Estimation of crossbreeding parameters for egg production 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 White Leghorn (WL) strain-breed. Data on 996 pullets from 79 sires and 441 dams were produced for five genetic groups (two purebreds and three crossbreds). Crossbreeding effects (direct additive effects, direct and maternal heterosis, and direct recombination) for age traits (ASM) and body weight (BWSM) at sexual maturity, weight of the first egg (WFE), egg number (EN90D) and egg mass (EM90D) during the first 90-days, total egg number (EN120D) and total egg mass (EM120D) during the 120-days of laying, and rate of laying egg per day during 90 days (RL90D) and 120 days (RL120D) were estimated. Partial recording traits such as period (days) in which first ten eggs were laid (PF10E), egg mass for first ten eggs (EMF10E), egg number (EN2D/W) and egg mass (EM2D/W) for two days per week, egg number (EN1W/M) and egg mass (EM1W/M) for one week per month, as well as pause periods during 90 days (PP90D) and 120 days (PP120D) were also studied. Single-trait animal model analysis was used to analyze the data of egg production traits.

Results showed that WL strain had superiority in most of the studied traits compared to GM, but GM strain had significantly heavier BWSM and WFE than WL. Averages of most of the traits studied in crossbreds were higher than purebreds. Percentages of direct additive effects were mostly positive (P<0.01) and ranged from -3.0 to 12.5%, -9.9 to 7.2% and -11.2 to -11.6% for traits of egg production, partial recording for egg production and pause periods of egg laying, respectively. Estimates of direct heterosis (H^I) and maternal heterosis (H^M) were positive and highly significant (P<0.01) for most of the traits studied. Percentages of H^I and (H^M) were -2.8 and (-0.7), 14.5 and (-1.0), 4.6 and (2.4), 23.0 and (10.9), 29.2 and (10.7), 18.1 and (8.3), 21.7 and (9.1), 23.0 and (10.9) and 18.2% and (8.4%) for ASM, BWSM, WFE, EN90D, EM90D, EN210D, EM210D, RL90D and RL120D, respectively. Also, these percentages were -18.7 and (-6.6), 1.2 and (0.6), 6.0 and (8.7), 3.1 and (-2.0), 11.2 and (4.1) and 11.3% and (3.8%) for PF10E, EMF10E, EN2D/W, EM2D/W, EN1W/M and EM1W/M, respectively. While the percentages for pause periods were -18.0 and (-7.5) and -15.6% and (-7.0%) for PP90D and PP120D, respectively. This indicates that crossing between GM and WL are associated with existence of positive and high percentages of heterotic (direct and maternal) effects on all the egg production traits. On the bases of complementarity between GM (better in growth and WFE traits) and WL breed (better in most egg production traits), it is justify the interest of crossing GM strain with WL breed to produce the synthetic line named Benha line (B-line), which showed similar performances in egg production traits to the best purebred parent.

Key word: direct additive effect, direct heterosis, maternal heterosis, partial recording

Introduction

In the last twenty years, the poultry industry in Egypt, particularly chickens, depends mainly on some exotic breeds while our local breeds and/or strains are somewhat negligible. The local breeds are more adapted to the Egyptian conditions and are not subjected to intensive selection and consequently is expected they had high additive genetic variation. Accordingly, the improvement of the most economic traits in these breeds is quite possible. Moreover, some Egyptian studies (Sheble et al 1990 and Iraqi 2008) reported that most of the native breeds had high non-additive genetic variance and, therefore the possibility of improvement of these breeds through crossbreeding could be evidenced.

Egg production is a complex metric trait affected by the grow period of the pullet. The study of egg production and its related traits such as age and body weight at sexual maturity and rate of laying attracted the attention of several investigators who found that there were wide variations in these traits among different breeds of chickens (El-Soudany 2000 and Iraqi *et al* 2007). Partial recording of egg production in hens is used to increase the efficiency of genetic selection as well as to shorten the generation interval. Results of many investigators show that a high genetic gain could be obtained in egg production when using partial recording (El-Labban *et al* 1991 and EL-Labban *et al* 2011).

