Effects on egg quality traits of crossing Egyptian Golden Montazah with White Leghorn chickens

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Abstract

A crossbreeding experiment was executed between an Egyptian strain of Golden Montazah (M) and a foreign breed of White Leghorn (L). Data on 996 pullets fathered by 79 sires and mothered by 441 dams produced from five genetic groups of M, L, ½M½L, $(½M½L)^2$ and $((½M½L)^2)^2$ were used to evaluate these genetic groups and to estimate the crossbreeding effects of direct additive effects ($D^I_{(M-L)}$), direct (H^I) and maternal heterosis (H^M) for some egg quality characteristics related to egg weight (EW), yolk weight (YW), albumen weight (AW), Haugh units (HU), shell weight (SW), egg shape index (ESI), albumen index (AI), yolk index (YI) and shell thickness (STH). Single-trait animal model analysis was used to analyze the data of these traits.

Results showed that eggs of crossbreds were generally better in egg quality traits than eggs in purebreds. Eggs of L breed were significantly better than M strain in most traits ($p<0.05$), while eggs of M strain were better in HU, ESI and STH compared to eggs of L breed. Eggs of $(½M½L)^2$ cross had the heaviest EW, AW, YW and SW compared to both ½M½L and $((½M½L)^2)^2$ crosses ($P<0.05$), while eggs of $((½M½L)^2)^2$ cross recorded the superiority in HU . Estimates of $D^I_{(M-L)}$ were significantly in favor of M chickens for EW, YW and SW; the percentages were in favor of M chickens by 3.9, 6.9 and 6.8 % relative to the mid-parents, respectively. The estimates were negatively in favor of L favorable for HU, ESI, AI and STH, but in favor of M by 0.5% for YI. Estimates of H^I were favourable and better for EW, AW, YW, SW, HU, AI and YI relative to the mid-parents. Estimates of maternal heterosis in actual units (H^M) were favourable for EW, AW, YW, SW, AI, YI and STH relative to the mid-parent.

Key words: additive effect, direct heterosis, genetic groups, maternal heterosis

Introduction

Monitoring of egg quality characters is considered as an important economic policy in egg production. Islam et al (2001) found that the external and internal egg quality traits of the breeds affecting performance differed among generations. Tumova et al (2007) showed that genotype significantly affected the egg shape index, yolk and albumen quality and yolk index. The genotype affects mainly egg weight and egg shell traits (Zita et al 2009). Also, yolk / albumen ratio is affected by breed or the strain within a breed (Curtis *et al* 1986). Whereas, Basmacioglu and Ergul (2005) reported that there was no significant effects of the genotype on egg shell percentage and thickness. Egg quality traits in indigenous breeds of chickens in Egypt were usually not subjected to intensive selection program and consequently, high additive and non-additive genetic variations appeared to have meaningful effects (Iraqi et al 2002, 2012). This could be an encouraging factor to cross these local strains together. However, the estimates of crossbreeding effects for egg quality traits in Egypt are scarce. Iraqi (2002) showed that direct heterotic effects were positive and low for most egg characteristics (e.g.1.5% for EW, 6.2% for AW, 0.5% for HU, and 1.8% for ESI), while negative estimates were recorded for YW (-5.2%), SW (-4.0%) and STH (-0.8%) in case of crossing Mandarah with Matrouh chickens.

The aims of this work were: (1) to evaluate genetic groups obtained from crossing chickens of Golden Montazah (M) with White Leghorn (L), and (2) to estimate the crossbreeding effects in such a program in terms of direct additive effects and direct and maternal heterosis using single-trait animal model analysis.

Materials and Methods

This experiment was carried out at the Poultry Research Farm, Faculty of Agriculture, Benha University, Egypt, during the period from March 2008 to October 2010.

Breeding plan and management

One thousand five hundred eggs from the White Leghorn breed and 300 eggs from Golden Montazah strain were chosen randomly from El-Takamoly chicken project, Alazab, El-Fayoum Governorate, Egypt. Golden Montazah (M) 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 eggs were incubated and hatched in the laboratory of Poultry Research Farm, 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 chickens, respectively. Each cock was mated with 10 hens housed separately in breeding pen to produce F_1 crossbred (½M½L), consequently inter-se mating was practiced for two generations to produce F_2 with a genetic structure of $(½M½L)^2$ and F_3 with a genetic structure of $((½M½L)^2)^2$. Also, purebreds from the two strains were produced. The pedigreed eggs of the two foundation strains of M and L and the three crossbreds of ½M½L, $(½M½L)^2$ and $((½M½L)^2)^2$ were collected daily for fifteen days and then incubated. The structure of data collected from all genetic groups is presented in Table 1.

