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# Estimation of crossbreeding components for growth traits in crossing Golden Montazah with White Leghorn chickens

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## ABSTRACT

A crossbreeding experiment was executed between the local strain of Golden Montazah (GM) and a standard breed of White Leghorn (WL). Data of 5029 chicks were produced by 79 sires and 441 dams from five genetic groups (two foundations of GM and WL, three crossbreds of GM x WL, $(GM \times WL)^2$ and $((GM \times WL)^2)^2$. Body weight of these chicks were individually recorded in grams at hatch (BW0), 4 (BW4), 8 (BW8), 12 (BW12) and 16 (BW16) weeks of age. Daily gains in weight (grams) during the age intervals of 0-4 (DG4), 4-8(DG8), 8-12(DG12) and 12-16(DG16) weeks were calculated. Single-trait animal model analysis was used to analyze the data of body weight and daily gain traits. Results showed that GM strain had superiority ($p<0.05$) in most of the studied traits compared to WL, except BW0. Averages of most of the traits studied in crossbreds were higher than purebreds. Percentages of direct additive effects were mostly negative and highly significant ($P<0.01$) and ranged from -14.29 to 2.51% for body weights and from -21.13 to 6.74% for daily gains in weight. Estimates of direct heterosis ($\mathbf{H^I}$) were positive and highly significant ($P<0.01$) for most of the traits studied. Percentages of $\mathbf{H^I}$ ranged from -12.18 to 17.87% for body weights and from 8.12 to 25.30% for daily gain traits. Estimates of maternal heterosis ($\mathbf{H^M}$) were negative and highly significant ($P<0.01$) for most of the traits studied. Percentages of $\mathbf{H^M}$ ranged from -8.93 to 5.36% for body weights and from -14.18 to 32.96% for daily gain traits. It is concluded that crossing of GM with WL are recommended to improve growth traits of chickens in Egypt.

**Key words: Crossbreeding effects, growth traits, direct additive effect, direct heterosis, maternal heterosis.**

## INTRODUCTION

Growth can be regarded as a direct fitness trait that increases productive efficiency and thereby decreases production costs. Crossing is one method that can improve growth performance in poultry. In Egypt, some authors **(Hanafi *et al.*, 1991; Mohamed, 1997; Nawar and Abdou, 1999; Sabri *et al.*, 2000; Afifi, *et al.*, 2002; Iraqi *et al.*, 2002)** crossed native breeds or strains of chicken with exotic adapted ones under Egyptian condations. Most of these reports evidenced that crossing local breeds with either local or exotic ones was associated with the existence of heterotic effects. Because native chicken breeds had high non-additive genetic variance (**Shebl *et al.*, 1990; Hanafi *et al.*, 1991; sabri *et al.*, 2000)**. This would encourage the Egyptian breeders to improve local breeds through crossbreeding.

Nowadays, we need more workers for crossing Egyptian native breeds with exotic ones to determine the superior breeds, gains in performance from complementary breed effects and heterosis and to develop the superior new breeds through selecting the best combination of several breeds. On the other hand, ignoring any source of variation (genetic or non-genetic effects) in the model would increase the sampling errors in genetic parameters (Dickerson, 1992). Some previous studies (**e.g. Hanafi *et al.*, 1977; Hanafi *et al.*, 1991; Mahamed, 1997**) ignored heterotic and purebred effects in the genetic model. This might increase bias in estimates of genetic parameters. Therefore, all sources of variations should be considered in the genetic model **(Harvey, 1979**).

The aims of this work were to estimate crossbreeding components (e.g. direct additive effects, direct and maternal heterosis, and direct recombination effect) for growth traits produced from crossing Golden Montazah strain with White Leghorn breed chickens, as the preliminary stage to produce a synthetic line of chickens under the hot climate conditions of Egypt.

## Materials and Methods

The experimental work of this study was carried out at the Poultry Research Farm, Department of Animal Production, Faculty of Agriculture, Benha University, Egypt during the period from March 2008 to October 2010.

