Egypt. Poult. Sci. Vol. (45) (II) : (187-201) (2025) **(2505-1321)**

Egyptian Poultry Science Journal

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

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

EVALUATION OF EGG PRODUCTION AND FEED EFFICIENCY TRAITS OF NEW CROSSES ESTABLISHED USING LOCAL CHICKEN STRAINS

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Received: 19 /05/2025 Accepted: 30 /06 /2025

ABSTRACT: Aiming to establish and evaluate new crosses, the current study was conducted at the research farm of the Poultry and Fish production department, at Menoufia University. Sinai, Gimmizah and Silver Montazah chicken were used in the current study. Egg production and feed efficiency traits recorded individually including age at sexual maturity, egg number during the first 90 days of production (EN90), egg weight and body weight at sexual maturity (EWSM and BWSM), body weight at 35 weeks of age (BWM), daily feed consumption and feed efficiency (DFC35 and EFE35). A partial diallel crossing scheme was applied and the performance of the different crosses was evaluated, and crossbreeding effects were estimated. All crosses from a recent study achieved higher EN90 than pure lines (Parental lines) ranging between 37.2 (SMGS cross) and 43.4 (MSSG cross) eggs compared to 31.3 (Montazah) and 37.0 (Gimmizah) eggs. The best feed utilization was observed for the cross MSSG which used 4.56 g feed to produce one gram of eggs. The worst genotype in its feed utilization was Gimmizah hens which utilized 7.24 g feed on average to produce one gram of eggs. Preferable genetic effect observed for MS genotype (originated by crossing Silver Montazah sires with Sinai dams) regarding all egg production traits including ASM (-6.43 days), EN90 (2.5 eggs), EWSM (5.5 g), EWM (-0.21 g), BWSM (-16.35 g) and BWM (-80.21 g). Heterosis % for ASM showed a negative (desirable) direction for GSSM and MSSG genotypes but with low estimates (-1.086 and -1.105 % respectively). Heterosis % for EN90 exhibited negative moderate -15.53 (SMGS); -16.91 (SGMS) and slightly low negative -7.343 (GSSM); -7.787 (MSSG) estimates. It can be concluded that the number of produced eggs during the first 90 days of production is negatively affected (negative heterosis) in hybrids mothered by lower egg production hens, and vice versa. Egg production during the first 90 days tends to be highly affected by heterotic effects.

Key Words: Local chickens, crossbreeding effects, egg production

INTRODUCTION

Poultry meat and eggs play a major role in meeting the growing demand for animal protein, especially when considering the economic value of its protein compared to large animals. Local chickens is considered one of the very important agricultural resources in Egypt characterized by many features such as good adaptation to the conditions of the Egyptian environment and its capabilities (Khalil *et al.*, 2018; El-Tahawy and Habashy 2021), In addition to the distinctive flavor, whether for meat or eggs, effort should be made to improve the productivity of such breeds and strains, maintaining by taking care of it and applying effective improvement programs.

Crossbreeding is one of the important tools that play a major role in the improvement of the chicken's performance. Improving the productivity of local strains is considered one of the priorities of the Egyptian poultry industry (Soliman et al., 2020). Crossbreeding plans are used to evaluate the ability of a population to combine with other populations (Jakubec, *et al.,* 1987). Diallel crossing was applied in poultry breeding in many experiments for a long time, and such results from these experiments are used for: 1) evaluation of the efficiency of pure- and crossbreds; 2) evaluation of population performance in pure- and crossbreeding; 3) estimating genotypic value and breeding potentials; 4) demonstration of the complementarity ability of both maternal and paternal populations in crosses; 5) predicting performance of different types of crosses; 6) give the information used in reciprocal recurrent selection programs and 7) step ahead to understand the nature of gene action affecting quantitative traits. However, under experimental and field breeding conditions, not every crossbreeding effort produces desirable results. It is therefore important that an animal breeder knows what mating method to employ and what breeding goals to accomplish.

The current experiment aimed at establishing and evaluating some new crosses for egg production and feed efficiency by crossing some local chicken strains including Sinai, Gimmizah and Silver Montazah.

MATERIALS AND METHODS

Experimental plan:

Three local chicken strains were used in a crossbreeding program (first phase) that was maintained at the Poultry Research farm, Fac. of Agriculture, Menoufia Univ during the seasons 2018-2020. Then, the second phase was carried out during the seasons 2020-2023 between the chosen genetic groups (plan of mating: Figure 1). The first generation was obtained during the season 2021- 2022. In the second phase (recent study) 7 genetic groups (Sinai strain, Gimmizah strain, Montazah strain, GSSM, MSSG, SGMS and SMGS crosses were tested. The three parental strains of Sinai, Gimmizah and Silver Montazah were reared till 90 days of egg production (all traits were recorded) and then were cross-mated (plane of mating) to obtain crosses and reciprocals.

Flock management:

All the experimental parents and hatching chicks received the same managerial treatments. All trap nested eggs produced from each breeding cage were individually recorded according to the genetic group and collected daily for 7 days period. At hatch, the chicks were wing-banded and weighted. Brooders with the starting temperature of 32˚C for the first week after hatching and then decreased 2-3˚C each week thereafter. At eight weeks of age the chicks were sexed, weighed, and moved to the rearing house.

Chicks were brooded in a floor brooder watered continuously and fed *ad libitum* during a brooding period a commercial starter diet containing 19.43 % crude protein and 2916 ME/kg. Kcal, then at 16 weeks the ration was changed by a layer ration containing 17.1% crude protein and 2760 ME/kg. Kcal.

