproductive traits.

The estimate of heritability of fertility in this study is low (0.03) this result is consistent with findings by Piles et al., (2004 and 2005) and Tusell *et al.*, (2010) who, obtained low heritability estimates of fertility in rabbit females. According to Piles and Tusell (2011), female fertility, measured as the ability or inability to conceive, has a low heritability (0.07). This reflects the importance of environmental factors and management for this trait.

The total number of services each conception (NSC) has a low heritability (0.02). This estimate agreed with Farid et al., (2008) who obtained a low heritability for NSC (0.04) in CAL rabbits and (0.03) in Baladi Red rabbits respectively. Fatma M. Behiry et al., (2021) obtained a similar result (0.01) in Baladi Black rabbits. The estimate of heritability of NSC was 0.026 in dairy cattle as reported by Legates (1954).

The doe body condition score, has a moderate heritability (0.21) in this study. We believe that, there is not detailed analysis for the estimation of heritability of doe body condition score and weight at mating for rabbits. This outcome mostly concurs with the findings of De Haer *et al.,* (2013), Bilal and Hayes (2016), and GALİÇ (2017), (0.21, 0.20, and 0.22) respectively in cows. Furthermore, Loker *et al.,* (2011) showed that using a multiple-lactation random regression animal model, the heritability values of dairy cattle body condition score were moderate in the first three lactations of Canadian Holstein dairy cattle and varied between (0.14 and 0.26). Bastin *et al.,* (2010) and Berry *et al.,* (2003) revealed that the heritability of cows body condition score varied from 0.39 at the beginning of lactation to 0.51 at mid-lactation in dairy cows when using an animal model with random regression. Tait *et al.,* (2018) reported a high estimate of BSC in New Zealand merino ewes (0.66) at pre-mating.

The heritability of body weight at mating (BW) is moderate (0.20). No previous enough results in the literature in our knowledge to compare within the same age using animal model in analysis. This estimate agreed with Mefti Korteby (2016) who reported a similar value for the heritability of Algerian female rabbit mating weight (0.20) using a simple model. Generally, this estimate agreed with those obtained by Garcia and Baselga (2002) who provide a heritability (0.19 and 0.20), respectively for the weight of a rabbit at 9 weeks. The heritability of mating body weight in this study was consistent with estimates in Gabali rabbits from Soliman *et al.,* (2014), which were 0.19, 0.23, and 0.16 for BW4, BW8, and BW12, respectively. Compared to other studies listed in the literature by Quirino *et al.,* (2009) who obtained a heritability value for individual weight at 4 weeks of age (BW4) was 0.09, this study's heritability is higher. Heritability at the same age was observed in earlier investigations by Garcia and Baselga (2002) to be 0.15 and 0.13, respectively. At 9 weeks of age, Lukefahr *et al.,* (1996) and Quirino *et al.,* (2009) discovered a heritability value of 0.12.

These moderate estimates of heritability for doe body weight and body condition score at mating may be because there was never a rigorous selection programme for Baladi strains. The Egyptian rabbit breeders are encouraged to enhance doe attributes by these moderate estimations of heritability in Baladi strains. These findings show that doe body condition score and weight at mating exhibit genetic diversity, suggesting that by include these parameters in a breeding program, it will be possible to improve these features. It will be better to respond directly to the selection.

Table 7. Means of the calculated marginal posterior distribution (CMPD), with standard deviation in parenthesis for additive genetic (σ^2_a), phenotypic (σ^2_p), residual (σ^2_e) variances, and heritability (h^2_d) for FER, NSC, BCS, and BW.

Traits	σ^2_a	σ^2_p	σ^2_e	h^2_d
FER	0.008(0.001)	0.247(0.001)	0.239(0.007)	0.032(0.002)
NSC	0.002(0.001)	0.101(0.012)	0.099(0.022)	0.019(0.002)
BCS	0.084(0.006)	0.406(0.006)	0.322(0.010)	0.207(0.009)
BW	0.031(0.005)	0.153(0.005)	0.122(0.038)	0.203(0.014)

FER= Fertility, NSC= Number of services each conception, BCS= Doe body condition score, BW= Body weight at mating.

