# DF-REML Genetic Assessment of Milk Production and Efficiency of New Zealand White and Baladi Black Rabbits

**By**

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**Abstract:** *A two years breeding plan involving New Zealand White (NZW) and Baladi Black (BB) rabbits was carried out. Traits evaluated were total milk yield (TMY) at 21 and 28 days for 97 NZW female and 82 BB female as well as mean bunny weight at 21 and 28 days and milk efficiency ratio (kg of litter gain per kg of milk suckled) at 21 and 28 days, for 134 NZW and 155 BB litters. Derivative Free Restricted Maximum Likelihood (DF-REML) Animal Model was used for obtaining reliable variance components and hence heritability estimates. The DF-REML animal model analysis included year season combinations (YS) as fixed effect and litter size at birth as a covariate as well as animals and common litter effect as random effects.*

*Flocks of the two evaluated breeds were raised at the Experimental Rabbitry, Animal Production Research Institute, Sakha, Kafr El-Sheikh Governorate, Egypt. NZW rabbits recorded relative superiority in performance over that of BB ones for the milk efficiency and mean bunny weight traits. Year-season combination exerted significant effect on TMY and MBW at 21 and 28 days in NZW rabbits while the significant effects were on most traits studied in BB rabbits. Heritability estimates were low and ranged from 0.17 to 0.16 and from 0.13 to 0.08 for ME traits in NZW and BB, while it varied from 0.06 to 0.04 and from 0.19 to 0.08 for TMY, and from 0.14 to 0.13 and from 0.59 to 0.22 for mean bunny weight (MBW) in the two breeds respectively. Estimates of correlations among traits were higher in BB than those of NZW. While the NZW recorded a higher transmitting ability ranges in the three sorts of traits studied.*

**Key Words:** Rabbit, Milk Efficiency, Heritability, correlation and transmitting ability.

## INTRODUCTION

In rabbits the reproductive efficacy of a female depends not only on its capacity to yield numerous births, but also on its effectiveness of raising the neonates till weaning. Therefore, milk efficiency ratio is a definitive appraise and estimation that measures the capacity of unit weight milk in a certain period of time during the suckling period to produce a unit of litter weight gain. The growth of progeny is greatly affected by any milk-supply or inadequacy of their nursing mother. Consequently, recognizing and distinguishing does' milk efficiency is indispensable in most breeding programs specially those associated with prolific breeds and/or accelerated and intensive kindling systems (ABDEL-GHANY, 2005). As early as 1982, FAO suggested that by the year 2000 the voluntary meat requirements of one-third of the human population will be satisfied by the supply of pork, poultry and rabbit meat. Virtually 82% of the world's production of rabbit meat takes place in the developed nations (Lebas et al., 1997), meaning that approximately only 18 percent of total rabbit meat production occurs in developing countries

Accurate determination of animals breeding values for economic traits in rabbits is essential for planning and to achieve success in breeding programs. In addition, genetic progress depends on the correlation among genetic and phenotypic values. Best linear unbiased prediction (BLUP) estimated by different procedures is an approach to predict breeding value (BV) of animals and to adjust simultaneously for fixed effects of the model (Lukefahr, 1992). Mixed-model procedures are useful means for obtaining estimates of genetic parameters specific for populations and for monitoring and then improving selection programs, and most progress in artificial industrial selection can be achieved when breeding values are estimated with parameters specific for the population so optimum emphasis can be given to each trait for specific breeding objectives (Ferraz and Johnson, 1993). Van der Werf et al., 1994 reported that prediction of breeding values using BLUP procedure has the property of minimizing the error variance.

FAO as a World Organizations have been working many years to detect the characterization of local farm animals' breeds of each country specially those in Mediterranean Pays, and in some instances making fingerprints for such breeds, so in an assisting effort this work was begun to analyze our local Baladi-Black (BB) breed of rabbits, comparing its genetic capacity and performance with the that of the adapted exotic and traditionally exploited New Zealand White (NZW).

## MATERIALS AND METHODS

Rabbit's milk production and mean bunny weight data of the present study consisted of field records collected through coarsely two consecutive years (1996 – 1997) on New Zealand (NZW) and Baladi Black (BB) raised in the Experimental Rabbitry, Animal Production Research Institute, Sakha, Kafr El-Sheikh Governorate, Egypt for genetic and environmental evaluation. Evaluated does were housed in individual cages provided with nest boxes, feeders and automatic nipple drinkers. Those does were fed on a commercial pelleted diet containing approximately 16% protein, 2.39% crude fat and

12.8% crude fiber. Feed and water were provided *ad libitum*.

