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GENETIC AND PHENOTYPIC EVALUATION OF EGG PRODUCTION TRAITS IN SELECTION EXPERIMENT PERFORMED ON BENHA CHICKENS

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ABSTRACT: A selection program for four generations (base and three selected generations) was started in 2011 in Benha University, Egypt to improve egg production traits in a synthetic line named Benha chickens. A total of 18 cockerels and 180 pullets were selected from Benha base population (control) according to their BLUP values for egg number during 90 days of laying Data of 756 pedigreed hens were used to obtain estimates of heritability, genetic and phenotypic correlations and BLUP for egg production traits, age (ASM) and body weight at sexual maturity (BWSM), weight of the first egg (WFE), egg number (EN), rate of laying (RL), egg mass (EM) recorded during 90 days (EM90D) and 120 days (EM120D) of production after sexual maturity. The selection effects, correlated responses and the genetic and phenotypic trends for egg production traits across generations were quantified and clarified applying the updated approach of the animal model program of BLUPF90. Heritability estimates were moderate; being 0.27, 0.32, 0.42, 0.31, 0.34, 0.28, 0.33, 0.14 and 0.19 for ASM, BWSM, WFE, EN90D, EM90D, EN120D, EM120D, RL90D and RL120D, respectively. The ranges in BLUP of most egg production traits in the control generation were higher than those estimates in the selected generations. Accuracies of BLUP estimates for egg production traits in all generations (control and selected) were moderate or high. The three selected generations were superior in most egg production traits than the base generation (P <0.05) and the contrasts among estimates of these generations were significant (P<0.05). The phenotypic trend increased from 1642 to 1759 g, 28.1 to 30.2 g, 57 to 64 egg, 79 to 84 egg, 2593 to 2977g and 3651 to 4027 g for BWSM, WFE, EN90D, EN120D, EM90D and EM120D, respectively. The genetic trends across the generations clarifying that the initial BLUP estimates for BWSM, WFE, EN90D, EN120, EM90D, EM120D were 12 g, 0.07 g, 0.9 egg, 0.5 egg, 0.57 g and 38 g in the base generation, then gradually increasing as the generation of selection advanced till reached 21 g, 0.03 g, 2 egg, 2.2 egg, 72g and 63 g in the first generation, and reached 32 g, 0.52 g, 3.4 egg, 4 egg, 87 g and 89 g in the second generation and finally 45 g, 0.8 g, 4.8 egg, 5.5 egg, 102 g and 114g in the third generation, respectively. The accumulative correlated selection responses were 140.5 g, 1.99 g, 5.45 egg, 418 g, 371g, 7.52 % and 4.22 % for BWSM, WFE, EN120D, EM90D, EM120D, RL90D and RL120D, respectively.

Keywords: Selection-egg production traits-genetic and phenotypic trends-correlated responses.

INTRODUCTION

Partial recording of egg production in pullets is used to increase the efficiency of genetic selection as well as to shorten the generation interval. Results of many investigators showed that more genetic gain could be obtained in egg production when using partial recording (EL-Labban *et al.*, 2011; EL-Attrouny, 2011). Most of the selection experiments in chickens supported the efficacy of partial recording as a selection criterion in improving both, part and annual egg production (El-labban, 2000; Iraqi, 2008; Iraqi *et al*., 2012). Selection for egg number as a partial record has decreased egg weight and reduced age at sexual maturity (Abd El-Ghany, 2005; Saleh *et al.*, 2006; Shalan *et al*., 2012)

In Egypt, the long-term selection experiments for productive traits were limited (Abd El-Ghany, 2005; Kosba *et al*., 2006; Iraqi *et al.*, 2012). Several studies reported that selection for egg number during the first 90 days of the laying period resulted in reducing the age at sexual maturity and increasing the annual egg production (Soltan *et al*., 2009; Aly *et al*., 2010a; EL-Attrouny, 2011; Younis *et al.*, 2014). A new synthesized line, named Benha chickens (B), that is characterized by high productivity of eggs could be used in solving this problem of egg shortage (Iraqi *et al.*, 2012 and 2016).

In the present study, a selection experiment was practiced on the synthesized chicken line (Benha, B). The selection experiment was carried out for three generations and the selection criterion was egg number during the first 90-days of egg production. The main objectives of the present study were: 1) to estimate the genetic parameters and BLUP estimates across three generations of selection for egg production traits, 2) to quantify the selection effect and comparing the generation contrasts, 3) to clarify the phenotypic and genetic trends across generations, and 4) to estimate the correlated responses in egg production over the three generations of selection in Benha chickens.