Table 1: Number of sires, dams, pullets and eggs collected in different genetic groups used in analyzing egg quality traits

Genetic group+	Sire group	Dam group	No. of sires	No. of dams	No. of Pullets	No. of eggs collected
L × L	L	L	18	64	267	1918
M × M	M	M	8	51	160	1038
F1, ½M½L	M	L	18	103	180	1103
F2, $(½M½L)^2$	F1	F1	18	106	179	604
F3, $((½M½L)^2)^2$	F2	F2	17	117	180	1440
Total			79	441	966	6103

+L and M = White Leghorn and Golden Montazah strains, respectively; the first letter denoted to the sire group

On the hatching day, chicks produced from all genetic groups were wing-banded and reared in floor brooder, then transferred to the rearing houses. Chicks produced from all genetic groups were fed *ad libitum* on diet containing 21% protein and 2700 kcal/kg, 18% protein and 2700 kcal/kg, and 16% protein and 2700 kcal/kg during the periods of growing (from hatch up to 8 weeks of age), rearing (from 8-20 weeks of age) and laying (more than 20 weeks of age), respectively. At 18 weeks of age, cockerels and pullets were moved to the breeding pens. At 20 weeks of age, pullets were exposed to a lighting program of 17 hours/day during the laying period. All birds were treated and medicated similarly throughout the experimental period.

Data collected

Three consecutive eggs per month were collected from each hen in all genetic groups during the first 90- days and 120- days of egg laying to characterize some external and egg quality in terms of egg weight (EW), albumen weight (AW), yolk weight (YW), shell weight (SW), Haugh unit (HU), egg shape index (ESI), albumen index (AI), yolk index (YI) and shell thickness (STH). A total number of 6103 eggs collected from all genetic groups (Table 1), were weighed to the nearest gram using a sensitive electronic scale then the length and width of each egg were measured using a compass sensitive to 0.01 mm. Then, the eggs were broken within 24 hours on a table glass cover and heights of yolk and albumen were measured with a micrometer sensitive to 0.01 mm. The width of the yolk and albumen and the albumen length were measured using a compass sensitive to the nearest 0.01 mm. Yolk of each egg was separated from the albumen, then weighted in grams and expressed as a percentage relative to the egg weight. Shell of each egg was washed under slightly flowing water to remove the remains of albumen, and then dried in the open air for 24 hours. The shell and membrane were weighted together in grams for each egg and expressed as a percentage relative to the egg weight. Haugh unit was computed as: HU =100 log (H+ 7.37-1.7 $EW^{0.37}$), where H = albumen height (mm) and EW = egg weight (g). Also, egg shape index (ESI) was calculated as: ESI = (Egg width in mm/ egg length in mm) x 100. Yolk index (YI) was calculated as: YI = (Yolk height/ yolk diameter) x 100. Albumen index (AI) was calculated as:

AI= {Albumen height / ((Albumen length + Albumen diameter)/2)} x 100

Statistical analysis

The statistical analysis was performed using single-trait animal model of 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 and the differences between means of genetic groups were tested ($P<0.05$). The model used in matrix notation was as follows:

$$\mathbf{y} = Xb + Z_a u_{\mathbf{a}} + Z_p u_p + \mathbf{e}$$

Where: y= n×1 vector of observation of the hens, n = number of records; X= design matrix of order n×p, which related to the fixed effects of genetic group and year-month of laying; b= p×1 vector of the fixed effects of genetic group (5 levels) and month-year of laying (14 levels); Z_a= the incidence matrix relating records to the additive genetic effect of the hen; u_a= the vector of random additive genetic of the hen; Z_p= the incidence matrix relating records to random permanent environmental effect of the hen; u_p= the vector of random permanent environmental effect of the hen; and e= n×1 vector of random residual effects.

Estimation of crossbreeding effects

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 (Dickerson 1992; Boldman et al 1995). An interesting point is to discuss the crossbreeding parameters that can be estimated related to the crossbreeding structure of this experiment. In the present experiment, there were five genetic groups and this means that five estimable function of crossbreeding parameters (Table 2) could be estimated. Some results show that the recombination loss (R^I) are negligible in many cases (Khalil et al 2004). Thus, we can eliminate this parameter, reducing the estimation to the difference between direct additive effects

(D_{M-L}) and maternal additive effects (M_{M-L}), the direct heterosis (H^I) and the maternal heterosis (H^M). However, the absence of reciprocal F_1 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_{M-L}, H^I and H^M.