### Breed of chickens used:

A local strain of chicken named Golden Montazah and a world breed of White Leghorn (reared in El-Takamoly chicken project, Egypt) were used. Golden Montazah

(GM) is a synthetic strain which has been developed in the Montazah Poultry Research Station, Alexandria Governorate, Egypt, from a cross between the Rhode Island Red and Dokki-4 chickens, using systems of breeding coupled with selection, for five generations (**Mahmoud *et al.*, 1974)**. The White Leghorn (WL) used in this study is characterized by weight of 2.5 kg for cocks and 2 kg for hens, early age at first egg (150 day), high food conversion efficiency rate of 3 kg feed: 1 kg eggs and egg production was up to 280 eggs per year.

***Breeding plan and management:***

One thousand five hundred eggs from the White Leghorn breed and 300 eggs from the Golden Montazah strain were chosen randomly. They came from El-Takamoly chicken project, Alazab, El-Fayoum Governorate, Egypt. These eggs were incubated and hatched in the laboratory of Poultry Research Farm, Department of Animal Production, Faculty of Agriculture, Benha University, Egypt. A total number of 18 cockerels and 180 pullets were chosen randomly from the Golden Montazah and White Leghorn strains, respectively. Each cock was mated with 10 hens housed in separately breeding pen to produce F1 crossbred (GM × WL), consequently inter-se matings were practiced for two generations to produce F2 with genetic structure of $(GM \times WL)^2$ and F3 with genetic structure of $((GM\times WL)^2)^2$. Also, purebreds from the two strains were produced. The pedigreed eggs from each individual breeding pen for the five mating groups (two foundations of GM and WL, three crossbreds of GM x WL, $(GM \times WL)^2$ and $((GM\times WL)^2)^2$ were collected daily for fifteen days and then incubated. The structures of data collected from all genetic groups are presented in Table 1.

**Table 1.** Number of sires, dams and their progenies used for the analysis of growth traits of purebred and crossbred groups.

| Genetic group[+] | Group of sire | Group of dam | No. of sires | No. of dams | Hatched chicks |
|---|---|---|---|---|---|
| WL × WL | WL | WL | 18 | 64 | 1002 |
| GM × GM | GM | GM | 8 | 51 | 775 |
| $F_1$, GM × WL | GM | WL | 18 | 103 | 1343 |
| $F_2$, $(GM\times WL)^2$ | F1 | F1 | 18 | 106 | 1011 |
| $F_3$, $((GM\times WL)^2)^2$ | F2 | F2 | 17 | 117 | 898 |
| Total | | | 79 | 441 | 5029 |

[+]*WL and GM = White Leghorn and Golden Montazah strains, respectively; the first letter denoted to the sire group*

On hatching day, chicks produced from all genetic groups were wing banded, then brooded on the floor and were grown in open houses up to 16 weeks of age. All chicks were medicated similarly and regularly and they were subject to the same managerial, hygienic and climatic conditions. During growing and rearing period, all chicks were fed *ad libitum* using diet containing 23% and 21% crude protein and 3200 and 2900 metabolizable energy kcal/kg during the period from hatch to 6 weeks and from 6 to 16 weeks of age, respectively.

### *Data and model analysis*

Individual body weight of 5029 chicks were recorded at hatch (BW0), 4 (BW4), 8 (BW8), 12 (BW12) and 16 (BW16) weeks of age. As well as, daily gains in weight (grams) for these chicks were calculated during the period from 0-4 (DG4), 4-8 (DG8), 8-12 (DG12) and 12-16 (DG16) weeks of age.

The data collected were analyzed using single-trait animal model, using the multiple-trait Derivative free restricted Maximum likelihood MTDFREML program (**Boldman *et al.*, 1995).** Firstly, data were analyzed using SAS program **(SAS, 2004)** to estimate the starting values of additive and residual variances to be used as prior values in the animal model analysis. The differences between means of genetic groups were tested ($P<0.05$) using **Duncan (1955)** test. The model used in matrix notation was as follows:

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

Where: y= n×1 vector of observation of the chicks, n = number of records; X= design matrix of order n×p, which related to the fixed effects of genetic group and year; b= p×1 vector of the fixed effects of genetic group (5 levels) and year (3 levels); $Z_a$= the incidence matrix relating records to the additive genetic effect of the chick; $u_a$= the vector of random additive genetic of the chick; $Z_c$= the incidence matrix relating records to random common environmental effect of chick; $u_c$= the vector of random common environmental effect of chicks; and e= n×1 vector of random residual effects.