MATERIALS AND METHODS

Selection experiment and breeding plan used:

A selection experiment was carried out at the Poultry Research Farm, Department of Animal Production, Faculty of Agriculture, Benha University, Egypt during the period from November 2011 and terminated in May 2015. A synthesized line of chickens, Benha line (B), was used in this study, and was developed by selection for egg number during first 90 days of egg production in Benha base population. The Benha base population was formed by crossing Golden Montazah with White Leghorn chickens and using the BLUP estimates to select the birds for three generations (Iraqi *et al.*, 2012).

A total of 18 cockerels and 180 pullets were selected according to their BLUP estimates for egg number during the first 90 days of egg production from Benha base population. Data of 756 hens were produced by 69 sires and 484 dams in four generations (base and three selected generations). Egg number (EN) was recorded for each hen by counting the number of eggs laid during the first ninety days after sexual maturity. Each selected cock was mated with 10 selected hens and housed separately in breeding pen to produce the first selected generation (G_1), then selection was practiced further for two generations to produce the second (G_2) and third (G_3) selected generations. In each generation, the pedigreed eggs in each breeding pen were collected daily for fifteen days and then incubated. The structures of data collected during the experiment are presented in Table 1.

Management:

Upon hatch, chicks in each generation were wing - banded and reared in floor brooders, then transferred to the floor pens. Chicks were fed *ad libitum* a diet containing 21% protein and 2950 kcal/kg during the growing period (from hatch to 8 weeks of age, a diet containing 18% protein and 2850 kcal/kg during the rearing period (from 8-20 weeks of ageand a diet containing 16% protein and 2700 kcal/kg during the laying period after 20 weeks of age. The feed requirements were supplied according to NRC (1994). All the birds were treated and medicated similarly throughout the experimental period.

Data and model of analysis

Records on 756 hens from different generations were collected to study the following traits: age and body weight at sexual maturity, weight of the first egg, egg number, rate of egg laying, egg weight and egg mass recorded during 90 days of and 120 days of production after sexual maturity. Rate of egg production per day during the first 90 days = (egg number in 90 days/90) ×100, and the rate of egg production per day during the first 120 days = (egg number in 120 days/120) ×100. Multi-trait animal model (in matrix notation) was used to analyze egg production traits.

$y = Xb + Za + e$

Where: y = n×1 vector of observation of the hen, n = number of records; X= design matrix of order n×p, which is related to the fixed effects of generation (four levels), b = p×1 vector of the fixed effects of generation; a = vector of random effects (additive genetic) of the hen; X and Z are the incidence matrices relating to fixed effects and the additive genetic effects respectively; and e = n×1 vector of random residual effects, NID (0, σ^2e). The permanent environment has not been considered in the model because each generation has produced in one year thus resulting in confounding effect between generation and year effects which causes error in the model outcomes. Heritability estimates of egg production traits were computed as: $h^2{}_a = \frac{\sigma^2{}_a}{\sigma^2{}_a + \sigma^2{}_e}$; where: σ^2a and σ^2e are the variances due to the direct additive genetic effects and the random error, respectively. The genetic (r_g) and phenotypic (r_P) correlations between egg production traits were also estimated.

Estimation of BLUP:

The BLUP were estimated using BLUPF90 Fortran program (Misztal *et al.*, 2014). Birds' solutions are computed from the pedigree file, one bird at a time (for both birds with and without records, i.e. hens, sires and dams). These BLUP estimates were calculated based on the theory of Kennedy (1989). The accuracy of BLUP (r_A) for each individual was estimated according to Henderson (1975) as: $r_{A\hat{A}} = \sqrt{1 + F - d_j\alpha}$; Where: F= inbreeding coefficient, dj = the diagonal element of inverse of the appropriate block coefficient matrix, and $\alpha = \sigma^2 e/\sigma^2 a$.

Estimation of selection effect:

The estimated (co) variances were used to estimate the fixed and the random effects by solving the corresponding mixed model equations using the BLUPF90 software (Misztal *et al.*, 2014). The estimates of the error (co) variance matrix were also obtained. Estimates of the contrasts between the four generations of selection were obtained by generalized least-squares analysis using the BLUPF90 software.

Genetic and phenotypic trends:

The phenotypic trend was measured as the regression of least - squares estimates on generation number, while the genetic trend was measured by regressing the BLUP estimates on generation number. As stated before, the BLUP estimates of the birds with and without records were estimated using the BLUPF90 program (Misztal *et al.*, 2014).