Matings started in Autumn-96 and terminated at the end of winter - 97. Saturdays and Tuesdays (twice a week) milk yield of does were recorded in grams using the weight-suckle-weight method described by Lukefahr et al., (1983). Averages of each week records is then multiplied by 7 to get the weekly milk yield, in addition to gain in litter weight up to $21^{st}$ and $28^{th}$ day of the suckling period. Litter milk efficiency was calculated as the gain in litter weight to 21 days divided by litter milk intake at the same interval. Mean bunny weight was calculated by dividing litter weight at a certain age by litter size alive at this age.

Data of NZW and BB rabbit does pertaining to milk production and mean bunny weight traits were analyzed using Derivative Free Restricted Maximum Likelihood Animal Model (Boldman et al., 1995). The model adopted for analyzing the data comprised the effect of year-season combination (as fixed effect) in addition to Animal additive and permanent environmental as random effects. Heritability estimates ($h^2$) were computed for each breed, as the ratio of additive genetic variance components relative to overall phenotypic variance. Numbers of does and dams along with number of litters for the two evaluated rabbit breeds are:

| Item | NZW | BB | Total |
|---|---|---|---|
| N°. of litters | 134 | 155 | 289 |
| N°. of evaluated does | 59 | 52 | 111 |
| N°. of evaluated dams | 38 | 30 | 68 |
| N°. of evaluated females | 97 | 82 | 179 |

**Statistical and Genetical analysis**

Total Milk yields for and Mean bunny weights at 21 and at weaning at 28 days of age traits for 289 litters of NZW and BB rabbits were recorded. Starting variance and covariance values, were obtained by REML method of VARCOMP procedure (SAS, 1996). Applying normally the same model used in SAS, these stating values were subsequently used for the estimation of more precise and reliable estimates of multi-trait animal model variance and covariance components.

The following animal model was used:

$$y = Xb + Z_a u_a + Z_c u_c + e$$

where y = vector of observations on animal; b = vector of unknown fixed effect peculiar to year-season (5 levels); $u_a$= vector of random additive genetic effect of the animal for the $i^{th}$ trait; $u_c$= vector of random permanent environmental effect (doe-parity of the litter combination); e = vector of random error; X, $Z_a$ and $Z_c$ are incidence matrices relating records of $i^{th}$ trait to the fixed, random animal and random common litter effects, respectively.

However, records of spring 1996 were not included in the statistical analysis because of their unavailability in view of that rabbits have been subjected to the effect of the viral hemorrhagic disease.

## RESULTS AND DISCUSSION

**Means and coefficients of variation of uncorrected records:**

Overall total milk yields (TMY), mean bunny weights (MBW) and milk efficiency ratio (ME ) (kg of litter gain per kg of milk suckled) at 21 and 28 days of age means, in NZW and BB rabbits, their standard deviations and coefficients of variation (CV%) during the suckling period are presented in table 1. Figures in this table revealed a general slight superiority of BB rabbits over NZW does regarding milk yield till 21 and 28 days, and the opposite trend was observed in the case of ME and MBW traits. Milk production of a doe can be increased by number of suckling kids (Bolet *et* al., 1996), even if they were fosters. ABDEL-GHANY, 2005 reported that milk production of does and consequently litter milk efficiency, is influenced by many factors. He added that both the litter weight at birth and number of suckling kids (specific characteristic of any given breed), influence milk production strongly. He revealed a superiority of NZW over CAL rabbits for ME traits. In this respect, Abou-Khadiga, 2004 reported that Straight-bred differences were highly significant regarding all milk yield traits with the V-line (a synthetic line) being the superior to that of Baladi Blacks. However, Abdel-Aziz, 1998 and Abdel-Aziz *et al.*, 2002 found that differences between El-Gabali and NZW for all milk efficiency traits were not significant with NZW breed showing persistently a higher performance. Milk efficiencies in this study were 0.60 and 0.78 for NZW which surpassed BB (0.57 and 0.74) at 21 and 28 days respectively. Hassan et al., 1992 recorded a lower estimate on NZW (0.49) for ME trait.