### *Estimation of crossbreeding components*

The animal model methodology was used to solve the model and to obtain estimable functions allowing comparisons among the genetic groups and estimation of crossbreeding parameters **(Boldman *et al.*, 1995; Dickerson 1992**). An interesting point is to discuss the crossbreeding parameters that can be estimated given the crossbreeding structure of this experiment. There are five genetic groups and this means that five estimable function of crossbreeding parameters (Table 2) could be estimated, but if it is noted that the same parameters with the same coefficient are involved to explain F3 the number is reduce to four parameters. Some results show that the recombination loss ($R^I$) are negligible in many cases (**Khalil *et al*., 2004, Iraqi et al., 2012**) thus we can eliminate this parameter, reducing the estimation to the difference between direct additive effects ($D_{GM\text{-}WL}$) and maternal additive effects ($M_{GM\text{-}WL}$), the direct heterosis ($\mathbf{H^I}$) and the maternal heterosis ($\mathbf{H^M}$). However, the absence of reciprocal F1 increases the co-linearity between direct and maternal effects that makes difficult to separate estimation of both, consequently we will limit the estimation to $D_{GM\text{-}WL}$, $\mathbf{H^I}$ and $\mathbf{H^M}$.

**Table 2.** Relationship between estimable genetic group effect (computed as the differences to White Leghorn, WL, breed effect) and estimable crossbreeding parameters$^{++}$.

| **Genetic group**$^{+}$ | $\mathbf{D^I_{(GM-WL)}}$ | $\mathbf{M^I}$ | $\mathbf{H^I}$ | $\mathbf{H^M}$ | $\mathbf{R^I}$ |
|---|---|---|---|---|---|
| GM-WL | 1 | 1 | 0 | 0 | 0 |
| $F_1$-WL | 0.5 | 0 | 1 | 0 | 0 |
| $F_2$-WL | 0.5 | 0.5 | 0.5 | 1 | 0.5 |
| $F_3$-WL | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |

$^{+}$ Genetic groups as defined in Table 1
$^{++}$ $D^I$, difference between direct additive effects; $H^I$ = direct heterosis; $R^I$ = recombination loss; $M^I$ = difference between maternal additive effects; $H^M$ = maternal heterosis

## *Results and discussion*

### Actual means

Means presented in Table 3 showed that the GM strain was significantly better ($P<0.05$) in most of the body weight and daily gain traits compared to WL breeds. But WL strain was better in BW0 and DG 8-12 compared to GM strain. This may be due to genetic makeup of the two strains **(El-Labban, 2000). Khalil *et al.* (1999)** showed that differences in growth traits between White Leghorn and Saudi chickens were significant ($p<0.01$). **Iraqi *et al.* (2002)** reported that Matrouh (MA) strain had significantly heavier body weight traits than Mandara (MN) when crossed between them.

**Table 3:** Means and standard errors (SE) for growth traits in Golden Montazah (GM), White Leghorn (WL) and their crosses of chickens.

| Trait[+] | Genetic group | | | | |
|---|---|---|---|---|---|
| | **GM (N=775 with15.41%)** | **WL (N=1002 with 19.92%)** | **GM × WL (N=1343 with 26.71%)** | **$(GM\times WL)^2$ (N=1011 with 20.1%)** | **$((GM\times WL)^2)^2$ (N=898 with 17.86%)** |
| | **Mean ±S.E** | **Mean ±S.E** | **Mean ±S.E** | **Mean ±S.E** | **Mean ±S.E** |
| **Body weight traits:** | | | | | |
| BW0 | $33.3\pm0.13^b$ | $34.1\pm0.12^a$ | $29.6\pm0.10^d$ | $32.3\pm0.12^c$ | $33.3\pm0.12^b$ |
| BW4 | $221.4\pm1.92^c$ | $216.7\pm1.67^c$ | $250.8\pm1.47^a$ | $234.9\pm1.68^b$ | $230.6\pm1.74^b$ |
| BW8 | $601.6\pm4.90^b$ | $515.2\pm4.23^d$ | $640.9\pm3.74^a$ | $554.2\pm4.32^c$ | $544.2\pm4.40^c$ |
| BW12 | $977.3\pm8.25^{bc}$ | $914.4\pm7.13^d$ | $1121\pm6.25^a$ | $992.4\pm7.29^b$ | $963.9\pm7.26^c$ |
| BW16 | $1347\pm11.90^d$ | $1279\pm10.27^e$ | $1517\pm8.98^a$ | $1490\pm10.46^b$ | $1443\pm10.42^c$ |
| **Daily gain traits;** | | | | | |
| DG04 | $6.71\pm0.06^d$ | $5.51\pm0.05^e$ | $7.90\pm0.05^a$ | $7.23\pm0.06^b$ | $7.04\pm0.06^c$ |
| DG48 | $13.52\pm0.14^b$ | $10.65\pm0.12^d$ | $13.92\pm0.10^a$ | $11.34\pm0.12^c$ | $11.24\pm0.12^c$ |
| DG812 | $13.26\pm0.17^c$ | $14.14\pm0.15^d$ | $17.06\pm0.13^a$ | $15.43\pm0.15^b$ | $14.96\pm0.15^c$ |
| DG1216 | $13.26\pm0.21^d$ | $13.11\pm0.18^d$ | $14.23\pm0.16^c$ | $17.78\pm0.19^a$ | $17.09\pm0.19^b$ |