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

Materials and Methods

The experimental work was carried out at the Poultry Research Farm, Department of Animal Production, Faculty of Agriculture, Benha University, Egypt, started in March 2008 and finished in October 2010.

A local strain of chicken named Golden Montazah strain 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 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 F_1 crossbred (GM × WL), consequently inter-se matings were practiced for two generations to produce F_2 with genetic structure of $(GM \times WL)^2$ and F_3 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 pullets for genetic groups used in the experimental work

Genetic group+	Group of sire	Group of dam	No. of sires	No. of dams	No. of Pullets
WL × WL	WL	WL	18	64	267
GM × GM	GM	GM	8	51	160
GM × WL, F_1	GM	WL	18	103	180
$(GM\times WL)^2$, F_2	F1	F1	18	106	179
$((GM\times WL)^2)^2$, F_3	F2	F2	17	117	180
Total			79	441	966

+*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 and reared in floor brooder, then transferred to the rearing houses. Chicks produced from all genetic groups were fed ad libitum during growing (from hatch up to 8 weeks of age), rearing (from 8-20 weeks of age) and laying (more than 20 weeks of age) periods on diets containing 21% protein and 2700 kcal/kg, 18% protein and 2700 kcal/kg, and 16% protein and 2700 kcal/kg, 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.

Studied traits

The studied egg production traits were: age (ASM) and body weight (BWSM) at sexual maturity, weight of the first egg (WFE), egg number (EN90D) and egg mass (EM90D) during the first 90-days, total egg number (EN120D) and total egg mass (EM120D) during the 120-days of laying, and rate of laying egg per day during 90 days (RL90D) and 120 days (RL120D). Partial recording traits such as period (days) in which first ten eggs were laid (PF10E), egg mass for first ten eggs (EMF10E), egg number (EN2D/W) and egg mass (EM2D/W) for two days per week, egg number (EN1W/M) and egg mass (EM1W/M) for one week per month, as well as pause periods during 90 days (PP90D) and 120 days (PP120D) were studied.

Statistical analysis

The statistical analysis was carried out 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 guessed 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:

$$\mathbf{y} = Xb + Z_a u_{\mathbf{a}} + Z_c u_c \mathbf{+e}$$

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; 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 hen; u_a= the vector of random additive genetic of the hen; Z_c= the incidence matrix relating records to random permanent environmental effect of the hen; u_c= the vector of random permanent environmental effect of the hen; and e= n×1 vector of random residual effects.

Estimation of crossbreeding components

Table 2. Relationship between estimable genetic group effect (computed as the differences to White Leghorn, WL, breed effect) and estimable crossbreeding parameters[++].

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

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 F_3 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) thus we can eliminate this parameter, reducing the estimation to the difference between direct additive effects (D_{GM-WL}) and maternal additive effects (M_{GM-WL}), 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_{GM-WL}, H^I and H^M.

Results and discussion

Actual means

Means presented in Table 3 showed that the WL breed was significantly better ($p<0.05$) in most of the studied traits compared to GM strain. But GM strain was better in BWSM and WFE compared to WL breed. This may be due to genetic makeup of the two strains (El-Labban 2000).

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, F_3, $((GM\times WL)^2)^2$, cross had superiority in means for most of the studied traits compared to the average of F_1 and F_2 crosses. Mahmoud et al (1974), Nawar and Abdou (1999) and El-Sisy (2001), found that crossbreeding increased egg number and egg mass. Thus, one would recommended the poultry breeders in Egypt to use the GM x WL cross as egg production type chickens.

Table 3. Means and standard errors (SE) for egg production, partial recording and pause period traits in Golden Montazah (GM), White Leghorn (WL) and their crosses of chickens.