Unexpectedly, results presented in table 1 revealed that BB rabbits showed generally higher TMY compared with that of NZW, while the opposite trend was obtained in both ME and MBW traits (i.e. the superiority was in the direction of NZW over BB rabbits). Conflictingly, values of TMY showed a general trend indicating that these values increased slightly from 21 to 28 days of the suckling period. These results may mean that under such intensive production system adopted in the flock under consideration, the nourishment of bunnies by their starting to use commercial feeds offered to their nursing mothers affected these obtained results. The opposite trend was greatly observable in case of ME and MBW traits. Nevertheless, ME and MBW performance of NZW rabbits , though not tested statistically, were some extent increased than that of BB which may be a process of acclimatization from those rabbits to the Egyptian environment.

Coefficients of variation (CV%), ranged from 17.82 to 17.95 for TMY, 34.28 to 35.66 for ME and from 29.82 to 34.44 for MBW in NZW rabbits. The respective ranges in BB were from 20.21 to 20.55, 29.1 to 32.35 and from 24.58 to 29.07; which seems wider and consequently less uniform than that for NZW. These higher phenotypic variability of BB rabbits could be advantageous if they are genetic in its derivation and associated with a reasonable heritability estimate.

Yamany et al., 1994 recorded a lower estimates of CV% for TMY on NZW (21.6%), while it was 21.5% for BB rabbits at 21 days.

**Year-season effect:**

Year-season effects were significant ($P \leq 0.05$; and $P \leq 0.01$) on BB rabbits' TMY at 21 days and ME at 21 in addition to weaning of both breeds of rabbits, while MBW trait showed no significance on neither NZW nor BB rabbits (Table 2). In this respect Abdel-Ghany, 2005 revealed that winter kindlers ($P < 0.01$ or $P < 0.001$) were the highest in their ME figures with regard to other seasons with the significance being generally converged to difference with summer lactating does. Lack of significant year-season effects on total milk yield for NZW and MBW for NZW and BB rabbits agreed with those reported by Hassan, 2005, that the year-season effects on milk yield traits (during the 1st , 2nd , 3rd and 4th week of the suckling period) were generally not significant.

The two breeds differed in which is the season they recorded the highest TMY and MBW at 21, also within each year autumn-kindlers recorded a high MBW in case of NZW rabbits at 28 days with no trend as regard to BB ones (Table 2). These changes between seasons within each production year might be due to the appropriate ambient temperature and relative humidity during these seasons for milk producing does. Papp et al., (1983) who reported that the highest milk production and daily milk yield were given at 15 °C and daily milk yield fell down by 7.7 g for every one degree centigrade increase in temperature above 20 °C. Maertens and De Groote (1990) reported that high ambient temperature above 30 °C causes the decline of milk yield by about 9%. These differences in milk yield with the change of year-season may be due to variation in climatic conditions (e.g. ambient temperature, relative humidity...) and day length from one year-season to another. Ahmed, (1997) attributed differences in litter traits by year-season to be due to variation in climatic conditions from one year-season to another.

**Variance component (σ):**

Putting in mind that the magnitude of the error term is to a great extent comparable, animal model analysis of TMY, ME and MBW traits revealed that $\sigma^2_A$ (diagonal elements - Table 3) in NZW are generally higher than those in BB rabbits except milk yield till 21 days post-kindling. However, the magnitude of the additive covariances (off-diagonal elements) were commonly in favor of BB rabbits for TMY at 21 days, while it was in favor of NZW for ME at 21 days of age. Hassan 2005 reported that $\sigma^2_A$ in NZW are generally higher than those in BB rabbits except milk yield till 21 days post-kindling.

These results give implication that NZW rabbits in the flock under consideration are expected to respond better to direct selection for ME than BB ones. Regarding MBW and with the same tendency of the error term to be greatly alike across breeds, $\sigma^2_A$ of NZW rabbits is generally higher than that in BB rabbits. These results reveal that resembling ME, BB rabbits in the flocks under consideration are expected to respond poorer to direct selection of MBW traits than NZW ones.