Studies traits:

The traits studied were measured and recorded for all strains and crosses.

Egg production traits: Egg production traits were individually recorded as follows:

1- Average age at sexual maturity (ASM).
2- Produced eggs during the first 90th days of production (EN90).
3- The average weight of the first five eggs (EWSM).
4- Body weight at the first egg (BWSM).
5- Body weight at 35 weeks (BWM).
6- The average weight of five eggs at 35 weeks (EWM).
7- Daily feed consumption at maturity (DFC35).
8- Feed conversion (efficiency) to eggs at maturity (EFE35).

Daily feed consumption was calculated, and the egg weight (mass) produced during the measuring period, then feed efficiency at (35 weeks) was calculated for all pure strains and hybrids according to the following equation,

$$feed\ efficieny\ (g\ feed/g\ egg) = \frac{(g) feed\ intake}{(g) egg\ mass}$$

Crossbreeding effects:

Different crossbreeding effects including direct genetic effect, maternal genetic effect, reciprocal effects, line heterosis, absolute heterosis (the absolute difference between the cross and the corresponding mid-parent), heterosis percentage (%) as from mid-parent, general combining ability (GCA) and specific combining ability (SCA) were calculated according to the genetic group.

Calculations of crossbreeding effects, for the current special partial diallel system have been done as the following model described by Jakubec *et al.* (1987).

$$Y_{ijk} = \mu + 1/2\, v_i + 1/2\, v_j + m_j + \delta(h_{ij} + r_{ij}) + e_{iik}$$

Where:

$i\ (j) = 1,2,\dots,p; k = 1,2,\dots,n$ (p = number of parental lines),

Y_{ijk} - the kth observation of the progeny of a mating of a dam from the jth line with a sire of the *i*th line,

μ - general mean (overall mean of parental lines)

v_i - direct genetic effect of the *i*th line,

m_j - maternal genetic effect of the *j*th line,

h_{ij} - heterosis obtained by crossing lines *i* and j, $h_{ij} = \bar{h} + h_i + h_j + s_{ij}\ (if\ p \geq 4)$, $\bar{h} =$ average heterosis , $h_i =$ line heterosis of i , $s_{ij} =$ specific heterosis obtained by crossing lines *i* and *j*,

r_{ij} - residual reciprocal effect of the cross *ij*,

δ - equal to 0 for parental line progeny ($i = j$), and $\delta = 1$ for crossbred progeny ($i \neq j$)

e_{iik} - random errors.

Heterosis percentage (H%): Heterosis percentage based on differences of means was calculated according to the equation of Fairfull and Gowe (1990) cited by Williams et al. (2002) as follows:

$$Heterosis\ \% = (F_1 - ([P_1 + P_2]/2))/([P_1 + P_2]/2) * 100$$

Where: F_1 - the average of cross progeny,

$P_1 and\ P_2$ - means of the progeny of the two parental lines.

Combining ability: General combining ability (GCA) and specific combining ability (SCA) are calculated according to the following equations as introduced by Odeh *et al.* (2003). General combining ability as a deviation from the general mean of the experimental groups for a specific trait (*i*)

$$GCA_i = \sum Y_i/n - \mu$$

Where:

μ - general mean of all crosses and pure lines

Y_i - the value of i trait for a progeny with either one of his or her parents or both parents from line *i*,

n - total number of progenies with either one of his or her parents or both parents from line *i*.

Specific combining ability is estimated as follows:

$SCA_{ij} = cross\ effect - (GCA_i + GCA_j)$

Where:

$cross\ effect$ = Mean of given cross − overall mean of the trait

GCA_i – the general combining ability of the sire line of a given cross (line *i*),

GCA_j – the general combining ability of the dam line of a given cross (line *j*),

Statistical analysis:

Collected data were entered and computerized and the analysis of variance was done according to the following model (one-way) using SPSS-IBM program v. 26.0 (2019). Significant differences among means were detected by the Duncan test procedure implemented in the SPSS-IBM software (2019).

$\boldsymbol{Y_{ij} = \mu + B_i + e_{ij}}$

Where:

Y_{ij} = the value of the trait (observation)

μ = the general mean of the trait

B_i = the fixed effect of i^{th} strain on the studied trait (i = Sinai, Gimmizah, S. Montazah).

e_{ij} = residual effect.

RESULTS AND DISCUSSION

Egg production traits:

Means of egg production traits (i.e. ASM, EN90, EWSM, EWM, BWSM and BWM) are recorded in Table (1). As shown in this table, the age at sexual maturity averaged 181.8 days regarding all genotypes researched in recent work ranging between 176.2 days (MSSG) and 189.6 days (Gimmizah chickens). Among pure lines Silver Montazah matured earlier than other pure lines, the latest matured pure genotype was the Gimmizah strain. It is well known that heavier birds sexually matured later than the lightest ones and there is a correlation (negative) between ASM and body weight. Age at sexual maturity affects egg production, the earlier matured hens are the highest egg producers. However, the ANOVA test doesn't show any statistical differences (P=0.106) between studied genotypic groups, Duncan's test indicated that there were significant differences between the mean ASM of the Gimmizah strain (189.6 days) and both GSSM and MSSG crosses (177.6 and 176.2 days, respectively), this variation reached its highest value (13.4 days) among Gimmizah and MSSG hens. Ranging between 4.9 to 13.4 days difference was observed between studied genotypes in ASM. Earlier sexual maturation was previously reported by Zahran 2021 in Silver Montazah (161.5 days), Sinai (172.3 days) and Gimmizah (180.5 days) chickens. It may be attributed to the different experimental conditions and the crossing effects.