Estimation of correlated selection responses:

The correlated selection response (CR_Y) in each trait (Y) was calculated using the following equation of Falconar and Meckay (1996): $CR_Y = (i_X)(h_X)(h_Y)(r_{GXY})(\sigma_{PY})$; Where i_X is the selection intensity assuming to be one for comparison only, h_X and h_Y are the square roots of heritability estimates of the two traits X and Y, respectively, r_{GXY} is the genetic correlation between the two traits and σ_{PY} is the standard deviation of phenotypic value of trait Y.

RESULTS AND DISCUSSION

Actual means and variations:

The actual means, standard deviations (SD) for egg production traits in Benha chickens are shown in Table (2). The actual means for ASM and BWSM were 161 d and 1704 g. Abd El-Ghany (1996) found that the actual means of BWSM in Bandara, Gimmizah and El-Salam chickens were 2025, 1943 and 1912 g, respectively. Samak (2001) reported that the means of ASM were 161, 160 and 164.4 d in Gimmizah, Mamourah and Bandara chickens, respectively, while the corresponding BWSM means were 1770, 1813 and 1823 g.

The actual means for egg number during the first 90 days of laying (EN90D) and egg number during the first 120-days of laying (EN120D) were 69 and 81.4 egg (Table 2). Amin (2015) reported that the mean of EN90D was 65 eggs and the mean of EM120D was 3296 g in Mandarah chickens.

The actual mean of the rate of egg production per day during the first 90 days (RL90D) and rate of egg production per day during the first 120 days (RL120D) were 67 and 68%, respectively (Table 2). Hassan *et al*. (2000) found that the means of rate of egg production for Alexandria, Golden and Silver Montazah were 47, 47.7 and 48%, respectively. Iraqi *et al.* (2012) found that the averages of RL90D and RL120D were 47 and 51% in Golden Montazah chickens, while they were 58 and 62% in White Leghorn-chickens. The means of the pause periods during the first 90 days and during the first 120 days were 29 and 39 d, respectively.

The percentages of variation (V%) for egg traits in Benha chickens presented in Table 2 ranged from 3.0 to 13.2%. Yousefi *et al.* (2013) found that the percentages of variation in ASM, BWSM and EN90D were 9.6, 11.2 and 4.8%, respectively. Jobin (2013) reported variation percentages **of** 6.7, 38.9 and 33.2% in ASM, EN90D and RL90D of Red Rhode Island chickens.

Variance components and heritability:

Estimates of additive (σ^2a) and residual (σ^2e) variances for egg production traits are given in Table (3). These estimates showed that σ^2a were moderate **to** high in magnitude for all traits; they were 8.9 d for ASM, 103 g for BWSM, 4.2 g for WFE, 34.4 eggs for EN90D, 55.3 g for EM90D, 124 egg for EN120D, 148.3 g for EM120D, 3.6% for RL90D, 26.6% for RL120D, 3.2 d for PP90D and 2.1 d for PP120D, respectively. Similar estimates of additive genetic variance for egg production traits computed from sire models were reported by El-Labban (2000), Iraqi (2008) and EL-Attrouny

(2011). Estimates of additive σ^2a for PP90D and PP120D were 3.2 and 2.1 d, respectively (Table 3). El-Attrouny (2011) reported that estimates of σ^2a ranged from 3.2 to 2.1 for pause period traits.

Heritability estimates for egg production traits are presented in Table (3). The estimates for ASM, BWSM, WFE, EN90D, EM90D, EN120D, EM120D, RL90D, RL120D, PP90D and PP120D were mostly moderate; being 0.27, 0.32, 0.42, 0.31, 0.34, 0.28, 0.33, 0.14, 0.19, 0.07 and 0.06 respectively. These estimates agreed with the estimates reported on native chickens in Egypt using sire and dam or animal model analyses. **(**Khalil *et al*., 2004; Saleh *et al.*, 2006; Kosba *et al.,* 2006; EL-Attrouny, 2011; Shalan *et al*., 2012; Abou EL - Ghar and Debes, 2013; Younis *et al*., 2014; Abdel A'al, 2016), which were within the ranges of 0.01 to 0.65 for ASM, 0.10 to 0.56 for BWSM, 0.01 to 0.74 for EN90D, 0.02 to 0.89 for EN120D, 0.03 to 0.66 for EM120D and 0.08 to 0.98 for WFE**.**

Genetic and phenotypic correlations:

Estimates of the genetic correlations between egg production traits showed that ASM was positively correlated with BWSM, WFE, PP90D by 0.65, 0.20, 0.32, respectively (Table 4), and was negatively correlated with EN90D (-0.29) and RL90D (-0.31). These correlations indicate that when the pullet reached sexual maturity at early age, it was lighter in weight. The estimates are in agreement with those reported by Iraqi *et al*. (2011), who estimated genetic correlation of 0.84 between ASM and BWSM. Also, the positive estimate of genetic correlation between BWSM and WFE (0.20) indicates that pullets with high body weights have higher weights for the first egg. These results are in agreement with EL-Labban *et al. (*2011) and EL-Attrouny (2011).