Table 8 shows all genetic correlations among fertility, doe body condition score, weight at mating, and number of services each conception. All genetic correlations between variables under study were moderate to high and positive. The doe body condition score and fertility had a moderately positive genetic correlation (r_g=0.23). These findings demonstrate relationships between fat reserves and reproduction over rabbit's reproductive lifetime, which can be helpful for both management and genetic selection. Based on measurements made at the beginning of reproduction, when the genetic variance for BCS is the largest, the indirect selection on BCS can produce the greatest genetic gain in fertility. The positive and moderate genetic correlation between BCS and FER in this study concurred with studies by Neuenschwander et al. (2009) working on Canadian Holstein cattle and Bastin et al., (2010) working on cows, who found a general positive genetic association between BCS and health and reproductive performance.

The positive genetic correlation among FER, NSC, BCS, and BW points to the correlated response among these traits. The positive genetic correlation among BCS and other characteristics (FER, NSC, and BW) indicates that the genetic improvement through selection to doe body condition score will lead to improvement in these traits.

These results suggest that genetic evaluations of reproductive traits performed in conjunction with BCS (as a correlated trait) might boost the accuracy and reliability of EBV for those traits, given its higher heritability and modest correlation with those traits.

Genetic correlation among BW and other traits (NSC, FER, and BCS) were positive that emphasizing the importance of entering BW in breeding programs. This outcome was in line with the findings of Bünger et al., (2005), who found a high genetic correlation between BW and reproductive fitness (ovulation rate and litter size) in rabbits. This result agreed with Bünger et al. (2005) who reported a strong genetic correlation between BW and reproductive fitness (ovulation rate and litter size) in rabbits.

The results showed a strong genetic association between BCS and BW (r_g = 0.54). This finding suggested that BCS and BW were closely correlated. The highest genetic correlation was estimated for the pair FER and NSC (0.98) may be considered the same trait in genetic terms.

Table 8: Means of the calculated marginal posterior distribution (CMPD), with standard deviation in parenthesis for genetic Correlations among fertility (FER), doe body condition score (BCS) and body weight at mating (BW).

Traits	FER	BW	BCS	NSC
FER		0.229± 0.004	0.231±0.004	0.980±0.002
BW			0.542±0.005	0.436± 0.013
BCS				0.146± 0.005

FER= fertility, BCS= doe body condition score, BW= body weight at mating, and NSC= number of services each conception

CONCLUSIONS

Doe body condition score and weight at mating were reasonably heritable in Baladi Black rabbits. Direct response to selection will be good. The majority of pregnant rabbits were seen in the doe with a medium body condition score. The medium body condition score is the ideal one, which showing the negative effects of poor or obese body fat.

The doe body condition score is suggested as a practical and quick instrument to enhance farm management of doe feeding and reproduction. It has the potential to be used to increase rabbit fertility. The fertility and the number of services each conception may be considered the same trait in genetic terms.

REFERENCES

Abd El-Aziz, M.M. 1998. Crossbreeding between Al-Gabali and New Zealand White rabbits in the North coast-belt of the Egyptian Western desert.Ph.D. Thesis, Fac. Agric., Moshtohor, Zagazig Univ., Banha Branch, Egypt.

Ahmed. E.G.A. 1997. Productive performance of different exotic strains of rabbits. Ph.D. Thesis, Fac. Agric., Suez Canal Univ., Ismailia, Egypt.

Banos, G., and Coffey, M.P. 2009. Genetic association between body energy measured throughout lactation and fertility in dairy cattle. Submitted to Animal. *Animal. 2010* Feb; 4(2):189-99. doi: 10.1017/ S 1751731109991182 . PMID: 22443872.

Bastin, C., S. Loker, N. Gengler, A. Sewalem, and F. Miglior. 2010. Genetic relationships between doe body condition score and reproduction traits for

Canadian Holstein and Ayrshire first-parity cows. *J. Dairy Sci.*, 93:2215–2228.

Berry, D. P., F. Buckley, P. Dillon, R. D. Evans, M. Rath, and R. F. Veerkamp. 2003. Genetic parameters for doe body condition score, body weight, milk yield, and fertility estimated using random regression models. *J. Dairy Sci.*, 86:3704–3717.

Bewley, J. M., and M. M. Schutz. 2008. Review: An interdisciplinary review of body condition scoring for dairy cattle. *Prof. Anim. Sci*., 24:507–529.

Bezdíček, J., Nesvadbová, A., Makarevich, A., and Kubovičová, E. 2020. Relationship between the animal body condition and reproduction: the biotechnological aspects, *Arch. Anim. Breed*., 63, 203–209, https://doi.org/10.5194/aab-63-203-2020, 2020.

