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# HETEROSIS, DIRECT AND MATERNAL ABILITIES OF POST-WEANING DAILY GAIN IN WEIGHT TRAITS OF TWO EGYPTIAN NATIVE BREEDS ON ACCOUNT OF CROSSING WITH NEW ZEALAND WHITE RABBITS

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## ABSTRACT

Data of the present study were on a total of 876 (straight-bred (393) and cross-bred (483)) weaned rabbits, produced from three breeds, one exotic, New-Zealand White (NZW) and two Egyptian, Baladi-Black (BB) and Baladi-Red (BR). An incomplete diallel crossing mating design excluding the two reciprocal crosses between the two indigenous breeds was adopted. The study aimed at the evaluation of the direct heterotic effect of biweekly progeny daily gain in weight traits from weaning (at $6^{th}$ wk of age) up to marketing age (at $16^{th}$ wk of age), as well as the estimation of the genetic and non-genetic factors affecting these traits. NZW and BB rabbits as well as their crosses recorded a general superiority in their average performance, of different traits considered and at most age stages studied, compared with either BR ones or their crosses. Direct effects showed a superiority of BB and an inferiority of NZW. The reverse was for maternal effects and, in general higher heterosis was observed in crosses NZWxBR than in cross of NZWxBB.

## INTRODUCTION

Crossing native Egyptian breeds of rabbits with exotic ones was associated, in most cases, with an improvement in doe reproductive and litter as well as progeny growth and carcass merit traits (Afifi et al., 1994 and Khalil, et al., 1995). Therefore, this study was conducted to evaluate genetically daily gain in weight traits (DG) using an incomplete diallel crossing scheme, involving two local breeds with another exotic one; to estimate the importance of some genetic (breed group, general combining and maternal additive abilities, direct additive) and non-genetic factors as well as overall and direct heterotic effect on the aforementioned traits.

## MATERIALS AND METHODS

This experiment was carried out at Kafr-El-Sheikh, Sakha research station, which belongs to Animal Production Research Institute, Ministry of Agriculture, Egypt. Data were obtained from a total of 876 (straight-bred (393) and cross-bred (483)) weaned rabbits produced from an incomplete diallel crossing between three breeds, one acclimatized exotic (i.e. sires and dams of the exotic breed were descendents of the New-Zealand, NZW rabbits raised under the Egyptian conditions) and two local ones (Baladi-Black, BB and Baladi-Red, BR). The breeding plan permits the simultaneous production of the straight-bred and crossbred rabbits between the aforementioned breeds eliminating the two reciprocal crosses between the local breeds. In the straight-bred groups, bucks were assigned at random to breed the dams though, as it is the case in the crossbred ones but with a restriction of avoiding the mating of animals with known common grandparent. Throughout the whole period of this study, each sire was allowed to sire all his bunnies from the same dam. The mating groups include three straight-bred (i. e. **NZWxNZW; BBxBB and BRxBR**) and four crossbred ones (i. e. **NZWxBB; BBxNZW; NZWxBR; and BRxNZW**).

Mixed model Least Squares and Maximum Likelihood Computer Program PC version 2 (Harvey, 1990) was used for analyzing the data. The linear fixed model adopted for the analysis comprised the effects of mating group, sex; feed type; month of birth; parity and litter size at birth; as well as the interactions. Crossbreeding effects (Additive maternal; additive direct; overall, direct, or separate cross heterotic effects) on post weaning daily gain in weight traits were derived applying a selected set of linear contrasts on mating groups' least squares means (Dickerson, 1992). Each single degree of freedom contrast was tested for significance with Student's t-test.

## RESULTS AND DISCUSSION

Table 1: Number of observation (N), means (X: grams), standard deviation (SD) and coefficient of variability (CV) for daily gain of various mating groups (BG) at different age stages.