Means with same letters within each trait are not significantly different (P<0.05).

Crossbred means were superior (P<0.05) for most traits, probably due to genetic and non-genetic additive effects of genes. Comparing the three crossbreds, it is showed that F3, $((GM\times WL)^2)^2$, cross had superiority in means for most of the studied traits compared to the average of $F_1$ and $F_2$ crosses. **Afifi *et al.* (2002) and Iraqi *et al.* (2002)** found that crossbreeds were significantly (P<0.01) superior in means of growth traits compared to foundations.

## Crossbreeding components:

### Direct additive effect ($D^I_{(WL-GM)}$):

Estimates of $D^I_{(WL-GM)}$ and their percentages for body weights and daily gains are given in Table 4.

**Table 4:** Estimates of direct effects ($D^I_{(WL-GM)}$) and their percentages for body weight and daily gain traits in crossing of Golden Montazah and White Leghorn chickens.

| Traits | $(D^I)\pm SD$ | %[+] | Significance[++] |
|---|---|---|---|
| **Body weight (g):** | | | |
| BW0 | 0.84±0.18 | 2.51 | ** |
| BW4 | -4.60±2.54 | -2.08 | ns |
| BW8 | -85.45±6.47 | -14.29 | ** |
| BW12 | -61.37±10.90 | -6.31 | ** |
| BW16 | -68.37±15.71 | -5.07 | ** |
| **Daily gain (g):** | | | |
| DG04 | -0.19±0.07 | -2.84 | ** |
| DG48 | -2.83±0.18 | -21.13 | ** |
| DG812 | 0.89±0.22 | 6.74 | ** |
| DG1216 | -0.19±0.27 | -1.41 | ns |

[+] Percentages of $\mathbf{D^I}$ computed as {Estimate of $\mathbf{D^I}$ / (GMxGM + WLxWL)/2] x 100}.
[++] ns = non-significant; ** = p<0.01.

Estimates of $\mathbf{D^I}$ ranged from -85.45 to 0.84 grams for body weight traits and from 0.89 to -2.83 grams for daily gain traits. These results indicated that $\mathbf{D^I}$ effects were negative and significant (P<0.01) for all traits, except for BW0 and DG1216. The percentages of these estimates to mid-parents for the corresponding traits were ranged from -14.29 to 2.51% for body weights and 6.74 to -21.13% for daily gains. This reflects the negative direct additive effect of genes on growth traits in this work. **Afifi *et al.* (2002)** found that estimates of general combining ability were mostly negative and significant (p<0.01) and ranged from -17.75 to 30.30 grams for body weight traits. The same results are obtained by **Sabri *et al.* (2000)** and **Iraqi *et al.* (2002)** with crosses among exotic and native chicken breeds. In crossing of Saudi chickens with White Leghorn, **Khalil *et al.* (1999)** reported that percentages of $D^I$ ranged from 4.9 to 10.2% for body weights and from 3.5 to 14.6 % for daily gains in weight.