Bilal, G., Cue, R. I., and Hayes, J. F. 2016. Genetic and phenotypic associations of type traits and body condition score with dry matter intake, milk yield, and number of breeding's in first lactation Canadian Holstein cows. *Canadian Journal of Animal Science*, 96(3), 434–447. https://doi.org/10.1139/cjas-2015-0127

Bonanno A., Mazza F., Di Grigoli A. and Alicata M.L. 2008. Doe body condition score and related productive responses in rabbit does. *9th World Rabbit Congress*, June 10-13, 2008, Verona, Italy.

Bonanno A., Mazza F., Di Grigoli A., Alicata M.L. 2005. Assessment of a method for evaluating the body condition of lactating rabbit does: preliminary results. In: Proc. 16th ASPA Congress, Torino, Italy. *Ital* J. of *Anim. Sci.*, Vol. 4, Suppl. 2, 560 (Abstract).

Broom D.M. 1986. Indicators of poor welfare. *Br. Vet. J., 142, 524-526*.

Bünger, L., R. M. Lewis, M. F. Rothschild, A. Blasco, U. Renne, and G. Simm. 2005. Relationship between quantitative and reproductive fitness traits in animals. *Phil. Trans. Royal Soc*. 360:1489–1502.

Cardinali R., Dal Bosco A., Bonanno A., Di Grigoli A., Rebollar P.G., Lorenzo P.L., Castellini C. 2007. Connection between doe body condition score, chemical characteristics of body and reproductive traits of rabbit does. *Livest. Sci. Doi:10.1016/j.livsci.2007.10.004.,*

Cardinali, R., A. Dal Bosco, A. Bonanno, A. Di Grigoli, P. G. Rebollar, P. L. Lorenzo, and C. Castellini. 2008. Connection between doe body condition score, chemical characteristics of body and reproductive traits of rabbit does. *Livest. Sci*. 116: 209–215.

Cervera C., Fernádez-Carmona J., Viudes P., Blas E. 1993. Effect of remating interval and diet on the performance of female rabbits and their litters. *Anim. Prod.,* 56: 399-405. doi:10.1017/S0003356100006450

Davoud A., Moeinim M.M., Shahir M.H., Sirjani M.A. 2012. Effect ofdoe body condition score, live weight and age on reproductive performance of

Afshariewes. *Asian Journal of Animal and Veterinary Advances*, 7(9): 904-909.

De Haer L., Jong G. and Vessies P. 2013. Estimation of Genetic parameters of Fertility Traits, for Virgin Heifers in the Netherlands. *Inter. Bull Bulletin* NO. 47. Nantes, France, August 23 - 25, 2013.

Farid A., Ahmed, M. A., Attalah, G.E.Y., Mabrouk, M. M. S., Gharib, M.G. 2008. Evaluation of some genetic parameters and permanent environmental effects for some maternal traits in two breeds of rabbits *Egyptian Journal of Rabbit Science*, 145-156.

Fatma M. Behiry, Hoda M. A. Shabaan, El Sayed M. Abdel-Kafy (2021). Characterization, genetic evaluation, and genetic trends for some reproductive traits of Baladi Black rabbits does. *Egyptian Journal of Rabbit Science.* Vol. (41) (I): (189-208). https://doi. org/ 10.21608/ epsj. 2021.64614.1147

Fuente De la, L.F. and Rosell, J.M. 2012. Body weight and body condition of breeding rabbits in commercial units. *J. Anim. Sci*., 2012.90:3252–3258.

GALİÇ, A. 2017. Determination the Body Condition and the Relationship with Milk Yield of Turkish Holstein Cows. Tarım Bilimleri Dergisi, *Journal of Agricultural Sciences*, 23(4). https://doi.org/10.15832/ankutbd.385869.

Garcia M. L. and Baselga M. 2002. Estimation of correlated response on growth traits to selection in litter size of rabbits using cyropreserved control population and genetic trends. *Live Stock Production Science* 78, 91-98.

Gharib, M.G. 2004. A comparative study of reproductive traits and growth rates in Baladi Red and Bauscat rabbits and their crosses. M.Sc. Thesis, Fac. Agric.,Al-Azhar Univ., Nasr-City, Cairo, Egypt.

Hatcher S., Graham P., Nielsen S., Gilmour A. 2007. Fat score of ewes at joining: the benefits of optimal nutrition, www.dpi.nsw.gov.au.

Legates J. E. 1954. Genetic Variation in Services Per Conception and Calving Interval in Dairy Cattle. *Journal of Animal Science Abstract* -This article in JASVol. 13 No. 1, p. 81-88. doi:10.2527/jas1954.13181x.