Trait^{+}	Genetic group^{++}				
	$((GM\times WL)^2)^2$ (N=180 with 18.6%)	$(GM\times WL)^2$ (N=179 with 18.5%)	GM × WL (N=180 with 18.6%)	WL (N=267 with 27.6%)	GM (N=160 with 16%)
	Mean ±S.E	Mean ±S.E	Mean ±S.E	Mean ±S.E	Mean ±S.E
Egg production traits					
ASM (days)	169±0.50^{a}	162±0.40^{bc}	158±0.49^{d}	161±0.49^{c}	163±0.49^{b}
BWSM (kg)	1.57±0.21^{c}	1.46±0.16^{d}	1.83±0.2^{a}	1.57±0.20^{c}	1.62±0.2^{b}
WFE (g)	27.9±0.18^{a}	26.1±0.14^{b}	28.3±0.17^{a}	27.9±0.17^{a}	28.1±0.17^{a}
EN90D (egg)	42.7±0.48^{e}	52.3±0.37^{d}	61.0±0.45^{a}	57.5±0.45^{b}	56.5±0.45^{c}
EM90D (kg)	1.81±0.25^{e}	2.28±0.19^{d}	2.78±0.24^{a}	2.50±0.24^{c}	2.55±0.24^{b}
EN120D (egg)	61.7±0.57^{e}	74.0±0.44^{d}	83.4±0.54^{a}	79.3±0.54^{b}	78.0±0.54^{c}
EM120D (g)	2.71±0.29^{e}	3.32±0.23^{d}	3.84±0.28^{a}	3.57±0.28^{c}	3.61±0.28^{b}
RL90D (%)	47.5±0.53^{e}	58.1±0.41^{d}	67.7±0.50^{a}	63.9±0.50^{b}	62.7±0.50^{c}
RL120D (%)	51.4±0.48^{e}	61.7±0.37^{d}	69.5±0.45^{a}	66.1±0.45^{b}	65.0±0.45^{c}
Partial recording					
PF10E (days)	28.0±0.35^{a}	21.1±0.27^{b}	16.8±0.33^{e}	19.7±0.33^{c}	18.7±0.33^{d}
EMF10E (g)	368±2.02^{a}	328±1.56^{c}	348±1.90^{b}	347±1.91^{b}	349±1.90^{b}
EN2D/W (egg)	17.3±0.14^{d}	19.5±0.11^{b}	20.2±0.13^{a}	19.0±0.13^{c}	19.2±0.13^{bc}
EM2D/W (g)	805±5.84^{d}	923±4.52^{a}	922±5.50^{a}	878±5.52^{b}	865±5.50^{c}
EN1W/M (egg)	15.4±0.13^{d}	17.8±0.10^{c}	19.1±0.13^{a}	18.2±0.13^{b}	18.3±0.13^{b}
EM1W/M (g)	700±5.57^{e}	825±4.31^{d}	880±5.25^{a}	834±5.26^{b}	846±5.25^{c}
Pause period					
PP90D (days)	46.0±0.49^{a}	33.7±0.38^{b}	27.9±0.46^{e}	31.4±0.46^{d}	32.5±0.46^{c}
PP120D (days)	57.3±0.57^{a}	42.0±0.44^{b}	36.3±0.53^{d}	39.6±0.54^{c}	41.8±0.53^{b}

$^{+}$ *Traits as defined in materials and methods*

$^{++}$*Genetic group as defined in Table (1)*

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

Crossbreeding components

Direct additive effect $D^{I}_{(GM\text{-}WL)}$

Results presented in Table 4 indicated that effects of $D^{I}_{(GM-WL)}$ on all egg production traits were mostly high, being 10.4% for EN90D, 12.5% for EM90D, 9.6% for EN120D, 10.6% for EM120D, 10.4% for RL90D and 9.8% for RL120D. All of these estimates were positive and highly significant (P<0.01), except for ASM and BWSM. This indicates that direct additive effect of genes on egg production traits in chickens were considerable and favored the WL chickens comparing with GM. This confirmed by Francesch *et al* (1997), Koerhuis *et al* (1996) and Iraqi (2008). Negative estimates of D^{I} for ASM in this study indicated that WL-hens gave an earlier ASM by 0.5% and a decrease in WFE by 3.0% (P<0.01). In this concern, Iraqi (2008) showed negative and not significant percentage of D^{I} (-0.79%) for ASM in cross of Mandarah and Matrouh. In addition**,** Khalil *et al* (2004) and Iraqi *et al* (2007) found that negative effects of D^{I} ranged from -1.9 to -16.2% for ASM trait (P<0.05 and P<0.01). On the other hand, Nawar and Abdou (1999), Khalil *et al* (2004) and Iraqi *et al* (2007) found positive and highly significant effects of D^{I} on traits of BWSM, WFE, TEN and TEM in chickens. In general, results in the present study indicated that egg production traits in local chickens in Egypt could be improved by crossbreeding.