| Mating groups | Statistic | | Periods (weeks) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 6-8 | | 8-10 | | 10-12 | | 12-14 | | 14-16 | |
| **NZW** | N | CV | 219 | 46 | 195 | 34 | 188 | 33 | 119 | 32 | 59 | 33 |
| | X | SD | 13.2 | 6.1 | 13.4 | 4.6 | 13.8 | 4.5 | 13.3 | 4.2 | 12.3 | 4.0 |
| **BB** | N | CV | 102 | 47 | 91 | 46 | 83 | 37 | 57 | 28 | 32 | 29 |
| | X | SD | 15.8 | 7.4 | 13.7 | 6.3 | 14.0 | 5.1 | 13.5 | 3.7 | 12.0 | 3.5 |
| **BR** | N | CV | 72 | 41 | 67 | 40 | 62 | 38 | 43 | 28 | 36 | 24 |
| | X | SD | 13.4 | 5.6 | 12.6 | 5.0 | 12.0 | 4.6 | 12.0 | 3.3 | 13.0 | 3.1 |
| Total (St) Straight-Bred | N | CV | 393 | 46 | 353 | 39 | 333 | 35 | 219 | 30 | 127 | 29 |
| | X | SD | 13.9 | 6.4 | 13.3 | 5.2 | 13.5 | 4.7 | 13.1 | 3.9 | 12.4 | 3.6 |
| **NZW*BB** | N | CV | 127 | 50 | 110 | 47 | 99 | 39 | 57 | 27 | 33 | 24 |
| | X | SD | 13.2 | 6.6 | 12.0 | 5.6 | 12.5 | 4.8 | 13.6 | 3.7 | 12.3 | 2.9 |
| **NZW*BR** | N | CV | 60 | 62 | 58 | 44 | 53 | 33 | 33 | 28 | 17 | 25 |
| | X | SD | 14.1 | 8.8 | 13.4 | 5.8 | 14.2 | 4.7 | 14.2 | 4.0 | 13.7 | 3.5 |
| **BB*NZW** | N | CV | 122 | 41 | 113 | 31 | 108 | 28 | 60 | 27 | 39 | 28 |
| | X | SD | 16.3 | 6.6 | 14.8 | 4.6 | 14.8 | 4.2 | 15.2 | 4.1 | 14.5 | 4.0 |
| **BR*NZW** | N | CV | 174 | 52 | 153 | 40 | 135 | 32 | 47 | 26 | 31 | 27 |
| | X | SD | 14.7 | 7.7 | 14.1 | 5.7 | 14.2 | 4.5 | 15.3 | 3.9 | 14.6 | 3.9 |
| Total (Cr) Crosses | N | CV | 483 | 50 | 434 | 40 | 395 | 33 | 197 | 27 | 120 | 27 |
| | X | SD | 14.6 | 7.4 | 13.6 | 5.5 | 14.0 | 4.6 | 14.6 | 4.0 | 13.8 | 3.7 |
| **Overall (St+Cr)** | N | CV | 876 | 49 | 787 | 40 | 728 | 34 | 416 | 29 | 247 | 29 |
| | X | SD | 14.3 | 7.0 | 13.5 | 5.3 | 13.8 | 4.7 | 13.8 | 4.0 | 13.1 | 3.7 |

NZW = New Zealand White; BB = Baladi Black; BR = Baladi Red, St±Cr = straightbreds ± Crossbreds

**Means and coefficients of variation of uncorrected records:** Simple statistics of individual daily gain in weight traits are given in Table 1. Results of pure breeds and their crosses

(Table 1), reveal that means of daily gain in weight traits are approximately near those reported in the available Egyptian literature (Ahmed, 1997 Ali, 1998 and Abdel-Aziz, 1998), while they were lower than those reported in the Non-Egyptian literature (Brun and Ouhayoun, 1988 and Zimmermann et al., 1988). Coefficient of variability (CV%) of daily gain in weight traits (Table 1) ranged between 29 – 46% in case of pure rabbits; meanwhile it extended from 27 – 50% with impures. Estimates of CV% given in Table 1 showed a general trend indicating that daily gain in weights at weaning (6$^{th}$ wk. of age) had higher phenotypic variations than that at marketing (16$^{th}$ wk. of age).

**Month of birth** effect was found to be significant on daily gain in weight at different age stages (Table 2). Variations due to Month-of-birth effects could be attributed to differences in the prevailing ambient temperature from one month to another and/or the monstrous monthly environmental variations on weaning weight through the amount of milk secreted by the nursing does, on the quality and quantity of the ingested feeds, on the appetite of the growing rabbits as well as on feed utilization capability of these young. Least squares means (LSM) in Table 2 show that there was a general trend implying that rabbits born during November and December attained the highest figures meanwhile those born during April and May attained the lowest.