In this respect, the phenotypic variance, (diagonal elements) phenotypic covariance (off-diagonal elements) of MY data revealed that NZW rabbits are generally senior than those of BB rabbits for both TMY and ME at 28 days and MBW at both ages studied, (Table 3 &4). Hassan, 2005 recorded a higher estimate belonging to NZW for MY traits. However in case of MY and ME at 21 days of age, BB rabbits recorded a higher estimate than NZW ones

These low and insignificant figures of additive variance components highlighted the importance and the strong magnitude of the environmental component of variance linked with the genetic differences connected with TMY, ME and MBW traits. This conclusion agreed with that reported by Hassan 2005 in the case of MY traits. As an estimator of such an environmental permanent environment variance was evaluated (This cyclic error variance was expressed as percentage). As regard to milk yield (Table 3), a general trend was observed that percentage variance was relatively greater in NZW when compared with BB ones which may indicate a larger sensitivity of NZW to such cyclic error variance with the magnitude being age dependent. Though of the magnitude was very slight in case of ME, but it seems that BB population was vaguely more sensitive to such environmental variations. However regarding MBW traits (Table 4), this cyclic error variance was somewhat weak in the two populations under study except that of the covariance which indicate opposite reaction direction with the magnitude being stronger in case of NZW (-0.980% in NZW vs. 0.031% in BB). Howbeit, the covariances between MY and ME traits were to some what controversial with the trend was mostly being negative relationships regarding this permanent environmental variance. Results of cyclic error variance could possibly indicate that adopting a repeatability model in the two populations considered might not be acceptable approximation to model variations regarding the traits evaluated

In this respect, Khalil et al., (1987) reported that the low percentages of sire variance component reflect the large environmental component of variance associated with the doe during kindling and raising its litters to weaning. They also added that since milk production and subsequently litter gain are from fitness traits and are influenced by litter size, it is supposed that the additive variance has been diminished through long term natural selection.

**Genetic parameters**

**Heritability estimates:**

Heritability estimates ($h^2$) using DF-REML methodology for MY and MBW traits in NZW and BB rabbits presented in table 5, were relatively very low. $h^2$ in BB rabbits were to some extent higher than those of NZW ones for TMY and MBW and ranged from 0.08 to 0.19 and from 0.22 to 0.59 in the two traits in BB rabbits; respectively. The superiority concerning TMY and MBW traits, $h^2$ estimates were generally in favor of BB rabbits with the same previously mentioned obvious trend of its diminishing magnitude as litters advance in age. While the breed of NZW have the superiority in $h^2$ estimate in ME traits. In this respect, Hassan , 2005 reported the same diminishing trend of $h^2$ estimates for TMY traits as litter advance in their age.

Howbeit, Ahmed (1997) reported that heritability estimates of milk production traits from kindling up to 21 days were low in both breeds (i.e. NZW and Californian) and ranged from 0.064 to 0.121 in NZW and from 0.014 to 0.261 in Californian rabbits. The low estimates of heritability for most studied traits in the two breeds under consideration, suggest that maternal effects and non-genetic factors constituted the major source of variation for those traits. While the high Heritability estimate for BB rabbits (0.59) at 21 days of age may propose that selection of this breed for MBW traits as early as 21 days of age would be beneficial.

**Genetic correlation**

Estimates of genetic correlations among traits studied, in both BB and NZW rabbits, presented in table 5& 6 proved that those traits are generally strongly and positively correlated in the two populations evaluated. Estimates in BB were to most circumstances higher than those of NZW ones for MY, ME and MBW traits. Similar findings were reported by Hassan, 2005. However, genetic correlation estimates between MY and MY seems to be greater between those at adjacent ages and tends to diminish as the interval between ages increased, but more in case of NZW (tilted toward negative estimates being -0.44, Table 5). Some of these age related decreased relationship among the two traits might be in that MY is partly used in the calculation of ME (part to all relationship), which makes the later a more composite and complex trait. Another explanation is that at later ages (actually at weaning at 28 days) litter gain could be greatly dependent on the quantity of feeds used by the bunnies causing less dependence on MY. It deserves referring that BB rabbits exhibited generally a larger genetic correlation estimates regarding the traits under consideration (Tables 5& 6). In this respect the studied populations trajectory regarding the effect of age on genetic parameters may possibly be supplementary elucidated and clarified if random regression analysis is applied and therefore they might need more investigation.