Table 4. Estimates of direct additive effects (D^{I}) and their percentages for egg production, partial recording and pause period traits in crossing of Golden Montazah and White Leghorn of chicken.

Trait^{+}	D^{I}±SE	%$^{++}$	Significance^{+++}
Egg production traits			
ASM (days)	-0.8±0.6	-0.5	ns
BWSM (gram)	2.4±29	0.2	ns
WFE (gram)	-0.9±0.3	-3.0	**
EN90D (egg)	4.4±0.2	10.4	**
EM90D (gram)	228±9.8	12.5	**
EN120D (egg)	5.9±0.3	9.6	**
EM120D (gram)	290±13	10.6	**
RL90D	5.0±0.2	10.4	**
RL120D	5.0±0.4	9.8	**
Partial recording traits			
PF10E (days)	-2.8±0.5	-9.9	**
EMF10E (gram)	-23.1±3.2	-6.3	**
EN2D/W (egg)	0.5±0.3	3.0	**
EM2D/W (gram)	45.4±6.9	5.6	**
EN1W/M (egg)	0.8±0.2	4.9	**
EM1W/M (gram)	50.7±5.1	7.2	**
Pause periods			
PP90D (days)	-5.3±0.3	-11.6	**
PP120D (days)	-6.4±0.3	-11.2	**

$^{+}$ *Traits as defined in materials and methods*

$^{++}$ *Percentages of D^{I} computed as {Estimate of D^{I}/(GMxGM + WLxWL)/2] x 100}*

$^{+++}$ *ns = non-significant; ** = P<0.01*

Estimates of $D^{I}_{(GM-WL)}$ for partial recording traits of egg production presented in Table 4 showed that all effects were highly significant (P<0.01) and positive for all traits, beyond PF10E and EMF10E. Percentages of these estimates were -9.9% for PF10E and -6.3% for EMF10E. This indicates the period of first ten eggs was decreased by crossing. This trait is a good indicator for hens which characterized by high rate of laying in the early stages of production. Estimates of $D^{I}_{(GM-WL)}$ were 3.0, 5.6, 4.9 and 7.2% for EN2D/W, EM2D/W, EN1W/M and EM1W/M, respectively. Iraqi (2008) showed that effect of D^{I} were positive and significant (P<0.01) for egg mass of the first 10 eggs (2.5%), egg number for one week/month (16.2%), egg mass for one week/month (17.4%), egg number for two days/week (14.1%) and egg mass of two days/week (15.4%), but not significant for egg number of the first 10 eggs (0.14%) when crossed Mandarah with Matrouh chickens. Nawar and Abdou (1999) found that pullets sired by RIR were superior in egg weight than pullets sired by Fayoumi. In conclusion, method of recording based on one-week per month was higher in percentage of direct additive than two-days per week for egg number and egg mass traits (Table 4). These results are agreed with Iraqi (2008). Conversely, Obeidah *et al* (1962) reported that the method of recording for egg production traits based on two-days per week was better than one-week per month.

Results in Table 4 showed that pause period traits were significantly (P<0.01) affected by direct additive gene effects. Effect of $D^{I}_{(GM-WL)}$ was decreased the pause periods by 11.6 and 11.2% during the first 90- and 120-days of egg production, respectively. This indicates that egg production is increased by crossing WL and GM chickens. In this concern, Iraqi (2008) found that percentage of $D^{I}_{(GM-WL)}$ for pause period for more than five days was decreased by 54.28% during the first 90 days and by 33.07% during total period (210 days) of egg production when Mandarah chickens was crossed with Matrouh strain. While pauses for one and two days were increased by 2.42% and 3.94%, respectively during 90 days and total period (210 days) of egg production.