Table 2: Genetic groups and coefficients of the matrix relating genetic group means with crossbreeding parameters

Genetic group and generation+	$D^I_{(M-L)}$	M^I	H^I	H^M	R^I
M-L	1	1	0	0	**0**
F_1-L	0.5	0	1	0	**0**
F_2-L	0.5	0.5	0.5	1	**0.5**
F_3-L	0.5	0.5	0.5	0.5	**0.5**

+L and M = White Leghorn and Golden Montazah strains, respectively.
++ D^I= difference between direct additive effects; M^I = difference between maternal additive effects; H^I = direct heterosis; H^M = maternal heterosis; R^I = recombination loss.

Results and discussion

Genetic groups comparisons

Least-squares means presented in Table 3 showed that eggs of L breed were better than eggs of M strain in most egg quality traits. But, M strain was better in HU, ESI and STH compared to L breed. This may be due to genetic makeup of the two strains (El-Labban 2000). Eggs of crossbred hens were superior in most traits, probably due to genetic and non-genetic additive effects of genes.

Eggs of the F_2 cross of $(½M½L)^2$ had the heaviest egg weight, albumen weight, yolk weight and shell weight compared to both F_1 and F_3 crosses. This may be due to hybrid vigor obtained from individual heterosis (in F_1) and maternal heterosis (in F_2). For HU, eggs of ½M½L, $(½M½L)^2$ and

$((½M½L)^2)^2$ recorded 88.9, 78.6, and 89.2, respectively, i.e. eggs of F_3 cross had superiority in HU comparable to eggs of F_1 and F_2 crosses; indicating a good quality of albumen of the egg in F_3 cross.

Eggs of crossbreds were heavier in EW, AW, YW and SW than eggs of purebred parents. These results indicate that egg components were improved when Golden Montazah was crossed with White Leghorn chickens. The same results were obtained by Kosba et al (1981), El-Sisy (2001) and Iraqi (2002).

Table 3: Least-square means and their standard errors for egg quality traits in Golden Montazah (M), White Leghorn (L) and their crosses of chickens

Trait	Genetic group				
	M (N=1038)	**L (N=1918)**	**½M½L (N=1103)**	**$(½M½L)^2$ (N=604)**	**$((½M½L)^2)^2$ (N=1440)**
	Mean ±S.E	**Mean ±S.E**	**Mean ±S.E**	**Mean ±S.E**	**Mean ±S.E**
Egg component:					
EW (g)	44.0±0.14^a	45.7±0.10^c	47.7±0.14^b	49.4±0.19^a	47.7±0.12^b
AW (g)	24.2±0.10^d	25.6±0.07^c	27.2±0.09^b	28.1±0.13^a	27.5±0.08^b
YW (g)	14.4±0.06^c	14.5±0.04^{bc}	14.7±0.06^b	15.4±0.08^a	14.5±0.05^c
SW (g)	5.5±0.02^d	5.5±0.01^c	5.8±0.02^b	6.0±0.03^a	5.9±0.02^b
HU	94.1±0.80^a	90.2±0.59^b	88.9±0.78^b	78.6±1.05^c	89.2±0.68^b
Shape index:					
ESI (%)	78.1±0.01^a	76.2±0.01^b	76.4±0.01^b	76.8±0.006^{ab}	76.8±0.01^{ab}
AI (%)	5.7±0.01^d	6.7±0.01^c	8.2±0.01^a	7.4±0.008^b	8.1±0.01^a
YI (%)	37.0±0.01^d	40.9±0.01^c	44.0±0.01^a	40.8±0.01^c	42.6±0.01^b
Shell thickness:					
STH (mm)	0.30±0.01^a	0.27±0.01^c	0.28±0.01^b	0.27±0.01^c	0.28±0.01^b

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

Crossbreeding effects

Direct additive effect ($D^I_{(M-L)}$)

Estimates of $D^I_{(M-L)}$ and their percentages for egg quality components are given in Table 4. All estimates were significantly in favor of M chickens for EW, YW and SW, but not significant for AW. Percentages of $D^I_{(M-L)}$ were in favor of M chickens for traits of EW, AW, YW and SW relative to the mid-parents, respectively. While, the estimate of $D^I_{(M-L)}$ for HU was negatively significantly in favor of L chickens. This indicates that direct additive effects were moderate and/or high in magnitude for egg components traits when M was crossed with L chickens. Iraqi (2002)found that percentages of direct additive effects were low and ranged from 0.95 to 4.39% for egg components when Mandarah chickens was crossed with Matrouh.