Estimate of the genetic correlation was 0.19 between EN90D and EM90D and 0.65 between EN90D and RL90D. These negative and closely correlations, meaning that the pullets producing more number of eggs and could having lower pause periods. The estimate of genetic correlation among EN90D and PP90D was -0.99 (Table 4).

The estimates of phenotypic correlations are presented in Table (4). The estimates between ASM and BWSM, ASM and EN90D, ASM and RL90D and BWSM and WFE were positive and low (0.14, 0.31, 0.24 and 0.23, respectively). The estimates of phenotypic correlation between WFE and EM90D, EN90D and EM90D and EN90D and RL90D were 0.36, 0.54 and 0.41, respectively. The correlations between ASM and WFE, ASM and PP90D and EN90D and PP90D, were -0.20, -0.29 and -0.99, respectively Shalan *et al*. (2012) reported that the estimate of phenotypic correlation between ASM and EN90D was 0.18. Younis *et al.* (2014) reported estimates of phenotypic correlation of -0.37 and 0.81 between ASM and EN90D and EN90D and EM90D, respectively.

BLUP estimates across generations:

The ranges of BLUP estimates and their standard errors and accuracy of prediction ($r_{\hat{a}}$) in different generations are presented in Table (5). The ranges in BLUP for most egg production traits were moderate to high in all generations; the ranges in the control, 1st, 2nd, and 3rd generations were 5.8, 5.8, 5.5 and 5.5 days for ASM, 317, 337, 360 and 345 g for BWSM, 4.7, 4.1, 4.7 and 1.45 g for WFE, 26, 25, 26 and 24 egg for EN90D, 702, 700, 740 and 745 g for EM90D, 25, 27, 25 and 25 egg for EN120D, 744, 740, 765 and 765 g for EM120D, 6.7, 6.4, 6.5 and 6.3% for RL90D, 6.2, 6.1, 5.8 and 5.8 for RL120D, 6.8, 6.6, 6.5 and 6.5 for PP90D and 5.9, 5.8, 5.6 and 5.6 d for PP120D, respectively. The high estimates of BLUP for egg production in the base generation indicate that improvement of egg production traits in Benha chickens could be achieved through selection.

Accuracies of BLUP for egg production traits in all generations were high and nearly similar (Table 5). This may be due to that the estimates of heritability were highly associated with more available pedigree information for all individuals. Accuracies of BLUP for egg production traits ranged from 0.51 to 0.85 in the base generation, 0.52 to 0.81 in the first selected generation, 0.52 to 0.84 in the second selected generation and 0.49 to 0.81 in the third selected generation. These results fall within the ranges reported by Hassan (2008)

Selection effect and generation contrasts:

Estimates of the most of egg production traits in the three generations of selection, obtained by generalized least squares using BLUPF90, were superior (P <0.05) than **in** the base generation (Table 6). Based on BLUPF90, the contrasts among estimates of these generations were significant (P<0.05). The third generation showed superiority in egg production traits compared to the average of the first and second generations. These results are in agreement with Soltan and Ahmed (1990), Abou El-Ghar *et al.* (2003) and Abd El_Ghany (2005), who reported that the means of most egg production traits in the selected generations were superior than in the control population. In Fayoumi chickens, Younis and Abd El-Ghany (2004) reported that the averages of BWSM during three generations of selection were 1554, 1527 and 1514 g, while these means were 1536, 1541 and 1554 g for the control line in the same generations, respectively. Aly *et al.* (2010a) found that the averages of ASM were 166, 171, 171, 191 and 172 day in the base, 1st, 2nd ,3rd and 4th generations of the selected Mandarah line, while the averages were 176, 175, 176, 198 and 180 day for the control Mandarah line, respectively. Shalan *et al.* (2012) reported that the averages of ASM of the base, 1st, 2nd,3rd and 4th generations were 197, 189, 190, 176 and 173 day for the selected population, while the averages were 196, 192, 197, 195 and 191 day for the control population, respectively. Aly *et al.* (2010a) indicated that the averages of RL90D were 34, 49, 50, 58 and 59% for the base, 1st, 2nd, 3rd and 4th generations of Mandarah selected line, while the averages were 34, 44, 45, 44 and 45% for Mandarah control line, respectively.