Egg numbers during the first 90 days of the production cycle (EN90) depicted in Table (1) ranged between 31.3 and 43.4 eggs (Montazah and MSSG, respectively). Significant differences have been noticed between genotypes under investigation (P=0.036). Unexpectedly, Gimmizah hens produced 37.0 eggs during the first 90 days of egg production cycle which matured later than other genotypes studied. The range of EN90 among all genotypes is located between 31.3 eggs (Montazah) and 43.4 eggs (MSSG). All crosses from a recent study achieved higher EN90 than pure lines (Parental lines) ranging between 37.2 (SMGS) and 43.4 (MSSG) eggs compared to 31.3 (Montazah) and 37.0 (Gimmizah) eggs. Reviewed research showed that EN90 in local Egyptian chicken strains ranged between 31.0 to 69.3 eggs on average.

Egg weight either at sexual maturity (EWSM) or at maturity i.e. at 35 wks of age (EWM) represented in Table (1) showed that EWSM ranged between 35.8 to 39.2 g (SMGS and Gimmizah chickens, respectively) with a general mean of 37.3 g. Moreover, EWM ranged from 43.9 to 48.5 g for the same genotypes as well as EWSM (i.e. SMGS and Gimmizah chickens, respectively). The overall average egg weight at maturity was 46.2 g/egg. These values of egg weight either EWSM or EWM fall in the previously reported range in reviewed literature for local Egyptian chickens' strains (Enab et al. 2010; Soltan 1997; Hassan et al. 2020; Ghanem et al. 2008 and Zahran 2021).

Body weight at sexual maturity (BWSM) and at maturity (BWM) ranged between 1129.0 to 1298.2 g for Sinai and Gimmizah hens, respectively (average of 1189.8 g) at sexual maturity, and between 1185.1 to 1332.1 g for Sinai and Gimmizah hens, respectively (average of 1257.5 g) at 35 wks of age i.e. BWM. It has been noticed that the lightest and the heaviest body weight either at sexual maturity or at maturity were recorded for pure genotypes (i.e. Sinai and Gimmizah strains). Crosses that included Gimmizah and Silver Montazah strains in parental lines as dams showed heavier weight than those that have Sinai chickens in parental lines in dam positions. Analysis of variance revealed statistically significant variation between different genotypes under investigation at both ages (BWSM and BWM) in body weight. Zahran 2021 reported the same trend for BWSM and BWM in her crossbreeding experiment on some local Egyptian chicken strains (including Sinai, Gimmizah, and Silver Montazah). She found that Sinai hens had the lightest body weight among studied strains followed by Silver Montazah then Gimmizah hens (heaviest weight) either at sexual maturity (range of 1094.0 to 1225.0 g) or at maturity (range of 1199.1 to 1407.5 g) in the second generation of her experiment. She also recorded significant differences between the genotypes investigated regarding body weight. Crosses from a recent study showed average body weight parental pure lines used, ranging between 1218.9 and 1305.3 g for all crosses.

Feed efficiency traits:

Results of feed efficiency traits (Table 2) including daily feed consumption (g feed/day) and egg feed efficiency (g feed/g egg) at 35 wks of age showed that average daily feed consumption among all genotypes from a recent study was 85.8 g/day ranging from 82.14 (Sinai) to 90.25 g/day (GSSM). Statistically important differences were observed in DFC35 among studied genotypes, with the highest feed consumption recorded by GSSM hens and the lowest feed consumption in a day recorded for Sinai hens. The best feed utilization was observed for the cross MSSG which used 4.56 g feed to produce one gram of eggs. The worst genotype in its feed utilization was Gimmizah hens which utilized 7.24 g feed on average to produce one gram of eggs. The general average feed efficiency from current research was 5.56 g feed / 1 g egg among all genetic groups. However, the difference in feed efficiency values between the highest and lowest values was 2.68 g feed / 1 g egg analysis of variance doesn't reflect significant differences between studied genotypes (P=0.697). The same trends regarding daily feed consumption and feed efficiency at 35 wks of age was previously reported by Zahran 2021 in a partial diallel crossing experiment on local Egyptian chickens.

Crossbreeding effects:

Direct, maternal, and reciprocal genetic effects:

Direct (v_i), maternal (m_i), and reciprocal (r_{ij}) genetic effects for studied egg production traits including ASM, EN90, EWSM, EWM, BWSM, and BWM in all genotypes depicted in Table (3). Preferable genetic effect observed for MS genotype (originated by crossing Silver Montazah sires with Sinai dams) regarding all egg production traits including ASM (-6.43 days), EN90 (2.5 eggs), EWSM (5.5 g), EWM (-0.21 g), BWSM (-16.35 g) and BWM (-80.21 g). On the other hand, the genotype SM from parental lines showed an unfavorable direct genetic effect on ASM, EN90, EWSM, and EWM among all investigated genetic groups (2.55 d, -1.48 eggs, -3.26 g, and -1.34 g respectively). Recent data fully agree with ones found earlier by Khalil *et al.*, 2004; Taha and Abd

El-Ghany 2013b; Hassan *et al.,* 2020; Zahran 2021, reported desired (negative) values of v_i on ASM in their crossing trials. Partially agreed results have been found by Elnahal 2011 who detected a positive 1.18 direct additive effect on age at sexual maturity in Alexandria chickens (meat and egg lines). In a recent experiment, positive v_i was also detected for ASM in the SG genotype. Results by Khalil *et al.,* 2004; Ghanem *et al.,* 2008; Elnahal 2011; El-Delebshany *et al.,* 2013; Amin 2014a; Soliman *et al.,* 2020 recorded a higher range (-15.73 to 23.90 eggs) of direct genetic effect on EN90 in Egyptian and Saudi chickens. Moreover, Zahran 2021 recorded similar estimates of -4.8 to 7.2 eggs in some local strains. Positive and negative estimates of v_i have been noticed in many reviewed works of literature for egg weight either EWSM or EWM (Amin 2014a; Hassan *et al.*, 2020; Soliman *et al.*, 2020; Zahran 2021).