**Transmitting abilities:**

Transmitting ability estimates for TMY, ME and MBW traits at 21 and 28 days of age in NZW and BB rabbits, presented in table 7, exhibited a common trend regarding the range of breeding values of BB rabbits being to some extent higher than those of NZW ones at 21 days of age. However the trend was reversed at 28 days of age favoring NZW rabbits and revealing a broader genetic variability in NZW rabbits to select form at weaning at 28 days of age. In this respect, Hassan 2005 came to the same results that transmitting ability ranges in BB rabbits were to some extent lower than those of NZW ones for total milk yield. Apart from the ranges and when considering the maximum transmitting ability estimates, it was found that NZW rabbits were greater to BB rabbits in most figures which would increase the expected performance of their progeny. Howbeit, the number of positive records of evaluated females exceeded 50% (ranged between 52.44 to 57.32%) in case of BB population while it was generally inferior in NZW (ranged between 43.30 to 52.58) which when connected with the higher $h^2$ estimates in BB (Tables 5& 6) reveals a greater promising possibility to be improved through individual selection. Wider ranges of the higher 25% females revealed a less homogeneity in the animals which are expected to be replacers. Adding to the last conclusion that the mean performance of BB population is as or even better compared with NZW (Table 1) and that the transmitting abilities were also as that or even better than NZW (Table 7). Therefore, these results may indicate extra and auxiliary advantages to BB rabbits to be devoted more selection trails to improve the traits under consideration. All these assessments also revealed that though of the intensive selection that NZW rabbits have been subjected to in their country of origin, they still have, under the Egyptian environment, an endurable genetical variability to be further improved.

## CONCLUSIONS

BB rabbits showed generally a higher TMY performance compared to that of NZW.

Putting in mind that low figures of additive variance components revealed the importance and the strong magnitude of the environmental component of variance linked with the genetic differences in MY and MBW traits.

Baladi Black rabbits perform well for MY; ME and MBW traits when compared with the exotic ones, this may be due to that exotic breeds after a period of acclimatization and subjection to unintended inbreeding weakened to the extent that they were comparable to or even lower than the native breed. Besides, and due to the intensive selection which was performed in their countries of origin, the additive variance of exotic breed was regressed. However, and due to that native breed was not subjected to such selection programs, native breed additive variance component is of high magnitude which enables selection for such traits giving greater and faster response than exotic ones.

Table (1): Overall actual Means; standard deviations (SD); and coefficients of variability (CV%) on Total milk yield, milk efficiency and mean bunny weight in New Zealand White (NZW) and Baladi Black (BB) rabbits till 21 and 28 days post kindling.

| Trait | New Zealand White rabbits | | | Baladi Black rabbits | | |
|---|---|---|---|---|---|---|
| | Mean | SD | CV% | Mean | SD | CV% |
| **Total Milk yield till 21 days** | 2.088 | 0.375 | 17.95 | 2.248 | 0.462 | 20.55 |
| **Total Milk yield till 28 days** | 2.453 | 0.437 | 17.82 | 2.622 | 0.530 | 20.21 |
| **Milk efficiency till 21 days** | 0.603 | 0.215 | 35.66 | 0.572 | 0.185 | 32.35 |
| **Milk efficiency till 28 days** | 0.783 | 0.269 | 34.28 | 0.745 | 0.217 | 29.10 |
| **Mean bunny weight at 21 days** | 0.285 | 0.098 | 34.44 | 0.281 | 0.082 | 29.07 |
| **Mean bunny weight at 28 days** | 0.407 | 0.122 | 29.82 | 0.400 | 0.098 | 24.58 |
| **LSB (Means of the Covariate trait)** | 27.810 | 1.932 | 6.948 | 27.030 | 1.845 | 6.826 |

LSB (litter size at birth) was used as a covariate in the model of the analysis.

