Egypt. Poult. Sci. Vol. (43) (I): (109-125) (2023) (2211-1227)

Egyptian Poultry Science Journal

http://www.epsj.journals.ekb.eg/

ISSN: 1110-5623 (Print) – 2090-0570 (Online)

HETEROTIC COMPONENTS FOR AGE AT FIRST EGG, EGG PRODUCTION, SOME PARTIAL EGG RECORDS, CLUTCH SIZES AND PAUSE DURATION IN CROSSING FOUR EGYPTIAN STRAINS OF CHICKENS

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Received: 12/12/2022 Accepted: 06 /03/2023

ABSTRACT: Four synthetic strains of chickens, including Matrouh (MT), Mandarah (MN), Silver Montazah (SM) and Inshas (IN), were used in a crossbreeding experiment for four years to estimate direct additive genetic effects (G^I), maternal effects (G^M), direct heterosis (H^I) and maternal heterosis (H^M) for age and weight of hen at the first egg, weight of the first egg, egg number and mass for the first 10 eggs, egg number and mass during 90 and 120 days of egg production, egg number and mass for two days per week of production, egg number and mass for one week per month of production and clutch sizes and pause durations during 90 and 120 days of egg production. The egg production traits were recorded for a total of 747 sexually mature hens belonging to the different genetic groups. A total of 34 sires and 230 dams from MT chickens, 32 sires and 199 dams from MN chickens were used to produce 2894 chicks of the parental generation of MN and MT. In crossbreeding generations, two-way crossbreds (653 chicks of ½MN½MT and ½MT½MN) and three-way crossbreds (809 chicks of ½IN¼MN¼MT and ½SM¼MT¼MN) were produced. The estimates of G^I on all egg traits studied were significantly in favour of MN strain (P≤0.01). Also, the estimates of G^M were significantly in favour of MN dams for age at first egg, most egg production traits and clutch sizes, while the estimates for pause durations were in favor of MT dams. Estimates of H^I were significant with favorable heterotic rates ranging from 3.8 to 28.5 % for maturity of hen at the first egg, 19.7 to 29.3 % for egg production and 3.2 to 36.1 % for partial egg recording (P≤0.05 or P≤0.01). The percentages of H^I were favorably positive for all clutch sizes (ranging from 13.1 to 57.4 %; P≤0.01), while they were favorably negative for all pause durations (ranging from -17.3 to -44.2 %; P≤0.01). The percentages of H^M were favorable with heterotic rate of -2.6 % for age at the first egg (P≤0.05) and 7.8 to 8.2 % for egg production (P≤0.01). The heterotic maternity was favorably positive and ranging from 3.2 to 10.5 % for four traits of partial egg recording (P≤0.05) and 4.6 to 15.5 % for most clutch sizes (P≤0.05 or P≤0.01), while they were favorably negative for all pause durations (-5.0 to -31.8 %; P≤ 0.05 or ≤ 0.01).

Keywords: Egyptian chickens, crossbreeding effects, egg production, clutch sizes.

INTRODUCTION

Crossbreeding is one of the methods used by poultry breeders in developing countries to take advantage of the genetic heterogeneity characterizing the local breeds of chickens. The major goal of crossing is to create superior crosses that will enhance the performance of native chickens and combine various breed characteristics to establish crosses with beneficial performance for egg production (Saadey *et al*., 2008; Lalev *et al.,* 2014; El-Tahawy, 2020; El-Tahawy and Habashy, 2021). In Egypt, the local strains of chicken that had high additive and non-additive genetic variations are reported by many investigators (e.g. Iraqi, 2008; El-Attrouny, 2011; Iraqi *et al*., 2012, 2013; El-Tahawy, 2020; El-Tahawy and Habashy, 2021). However, significant estimates of direct and maternal effects for maturity age and weight at the first egg, weight of the first egg, egg numbers and masses, partial egg recording, clutch sizes and pause duration are cited by several investigators (e.g. Nawar and Abdou, 1999; Szydlowski and Szwaczkowski, 2001; Szydlowski *et al*,. 2001; Khalil *et al.,* 2004; Iraqi *et al.*, 2007; Hassan, 2008; Iraqi, 2008; El-Attrouny, 2011; El-Tahawy, 2020; Soliman *et al.,* 2020; El-Tahawy and Habashy, 2021). In general, there were noticeable heterotic impacts on characteristics related to egg production when Egyptian breeds and/or strains of chickens were crossed (Iraqi *et al.,* 2007, 2012; Saadey *et al.*, 2008; El-Tahawy, 2020; Soliman *et al.,* 2020). The percentages of direct and maternal heterosis obtained in the Egyptian and non-Egyptian studies for maturity age and hen weight at the first egg, weight of the first egg, egg numbers and masses, partial egg recording, clutch sizes and pause durations were high and significant (Merat *et al.*, 1994; Zatter, 1994; El-Hanoun, 1995; Nawar and Abdou, 1999; Ledur *et al.,* 2000; Kamali and Horn, 2001; Kamali *et al.,* 2001; Chen *et al.*, 2002; El-Soudany, 2003; Iraqi *et al.*, 2007; El-Attrouny 2011; El-Tahawy, 2020; Soliman *et al.*, 2020). However, using partial egg recording and clutch sizes in pullets' selection could increase the efficacy of genetic selection and shortening the generation interval and consequently increasing the genetic gain in egg production and clutch sizes (El-Labban *et al.,* 2011; EL-Attrouny, 2011; El-Tahawy and Habashy, 2021). Unfortunately, there is little evidence in Egyptian studies available about the impact of crossbreeding on egg production traits, such as partial egg recording, clutch sizes and pause durations (e.g., Hassan, 2008; El-Labban *et al.,* 2011; Iraqi *et al.,* 2012; El-Attrouny *et al.,* 2019). So, the main objectives of the current study were: (1) to estimate crossbreeding effects of direct additive genetic effects, maternal effects, direct heterosis and maternal heterosis on age of hen at the first egg, egg production, partial egg recording, clutch sizes and pause durations, and (2) to decide which of the Egyptian strains could be used as a sire-strain or as a dam-strain in chickens crossbreeding programs in Egypt.