Table 2. Least squares means (gm) of factors affecting daily gain in weight during different periods from weaning (at 6 wk.) up to marketing (at 16 wk.) age.

| **Item** | Periods (weeks) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | 6-8 | N | 8-10 | N | 10-12 | N | 12-14 | N | 14-16 |
| Mating groups: | | **** | | **** | | **** | | ** | | * |
| NZW | 219 | 10.4±0.8 | 195 | 12.4±0.6 | 188 | 14.2±0.6 | 119 | 14.5±0.7 | 59 | 13.4±0.8 |
| BB | 102 | 13.0±0.9 | 91 | 12.6±0.7 | 83 | 14.1±0.7 | 57 | 14.4±0.7 | 32 | 14.0±0.9 |
| BR | 72 | 11.1±1.0 | 67 | 12.8±0.8 | 62 | 13.0±0.7 | 43 | 13.8±0.8 | 36 | 14.8±0.9 |
| NZW*BB | 127 | 10.2±0.9 | 110 | 11.3±0.7 | 99 | 12.4±0.7 | 57 | 11.5±1.1 | 33 | 12.0±1.1 |
| NZW*BR | 60 | 11.7±1.0 | 58 | 12.0±0.8 | 53 | 13.5±0.7 | 33 | 13.7±0.9 | 17 | 13.0±1.1 |
| BB*NZW | 122 | 15.3±0.9 | 113 | 15.1±0.7 | 108 | 15.5±0.7 | 60 | 15.7±0.7 | 39 | 15.3±0.7 |
| BR*NZW | 174 | 14.8±0.8 | 153 | 15.1±0.6 | 135 | 15.7±0.6 | 47 | 15.2±0.8 | 31 | 14.5±0.9 |
| Feed | | ***** | | ***** | | ***** | | ** | | ** |
| Pelleted | 392 | 13.7±0.7 | 335 | 14.2±0.6 | 311 | 15.1±0.5 | 247 | 14.8±0.6 | 147 | 14.8±0.6 |
| Crumbled | 484 | 11.0±0.8 | 452 | 11.8±0.6 | 417 | 13.0±0.5 | 169 | 13.4±0.7 | 100 | 13.0±0.8 |
| Month of birth: | | **** | | **** | | *** | | **** | | ** |
| November | 104 | 15.1±1.1 | 95 | 15.6±0.8 | 89 | 16.0±0.8 | 64 | 17.4±0.8 | 31 | 16.7±1.0 |
| December | 133 | 14.4±1.0 | 111 | 15.1±0.8 | 108 | 15.1±0.7 | 82 | 15.1±0.8 | 52 | 14.3±0.9 |
| January | 206 | 12.8±0.8 | 195 | 13.3±0.7 | 186 | 13.7±0.6 | 142 | 12.5±0.7 | 90 | 12.7±0.8 |
| February | 129 | 13.6±0.9 | 116 | 13.1±0.7 | 104 | 14.2±0.7 | 53 | 13.0±0.8 | 28 | 12.4±1.0 |
| March | 190 | 13.8±0.8 | 167 | 13.1±0.6 | 155 | 14.3±0.6 | 54 | 14.4±0.7 | 27 | 13.4±0.8 |
| April | 89 | 9.3±0.9 | 81 | 9.7±0.7 | 71 | 12.4±0.7 | 21 | 12.2±1.0 | 19 | 13.8±1.0 |
| May | 25 | 7.6±1.5 | 22 | 11.1±1.2 | 15 | 12.8±1.3 | | | | |
| Parity: | | ***** | | * | | **** | | Ns | | * |
| 1$^{st}$ | 425 | 13.9±0.8 | 382 | 14.1±0.6 | 363 | 15.4±0.6 | 245 | 14.5±0.6 | 146 | 14.7±0.6 |
| 2$^{nd}$ | 364 | 13.6±0.8 | 327 | 12.6±0.6 | 297 | 13.1±0.6 | 148 | 13.5±0.6 | 89 | 13.0±0.6 |
| 3$^{rd}$ | 87 | 9.7±1.0 | 78 | 12.4±0.8 | 68 | 13.8±0.7 | 23 | 14.3±1.0 | 12 | 13.8±1.3 |
| **Sex:** | | Ns | | Ns | | Ns | | Ns | | Ns |
| Male | 420 | 12.3±0.8 | 374 | 12.8±0.6 | 345 | 14.0±0.5 | 214 | 14.1±0.6 | 118 | 13.5±0.6 |
| Female | 456 | 12.4±0.7 | 413 | 13.3±0.6 | 383 | 14.2±0.5 | 202 | 14.1±0.6 | 129 | 14.2±0.7 |

† = Sire- breed is preceding the dam breed.

Ns = Not significant; * = Significant at (P ≤0.05); ** = significant at (P ≤0.01); *** = significant at (P ≤0.001); **** = significant at (P ≤0.0001).

**Parity** effect was found to be significant on daily gain in weights of rabbits at all studied age stages except from 12-14 wk. of age (Table 2). LSM, (Table 2) show a consistent trend for the effect of parity on daily gain in weight indicating that the 1$^{st}$ parity in general attained the heaviest figures followed in most cases by the 2$^{nd}$ one.