Table 4: Estimates of direct additive effects ($D^I_{(M-L)}$) and their percentages for egg quality traits in crossing Golden Montazah chickens with White Leghorn

Trait	$D^I_{(M-L)}$ ±SE	%$^+$	Significance^{++}
Egg components:			
EW(g)	1.70±0.42	3.9	**
AW (g)	0.30±0.30	1.2	ns
YW(g)	1.0±0.18	6.9	**
SW(g)	0.37±0.07	6.8	**
HU	-9.37±2.35	-9.5	**
Shape index:			
ESI (%)	-0.015±0.017	-1.9	ns
AI (%)	-0.004±0.001	-8.0	*
YI (%)	0.002±0.004	0.5	ns
Shell thickness:			
STH (mm)	-0.006±0.003	-2.0	ns

+ Percentages of $D^I_{(M-L)}$ computed as {Estimate of D^I / (mid-parents] x 100}.
*++ ns = Non-significant; * = p<0.05; ** = p<0.01.*

Estimates of direct additive effects were in favor of L for ESI, AI, and STH, but in favor of M for YI (Table 4). This means that using Golden Montazah as a local strain and White Leghorn as a foreign breed could be used for improving egg quality traits in Egypt. These results are in agreement with findings of Kosba et al (1978) and Bordas et al (1996). Iraqi (2002) found thatpercentages of D^I effects were ranged from -0.1 to -2.9% for shell characteristics and -1.8 to 2.7% for shape indexes.

Direct heterosis (H^I)

Estimates of H^I presented in Table 5 were positive and highly significant for EW, AW, YW, SW, but negative and highly significant for HU. Iraqi (2002) found that percentage of heterotic effects ranged from -5.2 to 6.2 % for egg components.

Table 5: Estimates of direct heterosis (H^I) and their percentages for egg quality traits in crossing Golden Montazah with White Leghorn chickens.

Trait	H^I ±SE	%$^+$	Significance^{++}
Egg components:			
EW(g)	3.7±0.37	8.4	**
AW(g)	1.9±0.26	7.7	**
YW(g)	1.2±0.16	8.6	**
SW(g)	0.6±0.06	10.1	**
HU	-14.1±2.04	-14.3	**
Shape index:			
ESI (%)	-0.01±0.014	-1.6	ns
AI (%)	0.01±0.001	10	**
YI (%)	0.02±0.003	5.4	**
Shell thickness:			
STH (mm)	-0.001±0.003	-0.33	ns

+ Percentages of H^I computed as {Estimate of H^I / [(mid-parents] x100}.

*++ ns = Non-significant; ** = p<0.01.*

For shape indexes and shell thickness of egg, results in Table 5 showed that estimates of H^I were positive and highly significant for AI and YI, but negative and non-significant for egg shape index; indicating that direct heterotic effects are important and high in magnitude for egg components traits and albumen and yolk indices. Therefore, egg quality traits could be improved by crossing Golden Montazah with White Leghorn chickens. These results are in agreement with reports of Nawar and Abdou (1999) and Nawar and Bahie EL-Deen (2000). Iraqi (2002) found that percentages of heterotic effects ranged from 1.8 to 11.1% for shape indexes and -0.8% for shell thickness**.** Bordas et al (1996**)** found a significant direct heterosis for egg weight and shell thickness when crossed two lines of Rhode Island Red (P<0.05). Conversely, Ezzeldin and EL-Labban (1989) showed a negative heterosis estimate for shell thickness when Dandarawi was crossed with Silver Montazah chickens.

Maternal heterosis (H^M)

Estimates of maternal heterosis (H^M), and percentages of H^M relative to the mid-parent, were favourable and highly significant by for EW, AW, YW, SW, AI, YI and STH (Table 6). These results indicated that maternal heterotic effects are important. This means that maternal heterotic effects are still having an important effect on albumen index, yolk index and shell thickness traits. Therefore, this is an encouraging factor to advise the Egyptian poultry breeders to use crossbred dams in crossbreeding programs for improving egg quality traits. No reports are available for maternal heterosis on egg quality traits to compare with our results.

Table 6: Estimates of maternal heterosis (H^M) and their percentages for egg quality traits in crossing Golden Montazah and White Leghorn chickens

Trait	H^M ±SE	%$^+$	Significance^{++}
Egg components:			
EW (g)	1.11±0.31	2.5	**
AW (g)	1.65±0.22	6.8	**
YW (g)	-0.67±0.14	-4.7	**
SW (g)	0.16±0.05	2.9	**
HU	-0.01±1.71	-0.01	ns
Shape index:			
ESI (%)	-0.002±0.012	-0.2	ns
AI (%)	0.01±0.001	0.2	**
YI (%)	0.02±0.002	5.4	**
Shell thickness:			
STH (mm)	0.016±0.002	5.3	**

+percentages of H^M computed as {Estimate of H^M / [mid-parents] x 100}.
*+++ ns = Non-significant; ** = p<0.01.*

Conclusions

- Crossing Golden Montazah with White Leghorn was associated with existence of positive and high percentage of heterotic effects for individual and maternal heterosis on most traits of egg quality studied, i.e. egg components were improved when Golden Montazah was crossed with White Leghorn.

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