Genotype has a direct genetic effect on body weight at sexual maturity either positively (GS and SG genotypes) or negatively (SM and MS genotypes), it is clear that the genetic origin of parental lines played an important role in the sign of the direct genetic effect, since genotypes that have Gimmizah strain in its component positively affected body weight however the genotypes which involved Silver Montazah strain in its origin negatively affected body weight. The same trend regarding v_i on mature body weight has been observed in the current study (Table 3). Results coincide with those found by Zahran 2021, she reported that the Gimmizah strain directly and positively affected BWSM and BWM, she added, the Silver Montazah strain moderately affected BWSM and BWM, while the Sinai strain negatively genetically affected these traits. Negative (for local), and positive (for exotic) effects on BWSM were noticed by Amin 2014a when crossed Mandarah (local) with Sasso (exotic) chickens. The same trend was observed for Alexandria chickens (Soliman *et al.,* 2020). The signs of direct genetic effects could be attributed to the body weight of purebreds included in the improvement plan (Zahran 2021).

The maternal (m_i) effect (Table 3) fluctuated between negative and positive estimates on all traits under investigation (ASM, EN90, EWSM, EWM, BWSM, and BWM). A desired maternal effect was observed for Sinai-sired genotypes, however, an unpreferable maternal effect was noticed in genotypes that the Sinai strain contributed with dams on its origin. The observed direction of maternal effects has been detected in the reviewed literature (Elnahal 2011 and El-Dlebshany *et al.,* 2013; Zahran 2021). In addition, negative maternal effects were observed in Sasso and Mandarah strains for age at sexual maturity (Amin 2014a). Zahran 2021 reported that maternal effects seem to be positively correlated to body weight of maternal lines. Negative maternal effects were detected also by Khalil *et al.,* 2004; Amin 2014a; Hassan *et al.,* 2020. The mentioned fluctuation between negative/positive and small/large maternal effects could be attributed to the variation of breeds in strains (genotypes) involved in crossbreeding plans (Zahran 2021). Egg weight in local chicken strains affected maternally, but these effects are usually negative and non-significant when crossed with exotic strains (Amin 2014a; Hassan *et al.,* 2020; Soliman *et al.,* 2020), fluctuated between positive and negative according to parental body weight when crossing with other local strains (Taha and Abd El-Ghany 2013b).

Reciprocal effects showed reverse signs in direct vs. reciprocal crosses, this fact is expected and logical since the sign of genetic reciprocal effects is inversed by changing the position of parental genotypes (i.e. sire and dam positions). All reviewed literature indicated this fact, and current study results fall in the earlier reported estimates of reciprocal effects from crossbreeding experiments (El-Dlebshany *et al.,* 2013; Soliman *et al.,* 2020; Zahran 2021).

Direct (v_i), maternal (m_i), and reciprocal effects for feed efficiency traits including daily feed consumption (DFC: g) and feed efficiency (FE: g feed/g egg) at maturity (35 wks of age) in all genotypes depicted in Table (4). However negative estimates (favorable) have been recorded by SM genotype regarding studied feed utilization characteristics SG genotypes showed a higher ability of feed converting to eggs (v_i = -1.29 g). Crosses that have SG genotype in dam position achieved the best-desired estimates of feed efficiency traits in recent work. The worst genotype in its utilization efficiency of feed was GS (0.23 g/day and 2.18 g feed/g egg). Slightly higher values were outlined by Amin (2014a) on how crossed Mandarah local strain with both Sasso and Italian exotic chickens. He noted that the direct effect on DFC during 180d of production was negative -9.9, -0.3, and 8.2g for Mandarah, Italian, and Sasso chickens, respectively.

The best maternal effect on feed efficiency traits at 35 wks of age was noticed in SG and GS genotypes that reduced the utilized feed to produce the same mass of eggs (have a negative m_i). The reciprocal effects sign depends on the position of the utilized genotype in the crossing scheme (sire or dam). Maternal and reciprocal effects have been detected for average daily feed consumption and egg production feed efficiency (Amin 2014a), fluctuating between significant and non-significant, however, it was non-significant for Mandarah as a local chicken strain. The estimates of maternal and reciprocal effects on feed consumption and efficiency lie in the previously reported range (-0.9 to 1.6 for daily feed consumption and -0.2 to 0.1 for feed efficiency) according to Amin 2014a and Zahran 2021.

Heterosis (direct line, absolute, percentage):

Heterosis effects on studied egg production traits including ASM, EN90, EWSM, EWM, BWSM, and BWM including line heterosis (h_i), difference from mid-parent and heterosis percentage depicted in Table 4. Direct h_i estimates for all genotypes were negatively signed for ASM (-0.334 to -0.599 days), however, the sign of h_i was positive for egg number (2.325 to 3.105 eggs) reflecting a favorable trend for these two traits. In addition, egg weight and body weight traits (either at sexual maturity or at maturity) showed a positive trend for SG and MS genotypes and a negative for SM and GS genotypes. Unexpectedly, although, direct line heterosis values were desirable for all genotypes, the absolute differences from mid-parent showed some positive 4.10 and 3.55 days for SGMS and SMGS crosses respectively, as well as all differences from mid-parent were negative for EN90 in all crosses from a recent study. Other traits fluctuated between negative and positive estimates.