MATERIALS AND METHODS

Crossbreeding experiment performed

A three-way crossbreeding experiment was performed between four local pedigreed strains of chickens named as Mandarah (MN; Abd-El-Gawad, 1981), Matrouh (MT; Mahmoud *et al*., 1974a), Inshas (IN; Bakir *et al*., 2002) and Silver Montazah (SM; Mahmoud *et al*., 1974b). Two-way crossbreds (½MN½MT and its reciprocal cross ½MT½MN) and three-way crossbreds (½IN¼MN¼MT and ½SM¼MT¼MN) were obtained. These four years experimental work (starting from February 2013 and terminated in 2016) were carried out in the Poultry Breeding Research Station at Inshas, Animal Production Research Institute (APRI), Agricultural Research Center, Ministry of Agriculture, in cooperation with Department of Animal Production, Faculty of Agriculture at Moshtohor, Benha University, Egypt. The egg production traits were recorded for a total of 747 sexually mature hens belonging to the different genetic groups. A total number of 34 cocks and 230 hens from MT strain and 32 cocks and 199 hens from MN strain were randomly chosen to be the sires and dams to produce about 2894 chicks of the parental generation. In the first generation of crossbreeding, 16 MT cocks and 71 MN hens and 17 MN cocks and 96 MT hens were used to produce 653 crossbred chicks of ½MN½MT and ½MT½MN. In the second generation of crossbreeding, 90 crossbred hens of ½MT½MN were artificially inseminated from fresh semen of 14 SM cocks to produce 578 three-way crossbred chicks (½SM¼MT¼MN), while 61 crossbred hens of ½MN½MT were artificially inseminated from fresh semen collected from 11 cocks of IN strain to produce 231 three-way crossbred chicks (½IN¼MN¼MT). The fresh semen was diluted with saline as 1:1 (1 saline: 1 semen), and each hen was inseminated with 0.2 *ml* of the diluted semen. The pedigreed eggs produced from the six mating groups were daily collected for ten days and incubated thereafter. The genetic groups produced, and number of sires, dams and chicks used in this experiment are described in Table 1.

Management practiced

The hatched chicks were wing-banded and reared in floor brooder, then transferred to the rearing houses. In the laying period, the pullets of parents were transferred to individual cages. The birds produced were fed *ad-libitum* during rearing, growing, and laying periods on diets containing 20.4, 16 and 16.5 % crude protein, 3.2, 3.9 and 4.4 % crude fiber, and 2950, 2850 and 2700 *kcal/kg* of Metabolizable energy, respectively. The feed requirements were supplied according to NRC (1994). The pullets were exposed to light for 17 hours per day from 22 weeks of age up to the end of the experimental period of egg production. All the birds were treated and similarly medicated throughout the experimental period, and they were housed under the same managerial, hygienic and climatic conditions.

Data and models of analysis

Records of 747 hens from six genetic groups (MT, MN, ½MN½MT, ½MT½MN, ½IN¼MN¼MT and ½SM¼MT¼MN) were collected to analyze genetically the following traits: age and weight of the hen at the first egg, weight of the first egg, egg number and mass for the first 10 eggs, number and egg mass recorded during the first 90 and 120 days of egg production, egg number and mass for two days of production per week, egg number and mass for one week of production per month and clutch sizes and pause durations during 90 and 120 days of egg production. To estimate the variance components of random effects and heritabilities, the VCE6 software was used (Groeneveld *et al.*, 2010).

$$y = X\beta + Z_a u_a + e$$

where: y = vector of observation on the hen; β = vector of the fixed effects of genetic groups (six groups); u_a = vector of random effects of the hen (additive genetic); X is the incidence matrix of the fixed effects; Z_a is the incidence matrix of the additive genetic effects; e = vector of random residual effects.

Estimation of crossbreeding effects

The coefficients (Table 2**),** relating the genetic crossbreeding effects to the solutions of the genetic groups were used to detect the differences between the strains in terms of direct additive genetic effects (G^I), maternal effects (G^M), direct heterosis (H^I) and maternal heterosis (H^M). Thus, four parameters were estimated according to Dickerson (1992), Wolf (1996) and Misztal *et al*. (2014):

$$b = [(G^I_{MN} - G^I_{MT}) \quad (G^M_{MN} - G^M_{MT}) \quad H^I \quad H^M]$$

The solutions of $\boldsymbol{b}$ were calculated by the method of generalized least squares (GLS) using the following equation: $\hat{b} = \left(X\acute{V}^{-}X\right)^{-1} XV^{-}y$ where X was the matrix of coefficients of estimable crossbreeding effects (Table 2), V^{-} = the inverse of generalized variance covariance matrix error, with the variance covariance matrix of $\boldsymbol{b}$ being: $Var\,\hat{b} = \left(X\acute{V}^{-}X\right)^{-1}$. The matrix in Table 2 was also used to test the significance of the crossbreeding effects.