Table (2): Year-season combinations Least squares means of total milk yield, milk conversion and mean bunny weight traits for New Zealand White (NZW) and Baladi Black (BB) rabbits from birth till 21 days of age and from birth till weaning.

| YEAR SEASON | NZW | | | | | BB | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No | TMY-21 *** | | TMY-28 | | No | TMY-21 * | | TMY-28 | |
| | | LSQ.M | SE. | LSQ.M | SE. | | LSQ.M | SE. | LSQ.M | SE. |
| 1st year-Autumn | 61 | 2.225 | 0.099 | 2.477 | 0.137 | 57 | 2.124 | 0.091 | 2.521 | 0.108 |
| 1st year-Winter | 13 | 1.912 | 0.109 | 2.660 | 0.150 | 53 | 2.205 | 0.101 | 2.561 | 0.120 |
| 2nd year-Autumn | 41 | 2.217 | 0.073 | 2.258 | 0.106 | 30 | 2.257 | 0.086 | 2.622 | 0.102 |
| 2nd year-Winter | 19 | 2.118 | 0.106 | 2.276 | 0.146 | 15 | 2.640 | 0.119 | 3.070 | 0.141 |
| YEAR SEASON | NZW | | | | | BB | | | | |
| | No | ME-21 | | ME-28 | | No | ME-21 | | ME-28 ** | |
| | | LSQ.M | SE. | LSQ.M | SE. | | LSQ.M | SE. | LSQ.M | SE. |
| 1st year-Autumn | 61 | 0.316 | 0.020 | 0.427 | 0.026 | 57 | 0.283 | 0.014 | 0.408 | 0.016 |
| 1st year-Winter | 13 | 0.289 | 0.022 | 0.423 | 0.028 | 53 | 0.287 | 0.016 | 0.406 | 0.017 |
| 2nd year-Autumn | 41 | 0.267 | 0.016 | 0.388 | 0.019 | 30 | 0.266 | 0.014 | 0.387 | 0.015 |
| 2nd year-Winter | 19 | 0.275 | 0.022 | 0.409 | 0.027 | 15 | 0.247 | 0.018 | 0.357 | 0.020 |
| YEAR SEASON | NZW | | | | | BB | | | | |
| | No | MBW-21 *** | | MBW-28 *** | | No | MBW-21 ** | | MBW-28 ** | |
| | | LSQ.M | SE. | LSQ.M | SE. | | LSQ.M | SE. | LSQ.M | SE. |
| 1st year-Autumn | 61 | 0.706 | 0.060 | 0.925 | 0.075 | 57 | 0.643 | 0.042 | 0.813 | 0.049 |
| 1st year-Winter | 13 | 0.670 | 0.065 | 0.939 | 0.081 | 53 | 0.573 | 0.046 | 0.767 | 0.054 |
| 2nd year-Autumn | 41 | 0.557 | 0.049 | 0.704 | 0.063 | 30 | 0.488 | 0.039 | 0.658 | 0.047 |
| 2nd year-Winter | 19 | 0.552 | 0.064 | 0.755 | 0.079 | 15 | 0.437 | 0.053 | 0.560 | 0.064 |

NZW = New Zealand White rabbits; BB = Baladi-Black rabbits.

TM-21 = Total milk yield from kindling till 21 days thereafter; TM-28 = Total milk yield from kindling till 28 days thereafter; ME-21 = milk Efficiency from kindling till 21 days thereafter; ME-28 = milk Efficiency from kindling till 28 days thereafter; MBW-21 = mean bunny weight at 21 days; MBW-28 = mean bunny weight at 28 days.

LSQ.M = Least squares means; SE = Standard error of least squares means.

* significant effect for year season combination at P< 0.05; ** significant at P< 0.01; *** significant at P< 0.001.

Table (3): Genetic and phenotypic variance (diagonal elements) and co-variance matrices; as well as percentages contribution for permanent environment and error from the phenotypic variance co-variance for milk yield (MY) and milk efficiency (ME) traits in New Zealand White (NZW) and Baladi Black (BB) rabbits till 21 and 28 days of age