The third generation was superior in most of the studied traits compared to the average of the first and second generations, and this is in agreement with previous results obtained on native chickens in Egypt (Taha and Abd El_Ghany *et al.*, 2013; Younis *et al.*, 2014; EL-Attrouny, 2017). These results indicated also that selection for egg number during the first 90 days of laying in Benha line of chickens was associated with an increase in egg number and this improvement was associated with an early sexual maturity and heavy body weight, weight of first egg, egg mass and high rate of laying.

The phenotypic trend across generations:

The phenotypic trends for egg production traits across the generations are presented in Figure 1. The first egg was laid at the age of 162.7 d in the base generation, then it gradually decreased to 161.6, 160.6 and 159.6 d in the first, second and third generation of selection, respectively (Fig

1-A). The reduction in age at sexual maturity during the three generations reflected that selection for high egg number could improve ASM in chickens. The same phenotypic trend was reported by Younis and Abd El-Ghany (2004), Abd El-Ghany (2006) and Aly *et al*. (2010).

The initial phenotypic value for body weight at sexual maturity was 1642 g in the base generation, and increased to 1681, 1720 and 1759 g in the first, second and third generation of selection, respectively (Figure 1-B). These results may be due to the positive genetic and phenotypic correlations between egg number and body weight at sexual maturity. The same phenotypic trend was reported by Younis and Abd El-Ghany (2004); El-Weshahy (2010); EL-Attrouny (2017) and EL-Attrouny *et al.* **(2017).**

The phenotypic value for weight at first egg was 28.1g in the base generation (Fig. 1-C), and reached to 29, 30 and 30.2 g in the first, second and third generation of selection, respectively. This trend could be due to that selected generations are characterized by heavier body weight at sexual maturity. Selection for partial egg recording is a common approach for improving egg production, which has shown to attain positive genetic progress**.** Egg number of the first 90 days of laying was positively highly correlated with the whole record (Soltan, 1997 and Flock, 1998).

The phenotypic values for EN90D and EM90D were 57 egg and 2593 g in the base generation (Fig.1-D and 1-E), and increased to -59 egg and 2721 g in the first generation, and 61 egg and 2849 g in the second generation and 64 egg and 2977 g in the third generation,. The selected generations yielded higher egg number during the first 90 days than the base generation. These results agreed with the results of El-Hadad (2003) and Younis and Abd El-Ghany (2004). Also Flock (1998) and Abou-Eliwa (2004) stated that selection among different generations was associated with increasing in egg number and egg mass in chickens.

The phenotypic values for EN120D and EM120D were 79 egg and 3651g in the base generation (Fig.1- F and 1-G), and increased to 80 egg and 3777 g in the first selection generation, 82 egg and 3902 g in the second selection generation, and 84 egg and 4027 g in the third selection generation.

For the rate of laying, the phenotypic values were 63 and 66% for RL90D and RL120D in the base generation, and gradually increased to 66 and 67% in the first generation, 68 and 69% in the second generation, and 70.1 and 69.3% in third generation,(Fig.1-H and 1-I). These results indicated that selection for three generations for egg number resulted in increasing the rate of egg laying, which is in agreement with the results of Younis and Abd El-Ghany (2004) and Aly *et al.* (2010b). The phenotypic trend for PP90D and PP120D showed that the initial values were 32 and 41 d in the base generation (Fig.1- J and 1-K), and gradually decreased to 30 and 39 d in the first generation, 28 and 38 d in the second generation, and 28 and 36 d in the third generation. The same trend was observed by Iraqi *et al.* (2012).

The genetic trend across generations:

The genetic trends for egg production traits across the generations are presented in Figure 2. The initial BLUP for ASM was 0.84 day in the base generation, then gradually decreased in the subsequent selection generations to 0.1 day in the third generation (Fig. 2-A). The initial BLUP for BWSM and WFE were 12 and 0.07 g in the base generation (Fig. 2-B and 2-C), and increased to 21 and 0.3 g in the first generation, 32 and 0.52 g in the second generation and 45 and 0.8 g in the third generation.