RESULTS AND DISCUSSION

Direct additive effects (G^I)

The generalized least square solutions given in Table 3 indicate that direct additive effects for maturity of hen at the first egg, egg production and partial egg recording were mostly significant (P≤0.01), being favorable for MN strain by -4.0 % (-6.2 *d*) for AFE, 9.1 % (120 *g*) for BWFE, 5.4 % (2.4 *egg*) for EN90, 4.4 % (88 *g*) for EM90, 3.6 % (2.3 *egg*) for EN120, 2.5 % (71 *g*) for EM120, -11.1 % (-1.7 *d*) for PF10E, 3.9 % (0.7 *egg*) for EN2DW, 6.2 % (0.8 *egg*) for EN1WM and 1.9 % (11.6 *g*) for EM1WM, i.e. maturity of hen at the first egg and egg production traits of Egyptian chickens could be improved by crossbreeding. The negative estimates for AFE and PF10E indicate that MN hens reported earlier AFE and a reduction in laying period of the first ten eggs, i.e. an excellent indication for hens with a high rate of laying in the early stages of egg production is PF10E. Khalil *et al*. (2004) and Iraqi *et al*. (2007) found that direct effects on AFE were mostly significant and ranged from -1.9 to -16.2 % (P≤0.05 or P≤0.01). El-Tahawy (2020) in crossing local Sinai with Alexandria chickens reported that the estimates of direct effects were in favour of Alexandria chickens by 5.0 *d* for AFE, 19.6 *egg* for EN90 and 725 *g* for EM90. Soliman *et al*. (2020) reported that the estimates of direct additive effects in crossing Alexandria with Lohmann strains were significant for ASM, EN90, EW90 and EM90 traits. In crossing Sinai (SI) with Lohmann Brown (LB) chickens, El-Tahawy and Habashy (2021) found that the direct effects were significantly in favour of LB breed for AFE and PF10E, while the estimates were significantly in favour of LB chickens for EN90, EW10, EW90 and EM90 traits.

The direct effects on clutch sizes were in favour of MN strain for clutches containing more than five eggs during the first 90 days (-8.9 %) and 120 days (-23.4 %) of egg laying, while the estimates were insignificantly lower in clutches containing less than five eggs during the same periods of egg production (-2.5, -3.5, -1.6 and -6.8 % for CS190, CS390, CS1120 and CS3120, respectively; Table

4), i.e. MN chickens showed a drop in clutches with less than five eggs and an increase in clutches with more than five eggs during the first 90 and 120 days of egg production. Hassan (2008) reported similar trend of direct effects on clutch size of the same strains of MN and MT and their cross of ½MN½MT**.**

The negative estimates of direct effects for pause durations were significantly in favour of MN hens during the first 90 and 120 days of egg production (Table 4). The negative estimates indicate that MN hens are favorably characterized in pause durations relative to MT hens by 12.3 % (1.6 *d*) for PD190, 26.6 % (1.4 *d*) for PD590, 31.1 % (1.1 *d*) for PD1120 and 26.2 % (1.4 *d*) for PD5120, respectively. Similarly, Iraqi (2008) when crossing MN with MT chickens found that the estimates of direct effects for pause durations were in favour of MN chickens by 54.2 % for pauses of more than five days during the first 90 days and by 33.0 % during the initial 210 days of egg production, while the pauses for one and two days were in favour of MT by 2.4 and 3.9 % during the first 90 and 210 days of egg production, respectively. Also, El-Attrouny (2011) in crossing Golden Montazah with White Leghorn found that direct effects were in favour of White Leghorn with a decrease in the pause duration by 11.5 and 11.1% during the first 90 and 120 days of egg production, respectively.

Maternal effects (G^M)

The solutions of maternal effects and their percentages for maturity of hen at the first egg, egg production and partial egg recording indicated that most of the solutions were significantly in favour of MN dams relative to MT dams by -2.9 % (-4.5 *d*), 8.6 % (114 *g*), 3.8 % (1.5 *g*), 5.8 % (2.6 *egg*), 6.8 % (136 *g*) and 3.3 % (92 *g*), 10.8 % (1.7 *d*), 3.0 % (25 *g*) and 10.8 % (16 *g*) for AFE, BWFE, WFE, EN90, EM90, EM120, PF10E, EM2DW and EM1WM, respectively ($P \leq 0.05$ or $P \leq 0.01$; Table 5). Hassan (2008) using the same crossbreeding scheme reported estimates of maternal effects to be in favour of MT chickens by 4.2, 4.6, 3.8 and 3.5 % for BWFE, EN90, EM90 and EN210, respectively. Khalil *et al*. (2004) in crossbreeding experiment involving White Leghorn and Baladi Saudi chickens found that the percentages of maternal effects were significantly in favour of White Leghorn by 1.9 % for AFE, 36.4 % for EN90 and 26.5 % for annual egg production ($P \leq 0.01$). El-Tahawy (2020) in a crossbreeding experiment involving Sinai and Alexandria chickens, reoprted significant estimates of maternal effects in favour of Alexandria chickens by 10.6, 12.4 and 53 % for AFE, EN90 and EM90, respectively ($P \leq 0.0001$). Soliman *et al*. (2020) reported that the estimates of maternal effects were significant and in favour of Alexandria chickens for ASM, and insignificant for EN90, EW90 and EM90 traits. El-Tahawy and Habashy (2021) showed that the maternal effects were significantly in favour of LB dams for EW90, but the estimates for AFE, PF10E, EN90, EW10 and EM traits were insignificant. Assefa *et al*. (2021) observed significant estimates for maternal effects on age at first egg in crossing Fayoumi with White Leghorn chickens.