| Traits | genetic Variance Co-variance Matrix | | | |
|---|---|---|---|---|
| | MY-21 | MY-28 | ME-21 | ME-28 |
| **New Zealand White rabbits** | | | | |
| Milk yield till 21 days (**MY-21**). | 0.022 | | | |
| Milk yield till 28 days (**MY-21**). | 0.050 | 0.150 | | |
| Milk efficiency till 21 days (**MY-21**). | 0.020 | 0.091 | 0.073 | |
| Milk efficiency till 28 days (**MY-21**). | -0.007 | 0.003 | 0.017 | 0.013 |
| **Baladi Black rabbits:** | | | | |
| Milk yield till 21 days | 0.148 | | | |
| Milk yield till 28 days. | 0.135 | 0.124 | | |
| Milk efficiency till 21 days. | 0.092 | 0.084 | 0.069 | |
| Milk efficiency till 28 days. | 0.001 | -0.001 | 0.005 | 0.006 |
| | **Phenotypic Variance Co-variance Matrix** | | | |
| | MY-21 | MY-28 | ME-21 | ME-28 |
| **New Zealand White rabbits** | | | | |
| Milk yield till 21 days | 0.497 | 0.985 | 0.361 | 0.043 |
| Milk yield till 28 days. | 0.985 | 2.688 | 0.970 | 0.152 |
| Milk efficiency till 21 days. | 0.361 | 0.970 | 0.434 | 0.110 |
| Milk efficiency till 28 days. | 0.043 | 0.152 | 0.110 | 0.078 |
| **Baladi Black rabbits:** | | | | |
| Milk yield till 21 days | 0.776 | 1.060 | 0.704 | 0.017 |
| Milk yield till 28 days. | 1.060 | 1.515 | 1.041 | 0.033 |
| Milk efficiency till 21 days. | 0.704 | 1.041 | 0.893 | 0.091 |
| Milk efficiency till 28 days. | 0.017 | 0.033 | 0.091 | 0.046 |
| **Traits** | **% permanent** | | | |
| | MY-21 | MY-28 | ME-21 | ME-28 |
| **New Zealand White rabbits** | | | | |
| Milk yield till 21 days | 0.160 | | | |
| Milk yield till 28 days. | 0.630 | 0.003 | | |
| Milk efficiency till 21 days. | -0.520 | 0.140 | 0.006 | |
| Milk efficiency till 28 days. | -0.012 | -0.073 | -0.640 | 0.044 |
| **Baladi Black rabbits:** | | | | |
| Milk yield till 21 days | 0.001 | | | |
| Milk yield till 28 days. | 0.730 | 0.001 | | |
| Milk efficiency till 21 days. | -0.086 | -0.007 | 0.027 | |
| Milk efficiency till 28 days. | 0.440 | -0.120 | 0.510 | 0.310 |
| **Traits** | **% Error** | | | |
| | MY-21 | MY-28 | ME-21 | ME-28 |
| **New Zealand White rabbits** | | | | |
| Milk yield till 21 days | 0.8 | | | |
| Milk yield till 28 days. | 0.92 | 0.94 | | |
| Milk efficiency till 21 days. | 0.93 | 0.92 | 0.82 | |
| Milk efficiency till 28 days. | 0.33 | 0.38 | 0.64 | 0.79 |
| **Baladi Black rabbits:** | | | | |
| Milk yield till 21 days | 0.81 | | | |
| Milk yield till 28 days. | 0.99 | 0.92 | | |
| Milk efficiency till 21 days. | 0.87 | 0.91 | 0.90 | |
| Milk efficiency till 28 days. | 0.11 | 0.18 | 0.53 | 0.56 |

Table (4): Genetic and phenotypic variance (diagonal) and co-variance matrices; as well as percentages contribution for permanent environment and error from the phenotypic variance co-variance for Mean bunny weight (MBW) traits in New Zealand White (NZW) and Baladi Black (BB) rabbits till 21 and 28 days of age

| | **Genetic Variance-CO- Variance** | | | | **Phenotypic Variance -CO- Variance** | | | |
|---|---|---|---|---|---|---|---|---|
| | **NZW** | | **BB** | | **NZW** | | **BB** | |
| | **MBW-21** | **MBW-28** | **MBW-21** | **MBW-28** | **MBW-21** | **MBW-28** | **MBW-21** | **MBW-28** |
| MBW-21 | 0.181 | | 0.127 | | 1.414 | | 0.216 | |
| MBW-28 | 0.113 | 0.132 | 0.039 | 0.012 | 1.080 | 0.914 | 0.100 | 0.055 |
| | **Permanent %** | | | | **Error %** | | | |
| MBW-21 | 0.004 | | 0.002 | | 0.870 | | 0.410 | |
| MBW-28 | 0.031 | 0.023 | -0.980 | 0.021 | 1.000 | 0.830 | 0.990 | 0.760 |