Heterosis % for ASM showed a negative (desirable) direction for GSSM and MSSG genotypes but with low estimates (-1.086 and -1.105 % respectively) Heterosis for ASM exhibited negative (Khalil *et al.,* 2004; Amin 2008; El-Dlebshany *et al.,* 2013; Taha and Abd El-Ghany 2013b) or positive (Amin 2008; Debes 2017; Soliman *et al.,* 2020) estimates according to the arrangement of parental lines included in the crossbreeding plan. Results of recent work are consistent with those previously reported in local chickens' crossbreeding studies. Heterosis % for EN90 exhibited negative moderate -15.53 (SMGS); -16.91 (SGMS) and slightly low negative -7.343 (GSSM); -7.787 (MSSG) estimates as presented in Table (6). Zahran 2021 reported either positive or negative estimates of h_i in her crossbreeding experiment regarding EN90 for Sinai (0.76), Gimmizah (4.24eggs) and Silver Montazah strain (-2.72). Many authors outlined negative and positive heterosis for EN90 in their experiments ranging between -39.28% (Ghanem *et al.,* 2008) and 37.2% (Amin 2008). According to the reviewed literature, it can be concluded that EN90 is negatively affected (negative heterosis) in hybrids mothered by lower egg production hens, and vice versa. Egg production during the first 90 days tends to be highly affected by heterotic effects (Zahran 2021).

Egg weight (EWSM) revealed a negative h_i for SG and MS genotypes, this effect was positive for SM and GS genotypes, and the same trend was noticed for heterosis percentage for all studied genetic groups. Moreover, EWM showed an opposite trend in h_i, but not for H% since all genotypes from the recent study exhibited positive H% estimates ranging between 0.217 (SMGS) and 7.427 % (MSSG). Results take the previously detected tendency regarding heterosis values (either h_i or H%) which was indicated by Zahran 2021, the heteroses values showed negative and positive small values for EWSM and EWM among all direct and reciprocal crosses in the current experiment. The differences from mid-parent in egg weight lie among all genotypes between 0.095 and 3.30 g as shown in Table 4. Results agreed with Amin 2008, he reported that egg weight either at sexual maturity or at maturity showed heterosis in his diallel crossing experiment. Numerous researchers reported positive low to moderate heterosis estimates for egg weight in their crossbreeding trials (Debes 2017; Soliman *et al.,* 2020, Zahran 2021), while negative values were noted by some and/or others (Taha and Abd El-Ghany 2013b; Hassan *et al.,* 2020; Zahran 2021). Heterosis estimates in the main hanging on the genetic construction of the parental genotypes involved in every report, some exhibited high values (59.8%; Amin 2008) and some others exhibited low or moderate negative (-6.79%; Soliman *et al.,* 2020).

Results given in Table (4) revealed that, h_i for BWSM and BWM recorded considerable positive value in SG and MS genotypes, in contrary negative h_i was observed in SM and GS genotypes. Heterosis % ranged between -9.198% for the SMGS cross and 5.541% for the MSSG cross. Heterosis in BWSM exhibited lower estimates than for BWM in the current study, this agrees with those found by Amin (2008). Our results partially agreed with those outlined by El-Dlebshany *et al.,* 2013, they reported negative values of heterosis for BWM in their work.

Line and percentage of heterosis in feed utilization traits for all genotypes (parental and either direct or reciprocal crosses) are shown in Table 7. Results indicated that, however, DFC showed positive h_i estimates in all parental genetic groups the egg FE revealed negative (favorable) values of h_i equal to -0.792 g in SM and GS genotypes. It has been noticed that although DFC was raised in SM and GS parental lines, they achieved the best utilization h_i for their feed. Negative differences from mid-parent have been detected for all crosses in the current study as well as feed efficiency differences (except SGMS cross 1.175). As a result, the heterosis percentage for every single cross in recent work was negative for either DFC between -23.185 (GSSM) and -30.526 % (MSSG) or feed efficiency since negative H% estimates were detected (except SGMS cross 24.004%) and ranged from -6.844 and -27.813 %. Moderate to high significant estimates of heterosis for feed efficiency traits have been reported by Amin 2014a and Zahran 2021, this trend is consistent with the values recorded in the current study.

General and specific combining abilities:

General (GCA) and specific (SCA) combining abilities for egg production traits in different genotypes and crosses from current work are introduced in Table (5). All parental genotypes showed positive GCA in ASM except the MS (-1.356) genotype. However negative estimates of GCA were noticed for all genotypes except SG line (0.769 eggs) in EN90. Positive GCA in all studied traits has been detected for the SG genotype, in contrast SM genotype exhibited negative GCA in all traits except for the ASM trait, reflecting undesirable complementarity to other genotypes regarding egg production. Our results are in harmony with those obtained by Zahran 2021 in crossbreeding work on some local Egyptian strains (including Sinai, Silver Montazah, and Gimmizah chickens). Slightly higher values of GCA were observed by Amin 2008 who crossed Mandarah local chickens with Sasso and Italian commercial chicken strains.

Fluctuation between positive and negative SCAs was noted for egg production traits for all direct and reciprocal crosses in a recent experiment as shown in Table (5). The best values of SCA recorded by GSSM cross showing Sinai-sired crosses showed the notability of all traits under investigation. Results are in good consistency with those reported by Amin 2008 and Zahran 2021 regarding the egg production traits studied.