Direct heterosis (H^{I})

Estimates of H^{I} presented in Table 5 were highly significant and positive for all egg production traits, but negative for only ASM. Negative percentage of H^{I} (-2.8%) for ASM indicate that crossing of GM and WL chickens gave a decrease in age of the hen at first egg. Similarly, most estimates available in the literatures (Singh *et al* 2000; Khalil *et al* 2004; Iraqi *et al* 2007 and Iraqi 2008) gave an evidence for such negative estimate of H^{I} (ranging from -1.19 to -12.05) for ASM.

On the other hand, positive percentages of H^{I} were 14.5, 4.6, 23.0, 29.2, 18.1, 21.7, 23.0 and 18.0% for traits of BWSM, WFE, EN90D, EM90D, EN120D, EM120D, RL90D and RL120D, respectively (Table 5). These results indicate that crossing GM with WL is associated with existence of positive and high percentages of heterotic effects on all traits of egg production. These results are in agreement with those reported by many investigators for BWSM (Iraqi *et al* 2007 and Hassan, 2008), EN90D and EM90D (Kamali *et al* 2001; El-Soudany 2003), TEN and TEM (Bordas *et al* 1996 and Khalil *et al* 2004).

Table 5. Direct heterosis estimates (H^I) and their percentage for egg production, partial recording and pause periods traits in crossing Golden Montazah with White Leghorn chicken.

Trait[+]	D^I±SE	%[++]	Significance[+++]
Egg production traits			
ASM (days)	4.7±0.5-	-2.8	**
BWSM (gram)	231±24	14.5	**
WFE (gram)	1.3±0.22	4.6	**
EN90D (egg)	9.8±0.16	23.0	**
EM90D (gram)	531±8.1	29.2	**
EN120D (egg)	11.2±0.2	18.1	**
EM120D (gram)	596±11	21.7	**
RL90D	10.9±0.2	23.0	**
RL120D	9.4±0.4	18.2	**
Partial recording traits			
PF10E (days)	-5.2±0.5	-18.7	**
EMF10E (gram)	4.5±3.0	1.2	ns
EN2D/W (egg)	1.0±0.3	6.0	**
EM2D/W (gram)	24.8±5.6	3.1	**
EN1W/M (egg)	1.7±0.1	11.2	**
EM1W/M (gram)	79.0±4.4	11.3	**
Pause periods			
PP90D (days)	-8.3±0.3	17.9-	**
PP120D (days)	-9.0±0.3	-15.6	**

[+] *Traits as defined in material and methods*
[++] *Percentages of* H^I *computed as {Estimate of* H^I */ [(GMxGM + WLxWL)/2] x 100}*
[+++] *ns = non-significant; ** = P<0.01*

Results given in Table 5 showed that effects of H^I on all partial recording traits were highly significant and positive, but negative for PF10E and not significant for EMF10E. Estimate of H^I for PF10E was negative (-18.7%), indicating that crossing GM with WL chickens gave a decrease in the period of laying the first ten eggs (5.2 days). These results are in agreement with findings of Bordas *et al* (1996) and Hassan (2008).

On the other hand, percentages of H^I were 1.2, 6.0, 3.1, 11.2 and 11.3% for traits of EMF10E, EN2D/W, EM2D/W, EN1W/M and EM1W/M, respectively. These results indicate that crossing GM with WL is associated with the existence of positive and high percentages of heterotic effects on most partial recording traits, except EMF10E. This is an encouraging factor for the poultry breeders in Egypt to improve egg production traits by crossing the foreign breeds with the local ones. Iraqi (2008) found that effects of H^I for PF10E (-43.8) and EMF10E (-6.5) were highly significant and negative, but highly significant and positive for traits of EN2D/W, EM2D/W, EN1W/M and EM1W/M; the percentages were 29.7, 23.0, 24.2 and 21.4%, respectively.

Results in Table 5 showed that estimates of H^I for pause periods (in days) during the first 90- and 120-days were -17.9 and -15.6%, respectively. These effects were negative and highly significant. It means that the pause periods in crossbred hens are decreased due to direct heterosis in this study. Thus, the rate of laying is increased and consequently egg production is increased. Hassan (2008) showed that percentages of H^I were 140.8, -50.7, -95.0, -133.1, -156.3 and -171.9 % for pause period equals 1, 2, 3, 4, 5 and more than 5 days, respectively.