**Sex** differences in daily gain in weight (DG) of rabbits at all post-weaning studied age periods (Table2) didn't prove any significance. Ahmed, 1997 and Ali, 1998 showed no significant sex effect on DG of rabbits during most age intervals. LSM of DG in Table 2 show that females transcend, in general males at most age stages with a relatively small difference between them.

**Feed type:** Differences between the effects of crumpled and pelleted (Table 2) feed types on post-weaning daily gain in weights of rabbits was significant at all age stages. However, least squares means (Table 2) were in favor of pelleted feed type. However, judging from DG these results may claim that re-grinding of pelleted feeds for weaned and growing rabbits was not advantageous.

**Breed group** differences were generally significant for post–weaning daily gain in weight traits at various age stages (Table 2). In agreement with the present results, Ali, 1998 and Abdel-Aziz, 1998 with miscellaneous breed groups and crosses indicated that breed group effect on post-weaning daily gain in weight and up to variable age stages was generally significant. LSM in Table 2, revealed that values of the cross that sired by BB bucks (i. e. BB*NZW) at all age stages except at 10-12 wk. excelled those of other crossbred rabbits which genitored by BR or NZW males. However, figures of the crosses that sired by BR bucks (i. e. BR*NZW) were generally the second in ranking meanwhile those sired by NZW males were regularly of lower rank. These results may verify that using males from Baladi-black rabbits and females from NZW would be the strategy for the creation of locally produced broiler rabbit.

**Straight-bred differences:** Results given in Table 3 revealed that there wasn't a general trend of superiority ranking could be detected. However, though NZW rabbits surpassed both BB and BR ones for DG at 10-12 and 12-14 wk., BR attained this superiority at 8-10 and 14-16 wk. However, BB achieved the highest rank at 6-8wk. Likewise, the results also exhibit that BR were premium compared with BB though the difference between them was not significant at any age period studied. These data were not in agreement with most of the Egyptian studies dealing with crossing of native breeds of rabbits with exotic ones, which indicate a general superiority of exotic breeds against local ones. However, these differences were not significant except at 6-8 wk. of age.

**Heterotic effect:** The purpose of crossing, among others, is to produce superior crosses (i.e. make use of hybrid vigor), to improve fitness and fertility traits and to combine different characteristics in which the crossed breeds were premium. The magnitude of heterosis depends, from many impetus upon the directional dominance and the relative merit of the dominance variance (Falconer, 1989). Estimates of direct heterosis, calculated in units' (g.) and as percentage (%) for post weaning daily gain in weight traits, DG (Table 3) were in general higher for the cross between NZW and BR than for the cross between NZW and BB. A trend is also observed of diminution and change of sign of the heterosis through the fattening period.

**Direct additive effect:** Contrasts of direct additive effects were consistently the highest for BB and the lowest for NZW (Table 3). This means that paternity of BB rabbits is better than either NZW or BR ones. The superiority of BB as sires suggest that the use of this breed as a sire breed in crossbreeding programs including NZW would be beneficial in improving post-weaning DG traits.

**Maternal additive (breed) effect** (Table 3) on daily gain in weight was positive and the highest in case of NZW at all age periods. Linear contrasts show that NZW-dammed crosses excelled those mothered by Baladi rabbits. These results lead to state that does of NZW rabbits is better concerning their mothering ability on post weaning daily gain in weight traits of their progeny than Baladi breeds. Therefore, it may be recommended to use NZW does as a dam breed in crossing programs that include these breeds. However, these conclusion were in coincidence with many Egyptian ones (e.g. Abdel-Aziz, 1998).

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Table (3): Estimates of pure breed differences and cross breeding effects (direct heterosis, direct additive and maternal additive effect, MA) on weaning and post-weaning daily gain in weight up to 16 wk. of age (Linear function ‡ ± SE).