The initial BLUP for EN90D, EN120D, EM90D, EM120D, RL90D and RL120D were 0.9 egg, 0.5 egg, 57 g, 38 g, 1.0% and 0.8%, respectively in the base generation (Fig.2-D, 2-E, 2-F, 2-G, 2-H, and 2-I), and gradually increased to 2 egg, 2.2 egg, 72 g, 63 g, 1.3% and 1.1% in the first generation, 3.4 egg, 4 egg, 87 g, 89 g, 1.6% and 1.4% in the second selected generation and 4.8 egg, 5.5 egg, 102 g, 114 g, 2.1% and 1.8% in the third selected generation. The genetic trend for PP90D and PP120D showed initial values of 1.5 and 1.3 d in the base generation (Fig.2-J and 2-K), and gradually decreased to 1.3 and 1.1 d in the first generation, 0.9 and 1.0 d in the second generation, and 0.8 and 0.9 d in the third generation.

Correlated selection responses

As a result of selection for EN90D, the correlated response for unselected traits of ASM, BWSM, WFE, EN120D, EM90D, EM120D, RL90D, RL120D, PP90D and PP120D at different generations are presented in Table (7).

A sharp decline was observed in ASM after three selected generations since the reduction in correlated response of ASM was -1.15, -0.51 and -0.81 d in the 1st, 2nd and 3rd selected generation, respectively, and the cumulative response was -2.47 d. A similar decline in age at sexual maturity was found by Kosba et al. (2002), Aly *et al*. (2010a), Shalan *et al*. (2012); Younis *et al*. (2014) and EL-Attrouny (2017). The correlated improvement response in BWSM was 88.3, 17.1 and 35.1 g for 1st, 2nd and 3rd generation respectively, and the cumulative response after three generations of selection was 140.5 g, indicating that selection for egg number was associated with an increase in BWSM. Similar trend was observed by Shalan *et al.* (2012a). The correlated response for WFE was 0.98, 0.69 and 0.32 in the 1st, 2nd and 3rd generation and the cumulative response was 1.99 g, indicating that selection for egg number could increase WFE.

Selection for egg number during the first 90 days of laying could improve egg mass since the correlated response of egg mass at 90 days was 195, 98 and 125 g in the 1st, 2nd and 3rd generation of selection respectively, with 418 g of cumulative response. The correlated response of EN120D was 3.1, 1.4 and 0.95 eggs in the 1st, 2nd and 3rd generation, respectively with cumulative improvement response of 5.4 eggs. The correlated response for EM120D was 215, 40 and 116 g in the same generations, respectively, and the cumulative response was 371g. The response may be due to the high and positive genetic and phenotypic correlations. Similar responses were reported by Younis and Abd El-Ghany (2004), Saleh *et al*. (2006), Aly *et al.* (2010b) and Younis *et al*. (2014).

The correlated response for RL90D was 3.4, 2.2 and 1.9% in the 1st, 2nd and 3rd generation respectively, and the cumulative response was 7.5%, indicating that selection for egg number was associated with the increase in RL90D. A similar trend was observed in the rate of lay during the first 120 days (RL120D). These responses are similar to those obtained by Aly *et al.* (2010a) and Iraqi *et al.* (2012). A sharp decline was observed in PP90D after three selected generations since the reduction in correlated response of PP90D was -3.0, -2.1 and -0.9 d in the 1st, 2nd and 3rd selected generation, respectively, and the cumulative reduction response was -6.0 d. A similar trend was observed in the pause periods during the first 120 days of lay (PP120D). Similar responses were reported by El-Attrouny (2017).

Table (1): Numbers of sires, dams and pullets used in the selection experiment.

Generation	No. of sires	No. of dams	No. of Pullets
Base (control) population	17	113	180
1st generation of selection	18	119	180
2nd generation of selection	17	117	180
3rd generation of selection	17	135	216
TOTAL	69	484	756

Table (2): Actual means, standard deviations (SD) and percentages of variation (V %) for egg traits at different ages in Benha chickens.

Trait	**Symbol**	**Mean**	**SD**	**V%**
Age at sexual maturity (days)	ASM	161	4.9	3.0
Body weight at sexual maturity (g)	BWSM	1704	226	13.2
Weight of first egg (g)	WFE	30	2.3	7.5
Egg number at the first 90-days of laying (egg)	EN90D	69	3.4	5.0
Egg number at the first 120-days of laying (egg)	EM90D	81.4	221	7.9
Egg mass at the first 90-days of laying (g)	EN120D	2800	3.3	4.0
Egg mass at the first 120-days of laying (g)	EM120D	3843	219	5.6
Rate of egg production during the first 90 days (%)	RL90D	67	4	5.6
Rate of egg production during the first 120 days (%)	RL120D	68	3	4.0
Pause period during the first 90-days (days)	PP90D	29	3.1	10.8
Pause period during the first 120-days (days)	PP120D	39	3.3	8.5

Table (3): Estimates of additive genetic (σ^2_a), remainder (σ^2_e) and phenotypic (σ^2_P) variances and heritability (h^2±SE) for egg production traits in Benha chickens.