The solutions of maternal effects for clutch sizes were favorable by 10.1, 12.2, 15.4 and 40.2 % for CS390, CS590, CS3120 and CS5120 in pullets mothered by MN dams, respectively ($P \leq 0.05$; Table 6). On the other hand, the estimates were significantly in favor of pullets mothered by MT dams for pause durations, where the estimates were moderately favorable by -17.6, -13.4 and -28.5 % for the pauses during the first 90 days and -25.6, -32.2 and -30.6 % for the pauses during the initial 120 days of egg production. A similar trend was observed by Hassan (2008) who reported that hens mothered by MT dams were superior in pause durations relative to those mothered by MN dams. This concept of maternal effects notified for clutch sizes and pause durations indicate that crossbreeding could increase the clutch sizes with the decrease in pause lengths and consequently improving egg production in the Egyptian chickens (Iraqi *et al*., 2007; Hassan, 2008; El-Tahawy, 2020).

Direct heterosis (H^I)

The generalized least square solutions of direct heterosis were highly significant for all traits studied (P<0.05 or P<0.01; Table 7). The negative estimates of direct heterosis of -5.9 *d* (with -3.8 %) for AFE and the positive estimate of 1.8 *g* (with -4.6 %) for WFE indicate that crossing MN with MT chickens was associated with a decrease in the age of the hen at the first egg and an increase in the weight of the first egg when MN and MT chicken breeds were crossed. The negative estimate of direct heterosis for AFE was also reported by Khalil *et al*. (2004) who reported a decrease of 2.7 %**,** Iraqi *et al*. (2007) who reported a decrease of 27.1 %, and Hassan (2008) who reported a decrease of 4.9 %**.** Soliman *et al*. (2020) reported that the estimates of direct heterosis were significant for ASM, and insignificant for EN90, EW90 and EM traits.

For weight of hen at the first egg, egg production and partial egg recording, the estimable solutions of direct heterosis were mostly moderate (P<0.01; Table 7), being 28.5 % (377 *g*), 29.3 % (13.3 *egg*), 28.8 % (495 *g*), 24.9 % (15.7 *egg*), 19.7 % (555 *g*), 36.1 % (5.7 *d*), 13.2 % (52 *g*), 17.4 % (3.2 *egg*), 17.9 % (147 *g*), 10.6 % (1.4 *egg*) and 8.8 % (53 *g*) for BWFE, EN90, EM90, EN120, EM120, PF10E, EMF10E, EN2DW, EM2DW, EN1WM and EM1WM, respectively. These figures indicate that crossing MN with MT was associated with significant heterotic effects on body weight at sexual maturity, egg number and mass and partial egg recording during the first 90 and 120 days of egg production**.** Similarly**,** Hassan (2008) reported significant estimates of direct heterosis to be 36.1, 28.7, 26.2 and 20.4 % for EN90, EM90, EN210 and EM210 and Iraqi *et al*. (2012) reported significant estimates to be 23.0, 29.2, 18.1 and 21.7 % for EN90, EM90, EN120 and EM120, respectively**.** Recently, El-Tahawy (2020) reported significant estimates of direct heterosis to be 16.3 % for EN90**.** El-Tahawy and Habashy (2021) stated that the estimates of direct heterosis were insignificant for AFE, PF10E, EN90, EW10, EW90 and EM90 traits. Assefa *et al*. (2021) reported that crossing Fayoumi with White Leghorn chickens exhibited high positive heterotic effects for body weight at first egg and negative heterotic effects for age at first egg.

The solutions of direct heterosis for clutch sizes were positive and favorable for all clutch sizes during the initial 90 and 120 days of egg production (P≤0.01), the estimates ranging from 16.6 to 57.4 % (Table 7). On the other hand, the percentages of direct heterosis for all pause durations were negative during the first 90 and 120 days of egg production (P≤0.01), the estimates ranging from -17.3 to -44.2 % (Table 7). These estimates illustrating that crossing MN with MT chickens could significantly improve the clutch sizes and pause durations in the Egyptian chickens. Hassan (2008) cited that crossing MN and MT chickens was associated with long clutches and short pauses of egg production. El-Attrouny (2011) reported negative and highly significant estimates of direct heterosis for pause days of egg production during the first 90 and 120 days (-17.9 and -15.6 %). Isa *et al*. (2020) showed that heterotic effects were negative and low for AFE but positive for egg numbers and clutch sizes in crossing Rhode Island Red with White Leghorn chickens. Also, they observed moderate heterosis for egg numbers at early (17.3–21.6%) and late periods of laying (13.8–17.4%).