General (GCA) and specific (SCA) combining abilities for DFC (g) and FE (g feed/ g egg) are stated in Table 8. The better combiner regarding daily feed consumption in a recent study was GS genotype (-6.912 g) but this is not applied to the FE trait, since the SG genotype realized the best (-0.751 g) GCA among all studied genetic groups. Amin 2014a reported negative GCA estimates in Mandarah chickens for feed utilization traits, but these estimates were positive for Sasso chickens in his research work. Results from a recent study agree with those found by Amin 2014a and Zahran 2021 regarding the values and the signs of GCA for feed efficiency traits.

The most efficiently utilized feed cross among involved crosses in current research is SMGS and MSSG crosses, they realized negative estimates of SCA for these traits. Slightly lower values of SCA have been observed in crossbreeding experiments on the Mandarah strain (local) and two foreign strains (Sasso and Italian), regardless of sign (Amin 2014a). Results are consistent with those reported by Zahran 2021 on her study on three local Egyptian chicken strains (Sinai, Gimmizah, and Silver Montazah).

CONCLUSION

Results from recent work argued that the genetic origin of parental lines played an important role on the sign of the direct genetic effect, it can be concluded that EN90 negatively affected (negative heterosis) in hybrids mothered by lower egg production hens, and vice versa. Egg production during the first 90 days tends to be highly affected by heterotic effects. Additionally, genotypes that have Gimmizah strain in its component positively affected body weight either at sexual maturity or at maturity, however, the genotypes which involved Silver Montazah strain in its origin negatively affected body weight .

Table (1): Egg production traits as affected by crossing between some local chicken strains (Mean ± S.E.)

Genotype	ASM	EN90	EWSM	EWM	BWSM	BWM
SS	184.7 ± 2.24^{ab}	34.4 ± 2.26^{bc}	37.1 ± 0.42^{bc}	45.6 ± 0.64^{bc}	1129.0 ± 19.38^{c}	1185.1 ± 20.83^{d}
GG	189.6 ± 5.60^{a}	37.0 ± 3.94^{abc}	39.2 ± 0.59^{a}	48.5 ± 1.29^{a}	1298.2 ± 22.94^{a}	1332.1 ± 31.87^{a}
MM	181.3 ± 2.87^{ab}	31.3 ± 2.58^{c}	38.7 ± 0.49^{a}	47.5 ± 0.79^{ab}	1200.8 ± 18.65^{b}	1255.6 ± 29.19^{bc}
GSSM	177.6 ± 2.50^{b}	40.8 ± 2.36^{ab}	37.2 ± 0.52^{bc}	44.2 ± 0.69^{c}	1212.3 ± 17.99^{b}	1279.6 ± 27.27^{ab}
MSSG	176.2 ± 2.81^{b}	43.4 ± 2.86^{a}	38.1 ± 0.54^{ab}	47.7 ± 0.87^{ab}	1240.1 ± 19.32^{b}	1292.8 ± 26.43^{ab}
SGMS	182.3 ± 2.84^{ab}	39.1 ± 2.82^{abc}	36.9 ± 0.49^{bc}	47.6 ± 0.8^{ab}	1213.3 ± 18.38^{b}	1305.3 ± 23.46^{ab}
SMGS	183.1 ± 2.22^{ab}	37.2 ± 2.01^{abc}	35.8 ± 0.35^{c}	43.9 ± 0.77^{c}	1139.4 ± 13.14^{c}	1218.9 ± 16.48^{cd}
Total	181.8 ± 1.06	37.3 ± 0.98	37.3 ± 0.19	46.2 ± 0.34	1189.8 ± 7.23	1257.5 ± 9.34
Analysis of variance according to genotype effect:						
Genotype	NS (0.106)	* (0.036)	** (0.00)	** (0.00)	** (0.00)	** (0.00)

SS = Sinai; GG = Gimmizah; MM = Silver Montazah; GSSM, SMGS, MSSG and SGMS = crosses and reciprocal crosses between GS, SM, MS, SG genotypes with sires in the first position; ASM = Average age at sexual maturity; EN90 = Eggs produced during first 90^{th} days of production; EWSM = Average weight of the first five eggs; EWM = Average weight of five eggs at 35 weeks; BWSM = Body weight at the first egg; BWM = Body weight at 35 weeks of age; $^{a, b, c}$ means have the same superscript letter are not differed significantly in each column.

Table (2): Daily feed consumption (g/hen/day) and egg feed efficiency (g feed/g egg) as affected by crossing between some local chicken strains (Mean ± S.E.).

Cross	DFC35	EFE35
SS	82.14 ± 2.03^{c}	5.02 ± 1.17
GG	87.96 ± 2.83^{abc}	7.24 ± 2.61
MM	84.88 ± 1.74^{abc}	6.61 ± 1.41
GSSM	90.25 ± 1.75^{a}	5.21 ± 0.58
MSSG	85.2 ± 2.1^{abc}	4.56 ± 0.5
SGMS	88.65 ± 2.09^{ab}	6.07 ± 1.19
SMGS	82.65 ± 1.21^{bc}	5.1 ± 0.69
Total	85.8 ± 0.77	5.56 ± 0.41
Analysis of variance according to genotype effect:		
Genotype	* (0.021)	NS (0.697)

SS = Sinai; GG = Gimmizah; MM = Silver Montazah; GSSM, SMGS, MSSG and SGMS = crosses and reciprocal crosses between GS, SM, MS, SG genotypes with sires in the first position; DFC35 = Daily feed consumption at maturity (g); EFE35 = egg feed efficiency (g feed / g egg) at 35 wks of age; $^{a, b, c}$ means have the same superscript letter are not differed significantly in each column.