Maternal heterosis (H^M)

Estimates of maternal heterosis (H^M) given in Table 6 indicated that most of them were highly significant and positive and ranged from low (2.4% for WFE) to high (10.9% for EN90D) in magnitude for all the studied traits of egg production, except ASM and BWSM that were negative and non-significant. Percentages of H^M were -0.7, -1.0, 2.4, 10.9, 10.7, 8.3, 9.1, 10.9 and 8.4 for ASM, BWSM, WFE, EN90D, EM90D, EN120D, EM120D, RL90D and RL120D, respectively. This reflects the importance and magnitude of maternal heterosis effects on egg production traits (especially for egg number and daily rate of laying during the first 90-days of production) in the present study. Khalil *et al* (2004) found that percentage of maternal heterosis were negative and highly significant (-16.4%) for age at sexual maturity, but positive and highly significant (19.1 and 12.3%) for egg number at 90 days and annual egg production when crossing Baladi Saudi with White Leghorn chickens in Saudi Arabia.

Results in Table 6 showed that percentages of H^M were -6.6, 0.6, 8.7, -2.0, 4.1 and 3.8% for traits of PF10E, EMF10E, EN2D/W, EM2D/W, EN1W/M and EM1W/M, respectively. These estimates were ranged from low to high. All effects of H^M on the studied partial recording traits were highly significant and mostly positive, but not for EMF10E. This indicates that the crossbred hens were superior in the period of first ten eggs and egg number for two days per week compared to the founders. The superiority of crossbred hens was 1.8 days and 1.5 eggs for these traits, respectively. This means that the rate of laying for hens-mothered by crossbred dams was increased. In general, estimates of H^M on most partial recording traits in this study were highly significant and in favor of hens-mothered by crossbred dams. Similarly, Nawar and Abdou (1999) concluded that pullets mothered by Fayoumi chickens were superior to those mothered by Rohde Island Red.

Table 6. Estimates of maternal heterosis (H^M) and its percentages for egg production, partial recording and pause periods traits in crossing Golden Montazah with White Leghorn chickens

Trait[+]	D^I±SE	%[++]	Significance[+++]
Egg production traits			
ASM (days)	1.2±0.5-	-0.7	**
BWSM (gram)	-15.4±22	-1.0	ns
WFE (gram)	0.7±0.2	2.4	**
EN90D (egg)	4.7±0.1	10.9	**
EM90D (gram)	194±7.4	10.7	**
EN120D (egg)	5.1±0.2	8.3	**
EM120D (gram)	247±9.9	9.1	**
RL90D	5.2±0.2	10.9	**
RL120D	4.3±0.3	8.4	**
Partial recording traits			
PF10E (days)	-1.8±0.4	-6.6	**
EMF10E (gram)	2.2±2.9	0.6	ns
EN2D/W (egg)	1.5±0.2	8.7	**
EM2D/W (gram)	-15.9±5.1	-2.0	**
EN1W/M (egg)	0.6±0.1	4.1	**
EM1W/M (gram)	26.3±4.0	3.8	**
Pause periods			
PP90D (days)	-3.4±0.3	-7.5	**
PP120D (days)	-4.0±0.2	-7.0	**

[+] *Traits as defined in material and methods*
[++] *Percentages of H^I computed as {Estimate of H^I / [(GMxGM + WLxWL)/2] x 100}*
[+++] *ns = non-significant; ** = P<0.01*

Results in Table 6 showed that estimates of H^M for pause periods (in days) during the first 90- and 120-days were -7.5 and -7.0%, respectively. These effects were negative and highly significant (P<0.05). It means that the pause periods in crossbred hens are decreased due to maternal heterosis in this study. Thus, the rate of laying was increased and consequently egg production was increased.

Conclusion

- 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 egg production traits) justify the interest of crossing Golden Montazah strain with WL breed to produce the synthetic line named Benha line (B-line). Thus, the F_3 crossbred which considered the B-line has showed similar performances in egg production and egg quality traits to the best purebred parent.

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Received 4 January 2012; Accepted 4 March 2012; Published 2 April 2012

Go to top