Maternal heterosis (H^M)

The negative estimates of heterotic maternity for AFE (-2.6 %) indicate that using crossbred hens mothered by ½MN½MT and ½MT½MN crossbred dams was associated with a decrease in age of hen at the first egg along with an increase in the laying rate of the first 90 and 120 days of egg production (Table 8). Khalil *et al*. (2004) when crossing Baladi Saudi with White Leghorn chickens in Saudi Arabia found that the percentages of maternal heterotic effects were favorably negative and significant for AFE (-16.4%; P≤0.01).

The solutions of maternal heterotic effects for all egg production traits were significantly moderate (P≤0.01); the estimates were 7.8 % (3.6 *egg*), 8.2 % (163 *g*), 7.8 % (4.9 *egg*), and 8.1 % (227 *g*) for EN90, EM90, EN120 and EM120, respectively (Table 8). These significant estimates reflect superior magnitude of heterotic maternity effects on egg number and egg mass during the initial 90 and 120 days of egg production. Iraqi *et al*. (2012) when crossing MN with MT chickens cited that the estimates of maternal heterosis were 10.9, 10.7, 8.3 and 9.1 % for EN90, EM90, EN120 and EM120, respectively. Khalil *et al*. (2004) in crossing Baladi Saudi and White Leghorn hens, found positive and highly significant maternal heterosis on egg number at 90 days and annual egg production (19.1 and 12.3 %; P≤0.01).

The effects of heterotic maternity on partial egg recording were significant in four traits out of six, indicating that crossbred dams were superior by 10.5 % (1.7 *d*) in PF10E, 7.2 % (1.3 *egg*) in EN2DW, 3.2 % (1.4 *egg*) in EN1WM and 10.5 % (1.7 *g*) in EM1WM relative to the parental MT and MN chickens (Table 8). These superiorities in crossbred dams indicate that the rate of egg laying was increased in hens mothered by crossbred dams, i.e. heterotic maternity for most partial egg recording traits were considerably favorable in hens mothered by crossbred dams. Iraqi *et al*. (2012) reported that the percentages of maternal heterotic effects were -6.6, 8.7, -2.0, 4.1 and 3.8% for PF10E, EN2DW, EM2DW, EN1WM and EM1WM, respectively.

The estimable heterotic maternities for clutch sizes were moderately positive and significant for most clutch sizes during the first 90 and 120 days of egg production by 11.2 % (1.5 *egg*) for CS190, 4.6 % (1.1 *egg*) for CS590, 15.5 % (1.9 *egg*) for CS1120, 7.8 % (1.2 *egg*) for CS3120 and 15.3 % (1.4 *egg*) for CS5120 (Table 8). For pause durations, the percentages of maternal heterotic effects were negative and ranged from -5.0 to -17.3 % during the first 90 days and from -6.9 to -31.8% during the first 120 days of egg production (Table 8), i.e.

pause durations were decreased due to the increase in heterotic maternity.

CONCLUSIONS

Based on the estimates of direct additive genetic and maternal effects, Mandarah chickens could be used as a sire-strain and Matrouh chickens as a dam-strain to improve maturity age and weight of hen at the first egg, egg production, partial egg recording and clutch sizes studied, while a reversible trend in favour of Matrouh chickens was observed for pause durations. Crossing Mandarah with Matrouh chickens was associated with high percentage of direct and maternal heterosis for most traits of hen maturity at the first egg, egg production, partial egg recording, clutch sizes and pause durations.

ACKNOWLEDGMENTS

The authors are gratefully acknowledged the members of Poultry Breeding Research Station at Inshas, APRI, Agricultural Research Center, Ministry of Agriculture, and members of Department of Animal Production, Faculty of Agriculture at Moshtohor, Benha University, Egypt for their support and providing the facilities of the experiment.

DECLARATION OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

All experimental procedures involving birds handling and treatment were approved by APRI, Agricultural Research Center, Ministry of Agriculture, Egypt.

SOFTWARE AND DATA REPOSITORY RESOURCES

Data used is available from the corresponding author upon reasonable request.

FINANCIAL SUPPORT

The experiment was financially supported by APRI, Agriculture Research Center, Ministry of Agriculture, Egypt.

Table (1): Genetic groups and numbers of cocks, hens, pullets and chicks used in the experiment.

Generation	Cock genetic group (No)	Hen genetic group (No)	No. of pullets	Chick genetic group (No)
Parental generation:				
	MT (34) MN (32) Total = 66	MT (230) MN (199) Total = 429	357 240 Total = 597	MT (1479) MN (1415) Total = 2894
First generation of crossing:				
	MT (16) MN (17) Total = 33	MN (71) MT (96) Total = 167	150 194 Total = 344	½MT½MN (394) ½MN½MT (259) Total = 653
Second generation of crossing				
	SM (14) IN (11) Total = 25	½MT½MN (90) ½MN½MT (61) Total = 151	156 71 Total = 227	½SM¼MT¼MN (578) ½IN¼MN¼MT (231) Total = 809
Grand total	124	747	1168	4356

* MN, MT, IN and SM = Mandarah, Matrouh, Inshas and Silver Montazah strains of chickens, respectively; No = Numbers used in each group.