Lokerl S. Bastin C. Miglior F. Sewalem A. Schaeffer L.R. Jamrozik J. Osborne V. 2011. Estimates of genetic parameters of doe body condition score in the first 3 lactations using a random regression animal model. *Journal of Dairy Science,* Volume 94, Issue 7, July, Pages 3693-3699.

Lukefahr S. D., Odi H. B. and Atakora J. K. A. 1996. Mass selection for 70-day body weight in rabbit. *Journal of Animal Science* 74, 1481-1489.

Luo M.F., Boettcher P.J., Schaeffer L.R., Dekkers J.C. 2001. Bayesian inference for categorical traits with an application to variance component estimation. *J. Dairy Sci.,* 2001 Mar; 84(3):694-704. doi: 10.3168/jds.S0022-0302(01)74524-9. PMID: 11286423.

Mefti Korteby H. 2016. Heritability and correlation of the zootechnical performance of the Algerian local rabbit. *International Journal of Advanced Research in Biological Sciences* (2016). 3(5), 36–41.

Misztal I., Tsuruta S., Lourenco D., Masuda Y. 2016. Manual for BLUPF90 Family Of Programs University of Georgia, Athens, USA. October 3, 2016.

Nazhat, S. A., Aziz, A., Zabuli, J., & Rahmati, S. 2021. Importance of Body Condition Scoring in Reproductive Performance of Dairy Cows: *A Review. Open Journal of Veterinary Medicine,* 11(07), 272–288. https://doi.org/10.4236/ojvm.2021.117018

Neuenschwander, T., F. Miglior, J. Jamrozik, and L. R. Schaeffer., 2009. Bivariate analyses of doe body condition score and health traits in Canadian Holstein cattle using random regression model.*Proc. 60th Annual Meeting of the European Association for Animal Production (EAAP)*, Barcelona, Spain. Book of abstracts No. 15, 104.Wageningen Academic Publishers, Wageningen, the Netherlands.

Pascual J.J., Savietto D., Cervera C., Baselga M. 2013. Resources allocation in reproductive rabbit does: a review of feeding and genetic strategies for suitable performance. *World Rabbit Sci., 21: 123-144. doi: 10.4995/ wrs.2013.1236.*

Piles M., and Tusell L. 2011. Genetic correlation between growth and femaleand male contributions to fertility in rabbit.Journal of Animal Breeding and Genetics. *J. Anim. Breed. Genet*. (2011) 1–8.

Piles M., Rafel O., Ramon J., Varona L. 2004. Genetic parameters of fertility in two lines of rabbit of different aptitude. *8th World Rabbit Congress*, September 7-10, 2004 – Puebla, Mexico.

Piles M., Rafel O., Ramon J., Varona L. 2005. Genetic parameters of fertility in two lines of rabbits with different reproductive potential. *J. Anim. Sci.,* 83, 340–343.

Quirino C., Peiró R., Santacreu M., Blasco A. 2009. Genetic correlation between live weight and ovulation rate. *60th Annual Meeting of the European Association of Animal Science* 2009.

Romero C., Nicodemus N., Martinez de Morentin C.G., Garcia A.I., De Blas C. 2011. Effect of grinding size of barley and dehydrated alfalfa on performance and body composition of does during their early reproductive cycles. *Livest. Sci., 140:55-61. doi:10. 1016/j. livsci. 2011.02.010*

Rosell, J.M. and De La Fuente, L.F. 2008. Health and body condition of rabbit does on commercial farms. *9th World Rabbit Congress*, June 10-13, 2008, ,Verona, Italy.

SAS, 2002. Copyright by *SAS Institute Inc*., Cary, NC, USA.

Savietto D., Friggens N.C., Pascual J.J. 2015. Reproductive robustness differs between generalist and specialist maternal rabbit lines: the role of acquisition and allocation of resources. *Genet. Sel. Evol., 47: 1-11. doi:10.1186/s12711-014-0073-5.*

Soliman H., Gad S., and Ismail I. 2014. Genetic parameters for post-weaning growth traits of Gabali rabbits in Egypt. *Egypt. Poult. Sci.*, Vol (34) (II): (655-664) (2014).

Sorensen, D. A., Andersen, S., Gianola, D., & Korsgaard, I. 1995. Bayesian inference in threshold models using Gibbs sampling. *Genetics, Selection, Evolution*, 27(3), 229–249. https://doi.org/10.1016/0999-193X (96) 80477-0.