Table (5): Heritability (diagonal) and genetic correlation estimates of Total milk yield (TMY) and Milk efficiency (ME) traits in New Zealand White (NZW) and Baladi Black (BB) rabbits till 21 and 28 days of age

| Traits | Heritability Estimates | | | |
|---|---|---|---|---|
| | **MY-21** | **MY-28** | **ME-21** | **ME-28** |
| **New Zealand White rabbits** | | | | |
| Milk yield till 21 days | 0.04 | | | |
| Milk yield till 28 days. | 0.86 | 0.06 | | |
| Milk efficiency till 21 days. | 0.49 | 0.86 | 0.17 | |
| Milk efficiency till 28 days. | -0.44 | 0.07 | 0.57 | 0.16 |
| **Baladi Black rabbits:** | | | | |
| Milk yield till 21 days | 0.19 ±0.44 | | | |
| Milk yield till 28 days. | 0.99 ±0.34 | 0.08± 0.44 | | |
| Milk efficiency till 21 days. | 0.91 ±0.32 | 0.90± 0.55 | 0.08±0.48 | |
| Milk efficiency till 28 days. | 0.03 ±0.90 | -0.02±1.60 | 0.22±1.06 | 0.13± 0.10 |

Table (6) Heritability (diagonal) and genetic correlation estimates of Mean bunny weight (MBW) traits in New Zealand White (NZW) and Baladi Black (BB) rabbits till 21 and 28 days of age

| | Heritability Estimates | |
|---|---|---|
| | **MBW 21** | **MBW 28** |
| **New Zealand White rabbits** | | |
| Mean bunny weight at 21 days | 0.13 | |
| Mean bunny weight at 28 days | 0.73 | 0.14 |
| **Baladi Black rabbits:** | | |
| Mean bunny weight at 21 days | .59± .5 | |
| Mean bunny weight at 28 days | .99± .09 | .22± .48 |

Table (7): Animal transmitting ability Maximum (Max.), minimum (Min.), number and percentages of positive records (+) as well as the minimum and range of the higher 25% of Total milk yield, milk Efficiency and Mean bunny weight traits for New Zealand White (NZW) rabbits till 21 and 28 days of age.

| Trait | Max. | Min. | Range | + Records | % + Records | Higher 25 % | |
|---|---|---|---|---|---|---|---|
| | | | | | | Min. | Range |
| **New Zealand White (NZW)** | | | | | | | |
| Total Milk yield till 21 days. | 0.262 | -0.160 | 0.421 | 43 | 44.33 | 0.024 | 0.238 |
| Total Milk yield till 28 days. | 0.703 | -0.388 | 1.091 | 45 | 46.39 | 0.055 | 0.6472 |
| Milk Efficiency till 21 days. | 0.369 | 0.060 | 0.309 | 47 | 48.45 | 0.038 | 0.3304 |
| Milk Efficiency till 28 days. | 0.151 | -0.163 | 0.314 | 51 | 52.58 | 0.006 | 0.1450 |
| Mean bunny weight at 21 day. | 0.118 | -0.073 | 0.191 | 44 | 45.36 | 0.006 | 0.1118 |
| Mean bunny weight at 28 day. | 0.073 | -0.143 | 0.216 | 42 | 43.30 | 0.010 | 0.0622 |
| Total Number of females | (dams + does)= 97 | | | | | | |
| **Baladi Black (BB)** | | | | | | | |
| Total Milk yield till 21 days. | 0.3096 | -0.473 | 0.783 | 47 | 57.32 | 0.0813 | 0.2283 |
| Total Milk yield till 28 days. | 0.2731 | -0.427 | 0.700 | 46 | 56.10 | 0.0782 | 0.1949 |
| Milk Efficiency till 21 days. | 0.1736 | -0.334 | 0.508 | 43 | 52.44 | 0.0565 | 0.1171 |
| Milk Efficiency till 28 days. | 0.0857 | -0.148 | 0.233 | 45 | 54.88 | 0.0233 | 0.0624 |
| Mean bunny weight at 21 day. | 0.1545 | -0.264 | 0.418 | 47 | 57.32 | 0.0357 | 0.1189 |
| Mean bunny weight at 28 day. | 0.0475 | -0.081 | 0.129 | 47 | 57.32 | 0.0110 | 0.0366 |
| Total Number of females | (dams + does)= 82 | | | | | | |

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