Table (2): Genetic groups of chicks with their sires and dams and coefficients of the matrix relating genetic group solutions of chicks with crossbreeding effects.

Chick genetic group	Sire	Dam	No. of hens	Coefficients of the matrix			
				G^I	G^M	H^I	H^M
MT	MT	MT	230	1	1	0	0
MN	MN	MN	199	1	1	0	0
½MT½MN	MT	MN	71	0.5	0.5	1	0
½MN½MT	MN	MT	96	0.5	0.5	1	0
½SM¼MT¼MN	SM	½MT½MN	90	0.5	0.25	0	1
½IN¼MN¼MT	IN	½MN½MT	61	0.5	0.25	0	1

* MN, MT, IN and SM = Mandarah, Matrouh, Inshas and Silver Montazah strains of chickens, respectively; G^I, G^M, H^I and H^M = Direct additive genetic effect, maternal effect, direct heterosis and maternal heterosis, respectively.

Table (3): Generalized least square solutions for direct additive effects (G^I=G^I_{MN}-G^I_{MT}) and their standard errors (SE) and percentages for maturity of hen at the first egg, egg production and partial egg recording.

Trait	Symbol	No of hens	Actual mean	G^I solution (units)	SE	G^I as %$^+$
Sexual maturity:						
Age of hen at the first egg (d)	AFE	747	154	-6.2**	0.04	-4.0
Body weight of hen at the first egg (g)	BWFE	747	1420	120**	0.45	9.1
Weight of the first egg laid (g)	WFE	747	39.4	0.3^{ns}	0.01	0.8
Egg production:						
Egg number during the first 90 days of laying (egg)	EN90	712	45	2.4**	0.06	5.4
Egg mass during the first 90 days of laying (g)	EM90	712	1958	88**	2.45	4.4
Egg number during the first 120 days of laying (egg)	EN120	710	62	2.3**	0.09	3.6
Egg mass during the first 120 days of laying (g)	EM120	710	2728	71**	3.97	2.5
Partial egg recording:						
Period of the first ten eggs laid (d)	PF10E	708	16	-1.7**	0.03	-11.1
Egg mass for the first ten eggs laid (g)	EMF10E	708	411	5.1^{ns}	0.09	1.2
Egg number for two days per week of production (egg)	EN2DW	707	18	0.7*	0.03	3.9
Egg mass for two days per week of production (g)	EM2DW	707	784	0.8^{ns}	1.21	0.1
Egg number for one week per month of production (egg)	EN1WM	708	13.5	0.8*	0.02	6.2
Egg mass for one week per month of production (g)	EM1WM	708	593	11.6*	0.99	1.9

+ G^I percentage computed as [Estimate of G^I in units /(MN+MT)/2]x100; ns= non-significant; *=P≤0.05 and **=P≤0.01.

Table (4): Generalized least square solutions for direct additive effects ($G^I=G^I_{MN}-G^I_{MT}$) and their standard errors (SE) and percentages for clutch sizes and pause durations.

Trait	Symbol	No of hens	Actual mean	G^I solution (units)	SE	G^I as %$^+$
Clutch sizes (egg):						
Clutch size of one egg during the first 90 days of production	CS190	662	4.9	-0.1^{ns}	0.01	-2.5
Clutch size of three eggs during the first 90 days of production	CS390	584	2.9	-0.1^{ns}	0.01	-3.5
Clutch size of five eggs and more during the first 90 days of production	CS590	550	1.7	-0.9*	0.01	-8.9
Clutch size of one egg during the first 120 days of production	CS1120	662	6.1	-0.1^{ns}	0.02	-1.6
Clutch size of three eggs during the first 120 days of production	CS3120	609	3.7	-0.8^{ns}	0.03	-6.8
Clutch size of five eggs and more during the first 120 days of production	CS5120	586	2.1	-1.6*	0.01	-23.4
Pause durations (d):						
Pause duration of one day during the first 90 days of production	PD190	702	9.5	-1.6**	0.02	-12.3
Pause duration of three days during the first 90 days of production	PD390	340	1.6	-0.1^{ns}	0.01	-1.9
Pause duration of five days and more during the first 90 days of production	PD590	360	1.2	-1.4**	0.01	-26.6
Pause duration of one day during the first 120 days of production	PD1120	703	12.6	-1.1**	0.02	-31.1
Pause duration of three days during the first 120 days of production	PD3120	400	1.9	-0.1^{ns}	0.01	-5.5
Pause duration of five days and more during the first 120 days of production	PD5120	361	1.2	-1.4**	0.01	-26.2

G^I percentage computed as [Estimate of G^I in units /(MN+MT)/2]x100; ns= non-significant; *=P≤0.05 and **=P≤0.01.

Table (5): Generalized least square solutions for maternal effects ($G^M = G^M_{MN} - G^M_{MT}$) and their standard errors (SE) and percentages for maturity of hen at the first egg, egg production and partial egg recording.