Table (3): Average direct genetic effects (li), average maternal genetic effects (mi), and reciprocal effect for egg production traits in all genetic groups.

	ASM	EN90	EWSM	EWM	BWSM	BWM	DFC35	EFE35
Line	**vi (direct genetic effect of the i-th line)**							
SG	5.04	0.58	-1.84	0.81	11.65	-19.37	4.87	-1.29
SM	2.55	-1.48	-3.26	-1.34	-58.32	-47.09	-5.37	-0.01
GS	-1.15	-1.60	-0.41	0.74	63.01	146.67	0.23	2.18
MS	-6.43	2.50	5.50	-0.21	-16.35	-80.21	0.27	-0.89
Line	**mi (maternal genetic effect of i-th line)**							
SG	-3.04	2.15	0.62	0.05	13.38	-6.26	-1.73	-0.76
SM	-2.75	1.81	0.68	0.13	36.35	30.45	3.80	0.06
GS	2.75	-1.80	-0.68	-0.13	-36.35	-30.45	-3.80	-0.05
MS	3.04	-2.15	-0.62	-0.05	-13.38	6.26	1.73	0.76
Cross	**rij (reciprocal effect in the cross ij (Model C))**							
SGMS	3.035	-2.150	-0.615	-0.050	-13.375	6.260	1.725	0.755
SMGS	2.750	-1.805	-0.680	-0.135	-36.345	-30.455	-3.800	-0.055

S = Sinai; G = Gimmizah; M = Silver Montazah; GSSM, SMGS, MSSG and SGMS = crosses and reciprocal crosses between GS, SM, MS, SG genotypes with sires in the first position; ASM = Average age at sexual maturity; EN90 = Eggs produced during first 90th days of production; EWSM = Average weight of the first five eggs; EWM = Average weight of five eggs at 35 weeks; BWSM = Body weight at the first egg; BWM = Body weight at 35 weeks of age; DFC35 = Daily feed consumption at maturity (g); EFE35 = egg feed efficiency (g feed / g egg) at 35 wks of age.

Table (4): Line heterosis, heterosis (absolute and percentage of mid-parent), and average heterosis for egg production traits.

	ASM	EN90	EWSM	EWM	BWSM	BWM	DFC35	FE35
Line	**hi (line heterosis i)**							
SG	-0.334	2.325	-1.601	0.640	15.884	83.835	14.353	1.538
SM	-0.599	3.105	1.074	-2.380	-39.781	-65.465	19.023	-0.792
GS	-0.599	3.105	1.074	-2.380	-39.781	-65.465	19.023	-0.792
MS	-0.334	2.325	-1.601	0.640	15.884	83.835	14.353	1.538
Cross	**Diff. (Difference from mid-parent)**							
SGMS	4.100	-7.970	-1.425	3.200	38.355	62.540	-33.985	1.175
SMGS	3.550	-6.845	1.185	0.095	-40.280	-123.47	-34.840	-1.965
GSSM	-1.950	-3.235	2.545	0.365	32.410	-62.565	-27.240	-1.855
MSSG	-1.970	-3.670	-0.195	3.300	65.105	50.020	-37.435	-0.335
Cross	**H % (heterosis as a % of mid-parent)**							
SGMS	2.301	-16.91	-3.717	7.202	3.264	5.032	-27.712	24.004
SMGS	1.977	-15.53	3.417	0.217	-3.414	-9.198	-29.654	-27.813
GSSM	-1.086	-7.343	7.340	0.833	2.747	-4.661	-23.185	-26.256
MSSG	-1.105	-7.787	-0.509	7.427	5.541	4.025	-30.526	-6.844

S = Sinai; G = Gimmizah; M = Silver Montazah; GSSM, SMGS, MSSG and SGMS = crosses and reciprocal crosses between GS, SM, MS, SG genotypes with sires in the first position; ASM = Average age at sexual maturity; EN90 = Eggs produced during first 90th days of production; EWSM = Average weight of the first five eggs; EWM = Average weight of five eggs at 35 weeks; BWSM = Body weight at the first egg; BWM = Body weight at 35 weeks of age; DFC35 = Daily feed consumption at maturity (g); EFE35 = egg feed efficiency (g feed / g egg) at 35 wks of age.

Table (5): General and specific combining ability for parental lines and crosses for egg production traits.

	ASM	EN90	EWSM	EWM	BWSM	BWM	DFC35	FE35
Line	**GCA (general combining ability)**							
SG	0.444	0.769	0.008	1.781	29.315	4.966	-4.355	-0.751
SM	0.467	-1.561	-1.099	-1.316	-20.33	-25.178	-6.245	-0.161
GS	1.067	-2.804	-0.602	-0.713	-4.118	19.106	-6.912	0.529
MS	-1.356	-0.024	2.045	1.407	11.065	-11.141	-4.738	-0.114
Cross	**SCA (specific combining ability)**							
SGMS	3.846	-4.463	-1.911	-0.561	-16.32	28.108	-5.632	1.328
SMGS	2.250	-1.303	0.792	0.956	-25.43	-58.426	-7.568	-0.876
GSSM	-3.250	2.308	2.152	1.226	47.258	2.484	0.032	-0.766
MSSG	-2.224	-0.163	-0.681	-0.461	10.428	15.588	-9.082	-0.182

S = Sinai; G = Gimmizah; M = Silver Montazah; GSSM, SMGS, MSSG and SGMS = crosses and reciprocal crosses between GS, SM, MS, SG genotypes with sires in the first position; ASM = Average age at sexual maturity; EN90 = Eggs produced during first 90th days of production; EWSM = Average weight of the first five eggs; EWM = Average weight of five eggs at 35 weeks; BWSM = Body weight at the first egg; BWM = Body weight at 35 weeks of age; DFC35 = Daily feed consumption at maturity (g); EFE35 = egg feed efficiency (g feed / g egg) at 35 wks of age.