Tait, I.M., Kenyon, P.R., Garrick, D.J., Pleasants, A.B. and Hickson, R.E.2018. Genetic and phenotypic correlations between production traits and adult body condition scores in New Zealand merino ewes. *New Zealand Journal of Animal Science and Production*, Vol 78: 71-75.

Templeman, R.j., 1993. Poisson mixed models for analysis of counts with application to dairy cattle breeding. Ph.D. Dissertation, Univ., Wisconsin, Madison.

Tůma1 J., Tůmová E. and Valášek V. 2010. The effect of season and parity order on fertility of rabbit does and kit growth. *Czech J. Anim. Sci*., 55, 2010 (8): 330–336.

Tusell L., García-Tomás M., Baselga M., Rekaya R., Rafel O., Ramon J., López-Bejar M., Piles M. 2010. Interaction of genotype × artificial insemination conditions for male effect on fertility and prolificacy. *J Anim Sc.*, 2010 Nov; 88(11):3475-85. doi: 10.2527/jas.2009-2773. Epub 2010 Aug 20. PMID: 20729284.

المعايير الوراثية لبعض الصفات التناسلية و درجة حالة جسم الأم ووزنها فى الأرانب

السيد محفوظ عبد الكافى، فاطمة محمد بحيرى، هدى عبد الرؤوف شعبان، شيرين سلامة غنيم

معهد بحوث الإنتاج الحيوانى والدواجن، (APRI)، مركز البحوث الزراعية ، جيزة ، مصر

تم استخدام ٢٦٠٠ سجل لعدد ٢١٨ أنثى من الأرانب البلدي الأسود وذلك لتقدير المعايير الوراثية لبعض الصفات التناسلية (الخصوبة، عدد مرات التلقيح اللازمة لحدوث الاخصاب) وكذلك لصفات حالة جسم الأم عند وقت التزاوج (وزن الجسم، درجة حالة الجسم). تم دراسة مدى تأثير صفات حالة جسم الأم عندعمر التلقيح على تلك الصفات التناسلية وذلك من خلال تقدير الارتباطات الوراثية بين هذه الصفات موضع الدراسة. تم

تقدير توزيع لهذه الصفات التناسلية على حسب درجة حالة جسم الأم من أجل وصفها على مستوى المزرعة.

أظهرت درجة حالة جسم الأم المتوسطة أفضل نسبة إناث مخصبة. يرجع فشل حدوث الإخصاب إلى زيادة الدهون في الجسم أكثر منها فى حالة الجسم السئ والضعيف. حققت درجة حالة جسم الأم المتوسطة اكبر عدد من الاناث التى تحتاج مرة واحدة من التلقيح لحدوث اخصاب (خدمة واحدة). وعلى ذلك فالدرجة المتوسطة لسمنة الجسم تعتبر المثالية. كانت قيم المكافئات الوراثية للصفات موضع الدراسة منخفضة إلى متوسطة. كانت قيم المكافئات الوراثية ٠.٠٣ و ٠.٠٢ و ٠.٢١ و ٠.٢٠ لصفات الخصوبة وعدد مرات التلقيح الازمة لحدوث الاخصاب و درجة حالة الجسم ووزن الجسم عند عمر التلقيح على التوالى.

يمكن تحسين أداء إناث الأرانب البلدى الأسود من خلال تضمين درجة حالة جسم الأم والوزن عند التزاوج في برنامج التربية. ستكون الاستجابة المباشرة للانتخاب معقولة. كانت الارتباطات الوراثية بين درجات حالة جسم الأم والصفات قيد الدراسة (وزن الجسم والخصوبة وعدد مرات التقليح اللازمة لحدوث الاخصاب) إيجابية. يؤدي التحسين الوراثي من خلال الانتخاب لدرجة حالة جسم الأم المتوسطة إلى تحسين الخصوبة وعدد مرات التقليح الازمة لحدوث الاخصاب مما يؤكد على أهمية صفة درجة حالة جسم الأم في برامج التربية.

التوصية: إدخال صفات درجة حالة جسم الأم والوزن عند التزاوج في برامج التربية والتحسين الوراثى لأمهات أرانب البلدى الأسود حيث أن الاستجابة المباشرة للانتخاب فى هذه الحالة ستكون جيدة وتؤدى إلى تحسين صفة الخصوبة فى القطعان المرباة. الانتخاب لدرجة حالة جسم الأم المتوسطة سيؤدى للتحسين المرجو فى خصوبة الأمهات حيث أن أدائها أفضل من الأمهات الضعيفة والسمينة فى الخصوبة وعدد مرات التقليح اللازمة لحدوث الاخصاب.