Trait[+]	No of hens	G^M solution (units)	SE	G^M as %[++]
Sexual maturity:				
AFE, d	747	-4.5*	0.8	-2.9
BWFE, g	747	114**	0.8	8.6
WFE, g	747	1.5*	0.3	3.8
Egg production:				
EN90, egg	712	2.6*	1.4	5.8
EM90, g	712	136*	5.7	6.8
EN120, egg	710	1.4ns	1.7	2.3
EM120, g	710	92*	7.6	3.3
Partial egg recording:				
PF10E, d	708	1.7*	0.6	10.8
EMF10E, g	708	7.6ns	1.8	1.8
EN2DW, egg	707	0.4ns	0.5	1.9
EM2DW, g	707	25*	20.3	3.0
EN1WM, egg	708	0.4ns	0.2	2.8
EM1WM, g	708	16*	11.9	10.8

[+] Traits as defined in Table (3); [++] Percentage computed as [Estimate of G^M in units /(MN+MT)/2]x100; ns= non-significant; *=P≤0.05 and **=P≤0.01

Table (6): Generalized least square solutions for maternal effects ($G^M = G^M_{MN} - G^M_{MT}$) and their standard errors (SE) and percentages for clutch sizes and pause durations.

Trait[+]	No of hens	G^M solution (units)	SE	G^M as %[++]
Clutch sizes (egg):				
CS190	662	0.03ns	0.03	0.6
CS390	584	0.29*	0.02	10.1
CS590	550	0.30*	0.02	12.2
CS1120	662	0.08ns	0.03	1.3
CS3120	609	0.58*	0.02	15.4
CS5120	586	1.03*	0.02	40.2
Pause durations (d):				
PD190	702	-1.47**	0.03	-17.6
PD390	340	-0.21*	0.01	-13.4
PD590	360	-0.45**	0.01	-28.5
PD1120	703	-0.94**	0.04	-25.6
PD3120	400	-0.59*	0.02	-32.2
PD5120	361	-0.49**	0.01	-30.6

[+] Traits as defined in Table (4); [++] Percentage computed as [Estimate of G^M in units /(MN+MT)/2]x100; ns= non-significant; *=P≤0.05 and **=P≤0.01.

Table (7): Generalized least square solutions and percentages for direct heterotic effects (H^I) and their standard errors (SE) for hen maturity at the first egg, egg production and partial egg recording, clutch sizes and pause durations.

Trait[+]	**No of hens**	**H^I solution (units)**	**SE**	**H^I as %**[++]	**Trait**	**No of hens**	**H^I solution (units)**	**SE**	**H^I as %**[++]
Sexual maturity:					**Clutch sizes (egg):**				
AFE (d)	747	-5.9*	0.07	-3.8	CS190	662	1.6**	0.02	13.1
BWFE (g)	747	377**	0.76	28.5	CS390	584	1.1**	0.07	16.6
WFE (g)	747	1.8*	0.02	4.6	CS590	550	1.3**	0.01	14.2
Egg production:					CS1120	662	1.4**	0.04	16.5
EN90 (egg)	712	13.3**	0.10	29.3	CS3120	609	1.5**	0.02	23.9
EM90 (g)	712	495**	4.48	28.8	CS5120	586	2.1**	0.14	57.4
EN120 (egg)	710	15.7**	0.15	24.9					
EM120 (g)	710	555**	6.72	19.7					
Partial egg recording:					**Pause durations (d):**				
PF10E (d)	708	5.7**	0.05	36.1	PD190	702	-1.79**	0.03	-21.4
EMF10E (g)	708	52**	0.15	13.2	PD390	340	-1.2**	0.11	-17.3
EN2DW (egg)	707	3.2**	0.05	17.4	PD590	360	-1.3**	0.01	-20.9
EM2DW (g)	707	147**	2.04	17.9	PD1120	703	-1.4**	0.04	-38.4
EN1WM (egg)	708	1.4**	0.04	10.6	PD3120	400	-1.8**	0.03	-44.2
EM1WM (g)	708	53**	1.68	8.8	PD5120	361	-1.5**	0.01	-34.3

[+] Traits as defined in Tables (3&4); [++] Percentage computed as [Estimate of H^I in units/(MN+MT)/2]x100; ns= non-significant; **=P≤0.01.

Table (8): Generalized least square solutions and percentages for maternal heterotic effects (H^M**)** and their standard errors (SE) for hen maturity at the first egg, egg production, partial egg recording, clutch sizes and pause durations.

Trait[+]	**No of hens**	**H^M solution (units)**	**SE**	**H^M as %**[++]	**Trait**	**No of hens**	**H^M solution (units)**	**SE**	**H^M as %**[++]
Sexual maturity:		**Clutch sizes (egg)**							
AFE (d)	747	-4.3*	0.04	-2.6	CS190	662	1.5**	0.01	11.2
BWFE (g)	747	16.4ns	0.43	1.2	CS390	584	0.2ns	0.01	0.07
WFE (g)	747	0.01ns	0.01	0.03	CS590	550	1.1*	0.05	4.6
Egg production:					CS1120	662	1.9**	0.07	15.5
EN90 (egg)	712	3.6**	0.06	7.8	CS3120	609	1.2*	0.06	7.8
EM90 (g)	712	163**	2.56	8.2	CS5120	586	1.4**	0.09	15.3
EN120 (egg)	710	4.9**	0.09	7.8					
EM120 (g)	710	227**	3.84	8.1					
Partial egg recording:		**Pause durations (d)**							
PF10E (d)	708	1.7*	0.03	10.5	PD190	702	-1.63**	0.12	-17.3
EMF10E (g)	708	0.7ns	0.09	0.2	PD390	340	-0.8*	0.02	-5.0
EN2DW (egg)	707	1.3*	0.03	7.2	PD590	360	-0.8*	0.01	-5.7
EM2DW (g)	707	6.5ns	1.17	0.7	PD1120	703	-1.2**	0.12	-31.8
EN1WM (egg)	708	1.4*	0.02	3.2	PD3120	400	-1.2*	0.05	-11.6
EM1WM (g)	708	1.7*	0.03	10.5	PD5120	361	-1.1*	0.01	-6.9