Trait	σ^2_a	σ^2_e	σ^2_P	h^2±SE
ASM (day)	8.9	24.2	33.1	0.27±0.04
BWSM (g)	103.0	217.2	320.2	0.32±0.05
WFE (g)	4.2	5.9	10.1	0.42±0.09
EN90D (egg)	34.4	76.9	111.3	0.31±0.02
EM90D (g)	55.3	107.1	162.4	0.34±0.05
EN120D (egg)	124	316	440	0.28±0.02
EM120D (g)	148.3	307.3	455.6	0.33±0.05
RL90D	3.6	21.4	25.0	0.14±0.01
RL120D	26.6	109.7	136.3	0.19±0.03
PP90D (day)	3.2	41.8	45.0	0.07±0.04
PP120D (day)	2.1	35.8	37.9	0.06±0.02

Table (4): Estimates of genetic (r_G±SE) and phenotypic (r_p±SE) correlations among some egg productions traits in Benha chickens.

Traits correlated	r_G±SE	r_P±SE
ASM & BWSM	0.65±0.33	0.14±0.03
ASM & WFE	0.20±0.04	-0.20±0.05
ASM & EN90D	-0.29±0.12	31.0±.0.09
ASM &PP90D	0.32±0.10	-0.29±0.05
ASM &RL90D	-0.31±0.13	0.24±0.08
BWSM & WFE	0.45±0.13	0.23±0.04
WFE & EM90D	0.27±0.11	0.36±0.09
EN90D & EM90D	0.19±0.04	0.54±0.07
EN90D & RL90D	0.65±0.07	0.41±0.05
EN90D & PP90D	-0.99±0.03	-0.99±0.08

Table (5): the ranges in BLUP estimates and their standard errors (SE) and accuracies of prediction ($r_{\hat{a}}$) estimated by multi-trait animal model for egg production traits in the base and selected generations in Benha chickens

Traits	Ranges in BLUP	SE	Accuracy	Ranges in BLUP	SE	Accuracy
	Base generation			**First selected generation**		
ASM (d)	5.8	1.35	0.57	5.8	1.35	0.57
BWSM	317	75.20	0.61	337	73.52	0.61
WFE (g)	4.7	1.12	0.51	4.1	1.14	0.52
EN90D	26	3.42	0.72	25	3.71	0.81
EM90D	702	98.32	0.79	700	96.1	0.80
EN120D	25	3.47	0.85	27	3.33	0.81
EM120D	744	108.2	0.60	740	115.1	0.67
RL90%	6.7	1.42	0.59	6.5	1.41	0.58
RL120%	6.2	1.39	0.62	6.1	1.39	0.62
PP90D	6.8	1.32	0.60	6.6	1.32	0.60
PP120D	5.9	1.29	0.64	5.8	1.29	0.63
	Second selected generation			**Third selected generation**		
ASM (d)	5.5	1.35	0.56	5.5	1.35	0.57
BWSM	360	73.54	0.63	345	74.21	0.61
WFE (g)	4.7	1.27	0.52	4.0	1.45	0.49
EN90D	26	3.15	0.75	24	3.62	0.75
EM90D	740	115.4	0.79	745	125	0.81
EN120D	25	5.32	0.84	25	4.32	0.79
EM120D	765	116.1	0.58	765	111.2	0.69
RL90%	6.4	1.41	0.58	6.3	1.40	0.58
RL120%	5.8	1.35	0.61	5.8	1.35	0.61
PP90D	6.5	1.31	0.60	6.5	1.31	0.60
PP120D	5.6	1.29	0.62	5.6	1.29	0.62

Table (6): Generalized Least-square means for egg production traits in different generations along with all possible of generalized least square generation contrasts and their standard errors (± SE) in Benha chickens