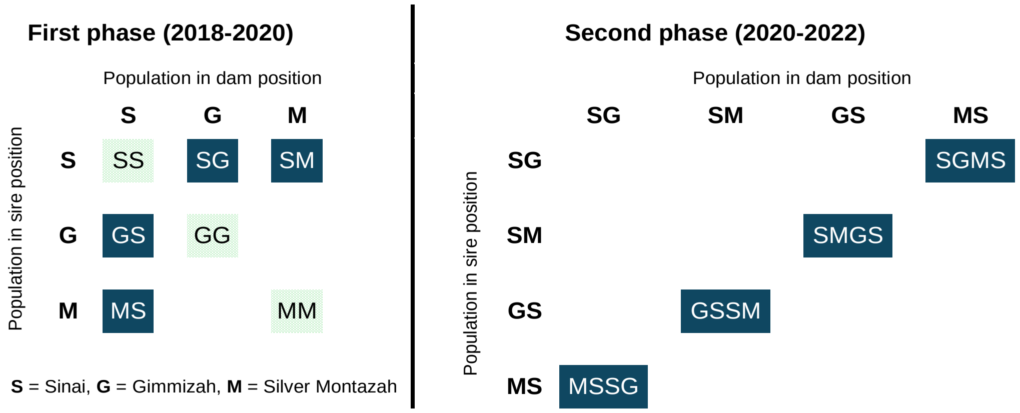

Figure (1): Partial diallel mating design used in the current study.

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الملخص العربى

تقييم صفات إنتاج البيض والكفاءة الغذائية لهجن جديدة باستخدام سلالات دجاج محلية

محمد السيد سلطان ، أحمد عبد الوهاب عنب ، إيمان متولى أبوعليوه ، مصطفى محمد عماره و سامى عبد الحى فراج
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أجريت الدراسة بهدف تكوين وتقييم هجن جديدة عن طريق الخلط بين بعض سلالات الدجاج المحلى فى مزرعة أبحاث الدواجن بقسم إنتاج الدواجن والأسماك – كلية الزراعة – جامعة المنوفية. تم استخدام سلالات دجاج سيناء والجميزة والمنتزه الفضى . تم تسجيل صفات إنتاج البيض بصورة فردية متضمنة العمر عند النضج الجنسى ، إنتاج البيض خلال الـ 90 يوم الأولى من الإنتاج ، وزن البيضة ، وزن الجسم عند النضج الجنسى ووزن الجسم عند النضج (35 أسبوع) علاوة على معدل استهلاك العلف اليومى والكفاءة الغذائية لإنتاج البيض . استخدم برنامج الخلط المتبادل الجزئى وجمعت البيانات لتقييم أدآء الهجن المختلفة الناتجة. تم تقدير تأثيرات الخلط الوراثية باستخدام الطرق الإحصائية المناسبة . لوحظت فروق معنوية بين التراكيب الوراثية تحت الدراسة (P=0.036) . حققت كل الهجن الناتجة متوسط إنتاج بيض خلال الـ 90 يوم الأولى أعلى من جميع الخطوط الأبية تروواح بين 37.2 (الهجين SMGS) و 43.4 بيضة (الهجين MSSG) مقارنة بـ 31.3 بيضة (المنتزه الفضى) و 37.0 بيضة (الجميزة) . كان الهجين MSSG هو الأفضل فى كفاءة تحويل غذائه حيث استخدم 4.56 جم علف لإنتاج 1 جرام بيض . وكان أسوأ الخطوط فى كفاءة تحويل الغذاء دجاج الجميزة الذى استخدم 7.24 جم علف لإنتاج 1 جرام من البيض . أفضل تأثير وراثى كان للتركيب الوراثى MS (والذى تكون أصلاً بخلط ذكور المنتزه الفضى مع إناث دجاج سيناء) وذلك بالنسبة لجميع صفات إنتاج البيض تحت الدراسة والتى شملت عمر النضج الجنسى (-6.43 يوم) ، إنتاج البيض خلال أول 90 يوم (2.5 بيضة) وزن البيضة عند النضج الجنسى (5.5 جم) ، وزن البيضة عند النضج (-0.21 جم) ، وزن الجسم عند النضج الجنسى (-16.35 جم) و وزن الجسم الناضج (80.21 جم). أظهرت قوة الهجين اتجاهاً مرغوباً (سالب) للهجن GSSM و MSSG ولكن بقيم منخفضة (-1.086 و -1.105% على التوالى) . كانت قوة الهجين لصفة العمر عند النضج الجنسى سالبة بقيم متوسطة -15.53% (الهجين SMGS) و -16.91% (الهجين SGMS) وبقيم تميل إلى الإنخفاض -7.343% (الهجين GSSM) و -7.787% (الهجين MSSG) . يتضح من النتائج أن إنتاج البيض خلال الـ 90 يوم الأولى تأثر سلباً (قوة هجين سالبة) فى الهجن التى كانت أمهاتها من دجاج منخفض فى إنتاج البيض والعكس صحيح ، وأن إنتاج البيض خلال الـ 90 يوم الأولى يتأثر تأثراً كبيراً بالخلط والتهجين بين السلالات فى التجربة الحالية .