| ***Item*** | Age per weeks | | | | |
|---|---|---|---|---|---|
| | 6-8 | 8-10 | 10-12 | 12-14 | 14-16 |
| **Straight-bred differences:** | | | | | |
| New Zealand White vs. the rest | $-1.60 \pm 0.66^{*}$ | $-0.27 \pm 0.53^{Ns}$ | $0.66 \pm 0.48^{Ns}$ | $0.38 \pm 0.51^{Ns}$ | $-1.04 \pm 0.64^{Ns}$ |
| Baladi–Black vs. the rest | $2.18 \pm 0.77^{**}$ | $0.04 \pm 0.62^{Ns}$ | $0.46 \pm 0.57^{Ns}$ | $0.27 \pm 0.60^{Ns}$ | $-0.13 \pm 0.77^{Ns}$ |
| Baladi–Red vs. the rest | $-0.58 \pm 0.84^{Ns}$ | $0.23 \pm 0.67^{Ns}$ | $-1.12 \pm 0.62^{Ns}$ | $0.65 \pm 0.63^{Ns}$ | $1.17 \pm 0.69^{Ns}$ |
| New Zealand White vs. Baldi–Black | $-2.52 \pm 0.77^{***}$ | $-0.20 \pm 0.63^{Ns}$ | $0.14 \pm 057^{Ns}$ | $0.07 \pm 0.61^{Ns}$ | $-0.60 \pm 0.83^{Ns}$ |
| New Zealand White vs. Baldi-Red | $-0.67 \pm 0.87^{Ns}$ | $-0.33 \pm 0.69^{Ns}$ | $1.19 \pm 0.63^{Ns}$ | $0.68 \pm 0.65^{Ns}$ | $-1.47 \pm 0.72^{Ns}$ |
| Baladi–Black vs. Baladi-Red | $1.84 \pm 0.98^{Ns}$ | $-0.13 \pm 0.79^{Ns}$ | $1.05 \pm 0.72^{Ns}$ | $0.61 \pm 0.74^{Ns}$ | $0.86 \pm 0.88^{Ns}$ |
| **Cross breeding effect:** | | | | | |
| **Direct Heterosis contrasts:** ‡‡ | | | | | |
| NZW * BB Units | $1.05 \pm 0.60^{Ns}$ | $0.63 \pm 0.49^{Ns}$ | $-0.19 \pm 0.45^{Ns}$ | $-0.78 \pm 0.62^{Ns}$ | $-0.01 \pm 0.67^{Ns}$ |
| % | 8.97 | 5.04 | -1.34 | -5.40 | 0.07 |
| NZW * BR Units | $2.50 \pm 0.65^{Ns}$ | $0.93 \pm 0.52^{Ns}$ | $0.97 \pm 0.47^{*}$ | $0.34 \pm 0.63^{Ns}$ | $-0.36 \pm 0.83^{Ns}$ |
| % | 23.26 | 7.38 | 7.13 | 2.40 | -2.55 |
| **Direct additive:** ‡‡‡ | | | | | |
| New Zealand White (NZW). | -3.75 | -2.48 | -1.35 | -1.63 | -2.29 |
| Baldi –Black (BB). | $3.78 \pm 0.48^{***}$ | $1.52 \pm 0.68^{*}$ | $1.63 \pm 0.62^{**}$ | $2.51 \pm 0.88^{**}$ | $1.62 \pm 0.94^{Ns}$ |
| Baldi-Red (BR). | $-0.03 \pm 0.91^{Ns}$ | $0.96 \pm 0.72^{Ns}$ | $-0.28 \pm 0.67^{Ns}$ | $-0.88 \pm 0.87^{Ns}$ | $0.67 \pm 1.01^{Ns}$ |
| **Maternal additive:** ‡‡‡‡ | | | | | |
| New Zealand White (NZW). | 2.70 | 2.30 | 1.82 | 1.88 | 1.59 |
| Baladi –Black (BB). | $-2.33 \pm 0.66^{**}$ | $-1.49 \pm 0.53^{**}$ | $-1.33 \pm 0.49^{**}$ | $-2.33 \pm 0.80^{**}$ | $-1.70 \pm 0.82^{Ns}$ |
| Baladi-Red (BR). | $-0.37 \pm 0.70^{Ns}$ | $-0.81 \pm 0.56^{Ns}$ | $-0.49 \pm 0.52^{Ns}$ | $0.45 \pm 0.78^{Ns}$ | $0.11 \pm 0.91^{Ns}$ |

‡ Linear functions may deviate a bit from calculations based on least squares means due to rounding errors.

‡‡ Direct heterosis of any two reciprocal crosses (Units) = average of the two reciprocal crosses minus the mid parent value. Heterosis % = 100* (Heterosis, Units / mid parent).

‡‡‡ NZW direct additive estimate = - (BB direct additive estimate + BR direct additive estimate).

‡‡‡‡ NZW Maternal additive estimate = - (BB Maternal additive estimate + BR Maternal additive estimate).

Ns = Not significant; * = Significant at ($P \leq 0.05$); ** = significant at ($P \leq 0.01$); *** = significant at ($P \leq 0.001$); **** = significant at ($P \leq 0.0001$).