**Direct heterosis ($H^I$)**

Estimates of $H^I$ for growth traits presented in Table 5 revealed that heterosis estimates were positive and highly significant. The percentages of $H^I$ ranged from -12.18 to 17.87% (averaged 12.60%) for the body weights and from 8.12 to 25.30% (averaged 16.47%) for the daily gain traits. These results indicated that crossing GM with WL is associated with the existence of positive and high percentages of heterotic effects on most growth traits. This is an encouraging factor for the poultry breeders in Egypt to improve growth traits by crossing the foreign breeds with the local ones to get hybrid vigor in growth traits. **Iraqi *et al.* (2002)** found that crossbreds obtaind form crossing between local strain (Matrouh and Mandara) have positive and high magnitude of heterosis (average 30.6%) for body weight at different ages. Most reviewed studies showed that body weights of crossbred chickens at different ages were associated with positive heterotic effects for growth traits (**Sabri and Hataba, 1994; Khalil *et al.*, 1999; Sabri *et al.*, 2000).**

**Table (5):** Estimates of direct heterosis ($H^I$) and their percentages for body weight and daily gain traits in crossing of Golden Montazah and White Leghorn chickens.

| **Traits** | **$H^I$±SD** | **%$^+$** | **Significance$^{++}$** |
|---|---|---|---|
| **Body weight(g):** | | | |
| BW0 | -4.07±0.13 | -12.18 | ** |
| BW4 | 31.62±1.94 | 14.31 | ** |
| BW8 | 81.39±4.94 | 13.61 | ** |
| BW12 | 173.64±8.28 | 17.87 | ** |
| BW16 | 203.7±11.92 | 15.12 | ** |
| **Daily gain (g):** | | | |
| DG04 | 1.27±0.06 | 18.98 | ** |
| DG48 | 1.81±0.13 | 13.51 | ** |
| DG812 | 3.34±0.17 | 25.30 | ** |
| DG1216 | 1.09±0.21 | 8.12 | ** |

$^+$ Percentages of $\mathbf{H^I}$ computed as {Estimate of $\mathbf{H^I}$ / [(GMxGM + WLxWL)/2] x 100}.
$^{++}$ ** = P<0.01.

## Maternal heterosis *($H^M$)*

Estimates of maternal heterosis ($H^M$) in Table 6 were positive and highly significant for BW0, BW16, DG1216, but negative for BW8, BW12, DG48 (P<0.01) and BW4, DG04, DG48 (not significant). This indicated that maternal heterotic effects are important and ranged from low (2.96%) to moderate (-8.93%) magnitudes for body weights and from -14.18% to 32.96% for daily gain traits. No reports are available in the literature for maternal heterosis of growth traits in chickens to compare the obtained results.

**Table 6:** Estimates of maternal heterosis ($H^M$) and their percentages for body weight and daily gain traits in crossing of Golden Montazah and White Leghorn chickens.

| **Traits** | **$H^M$ ±SD** | **%$^+$** | **Significant$^{**}$** |
|---|---|---|---|
| **Body weight:** | | | |
| BW0 | 0.99±0.13 | 2.96 | *** |
| BW4 | -1.02±1.88 | -0.46 | ns |
| BW8 | -53.40±4.82 | -8.93 | ** |
| BW12 | -53.61±8.10 | -5.51 | ** |
| BW16 | 72.29±11.64 | 5.36 | ** |
| **Daily gain (DG)** | | | |
| DG04 | -0.08±0.06 | -1.19 | ns |
| DG48 | -1.90±0.13 | -14.18 | ** |
| DG812 | -0.06±0.16 | -0.45 | Ns |
| DG1216 | 4.42±0.20 | 32.96 | ** |

+Percentages of $\mathbf{H^M}$ computed as {Estimate of $\mathbf{H^M}$ / [(WL x WL + GM x GM)/2] x 100}.
$^{+++}$ ns = non-significant; ** = P<0.01.

## Conclusions

The Golden Montazah strain has higher growth traits than WL breed. Moreover, values and signs of individual (**$H^I$**) and maternal (**$H^M$**) heteroses along with the complementarity between Golden Montazah and WL breed (that is better in most body weight traits) justify the interest of crossing Golden Montazah strain with WL breed to produce the synthetic line named Benha line (B-line). Thus, the F3 crossbred which considered the B-line has showed similar performances in body weight and daily gain traits to the best purebred parent.

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