[+] Traits as defined in Tables (3&4)
[++] Percentage computed as [Estimate of H^M in units/(MN+MT)/2]x100; ns= non-significant; **=P≤0.01.

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Egyptian chickens, crossbreeding effects, egg production, clutch sizes.

الملخص العربي

مكونات الخلط لعمر النضج عند أول بيضة، إنتاج البيض، التسجيل الجزئي للبيض، طول سلاسل وضع البيض، وفترات التوقف عن وضع البيض في خلط أربعة سلالات من الدجاج المصري

هبة أحمد حسن[1،2] ، ماهر حسب النبي خليل[1]، محمود مغربي عراقي[1]، جعفر محمود الجندي[1]، أيمن النجار[1]

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أجريت تجربة خلط لمدة أربعة سنوات بإستخدام أربعة سلالات مستنبطة من الدجاج تشمل مندرة، مطروح، إنشاص والمنتزه الفضي لتقدير التأثيرات الوراثية التجمعية المباشرة، التأثيرات الأمية، قوة الخلط المباشرة وقوة الخلط الأمية لصفات عمر ووزن الدجاجة عند أول بيضة، وزن أول بيضة، فترة وضع البيض، كتلة البيض لأول 10 بيضات، عدد وكتلة البيض خلال 90 ، 120 يوماً من إنتاج البيض، عدد وكتلة البيض لمدة يومين لكل أسبوع من الإنتاج ، وعدد البيض وكتلته لمدة أسبوع واحد خلال شهر من الإنتاج، طول سلاسل وضع البيض وفترات التوقف خلال 90، 120 يوماً من إنتاج البيض. تم تسجيل صفات إنتاج البيض لعدد 747 دجاجة في عمر النضج الجنسي من المجاميع الوراثية المختلفة. تم إستخدام عدد 34 أب ، 230 أم من سلالة مطروح، و 32 أب ، 199 أم من سلالة مندرة لإنتاج عدد 2894 كتكوت من جيل الآباء النقية المندرة ومطروح. تم إنتاج الخلطان الثنائية في الجيل الأول من الخلط (653 كتكوت من ½مندرة½مطروح، ½مطروح½مندرة) والخلطان الثلاثية في الجيل الثاني من الخلط (809 كتكوت من ½إنشاص¼مندرة¼مطروح، ½منتزه فضي¼مطروح¼مندرة). تم تقدير تأثيرات الخلط بإستخدام طريقة المربعات الصغرى المعممة Generalized least-squares بإستخدام برنامج BLUPF90. كانت قيم التأثيرات الوراثية التجمعية معنوية لجميع صفات البيض المدروسة وفي صالح سلالة المندرة. كما كانت التأثيرات الأمية معنوية لصالح الأمهات المندرة لصفات نضج الدجاجة عند وضع أول بيضة ومعظم صفات إنتاج البيض وطول سلاسل وضع البيض، بينما كانت التأثيرات الأمية على صفات التوقف عن وضع البيض معنوية ولصالح الأمهات مطروح. كانت نسب قوة الخلط المباشرة مرغوبة وتراوحت بين 3.8 إلى 28.5 % لعمر النضج عند أول بيضة، وتراوحت بين 19.7 إلى 29.3 % لصفات إنتاج البيض ومن 3.2 إلى 36.1 % لصفات التسجيل الجزئي للبيض. كانت نسب قوة الهجين المباشرة موجبة ومرغوبة معنوياً لجميع صفات طول سلسلة وضع البيض وتراوحت بين 13.1 إلى 57.4 %، بينما كانت قوة الهجين سالبة ومرغوبة لجميع صفات التوقف عن وضع البيض وتراوحت بين -17.3 إلى -44.2 %. كانت نسب قوة الخلط الأمية معنوية ومرغوبة بمعدل -2.6% للعمر عند أول بيضة، وتروا‌حت بين 7.8 إلى 8.2 % لإنتاج البيض. كانت قوة الخلط الأمية موجبة ومرغوبة معنوياً وتراوحت بين 3.2 إلى 10.5 % لأربعة من صفات التسجيل الجزئي للبيض، وبين 4.5 إلى 15.5 % لمعظم صفات طول سلاسل وضع البيض، بينما كانت قوة الخلط الأمية سالبة ومرغوبة لجميع صفات فترات التوقف عن وضع البيض بنسب تراوحت بين -5.0 إلى -31.8 %. وخلصت الدراسة أنه يمكن إستخدام دجاج المندرة كسلالة أبوية ودجاج مطروح كسلالة أمية وذلك لتحسين عمر النضج وصفات إنتاج البيض وطول سلاسل وضع البيض وفترات التوقف من وضع البيض.