Generation	**ASM (d)**	**BWSM (g)**	**WFE (g)**	**EN90D (egg)**	**EM90D (g)**	**EN120D (egg)**	**EM12D (g)**	**RL90D (%)**	**RL120D (%)**	**PP90D (day)**	**PP120D (day)**
G$_0$	163.0±0.5^{a}	1619±16^{b}	28.1±0.1^{c}	56.4±0.1^{d}	2551±1^{d}	77.9±0.1^{d}	3613±1^{d}	62.7±0.2^{d}	65.0±0.4^{c}	33.5±0.2^{a}	42.0±0.4^{a}
G1	161.0±0.3^{b}	1711±17^{a}	29.0 ±0.1^{b}	60.0±0.1^{c}	2778±1^{c}	81.6±0.1^{c}	3840±1^{c}	66.7±0.2^{c}	68.0±0.4^{b}	30.0±0.2^{b}	38.4±0.3^{b}
G2	160.5±0.4^{bc}	1723 ±17^{a}	30.1±0.1^{a}	62.1±0.1^{b}	2861±1^{b}	82.4±0.1^{b}	3866±1^{b}	69.0±0.2^{b}	68.7±0.4^{ab}	27.9±0.2^{c}	37.5±0.3^{bc}
G3	159.7±0.3^{c}	1752 ±16^{a}	30.2±0.1^{a}	63.1±0.1^{a}	2979±1^{a}	83.2±0.1^{a}	4019±1^{a}	70.1±0.31^{a}	69.4±0.5^{a}	26.9±0.2^{d}	36.7±0.3^{c}
G$_0$ VS G1	2.0±0.5	-92.0 ±23*	-0.9±0.1*	-3.6±0.2*	-227±1*	-3.7±0.2*	-227±1*	-4.0±0.2*	-3.0±0.1*	3.5±0.19*	3.6±0.2*
G$_0$ VS G2	2.5±0.5*	- 104 ±23*	-2 ±0.1*	-5.7±0.2*	-310±1*	-4.5±0.2*	-253±1*	-6.3±0.2*	-3.7±0.1*	5.6±0.19*	4.5±0.2*
G$_0$ VS G3	3.3±0.5*	-133±22*	-2.1 ±0.1*	-6.7±0.2*	-428±1*	-5.3±0.2*	-406±1*	-7.4±0.2*	-4.4±0.1*	6.6±0.19*	5.3±0.2*
G1 VS G2	0.5±0.5	-12.0±23	-1.1±0.1*	-2.1±0.2*	-83±1	-0.8±0.2*	-26±1	-2.3±0.2	-0.7±0.1	2.1±0.19*	0.9±0.2
G1 VS G3	1.3±0.4*	-41.0±22*	-1.2±0.1*	-3.1±0.2*	-201±1*	-1.6±0.2*	-179±1*	-3.4±0.2*	-1.4±0.1*	3.1±0.19*	1.7±0.2*
G2 VS G3	0.8±0.4	-29.2±22*	-0.1±0.1	-1.0±0.2*	-118±1*	-0.8±0.2*	-153±1*	-1.1±0.2*	-0.7±0.1	1.0±0.19*	0.8±0.2

G0 = Base generation, G1 = 1st generation, G2 = 2nd generation, G3 = 3rd generation
a, b, c, d Means with the same letters within each trait are not significantly different (P<0.05).
* Generation effect significantly different from 0, α = 0.05.

Table (7): Realized correlated selection response for unselected traits in Benha chickens through three generations of selection.

Trait	Correlated selection response as a result of selection for egg number at 90 day of laying (EN90D)			
	1st generation	2nd generation	3rd generation	Cumulative
ASM (d)	-1.15	-0.51	-0.81	-2.47
BWSM (g)	88.3	17.1	35.1	140.5
WFE (g)	0.98	0.69	0.32	1.99
EN120D (egg)	3.1	1.4	0.95	5.45
EM90D (g)	195	98	125	418
EM120D (g)	215	40	116	371
RL90D (%)	3.4	2.2	1.92	7.52
RL120D (%)	2.9	0.62	0.70	4.22
PP90D	-3.0	-2.1	-0.9	-6.0
PP120D	-2.8	-1.4	-0.8	-5.1

Figure (1): The phenotypic trend for egg production traits across the selected generations.

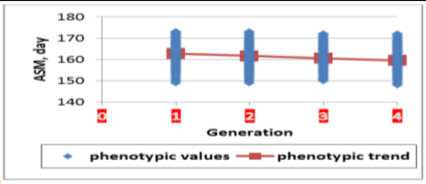

Fig. 1-A

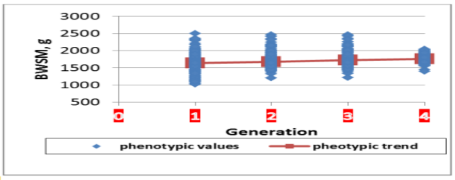

Fig. 1-B

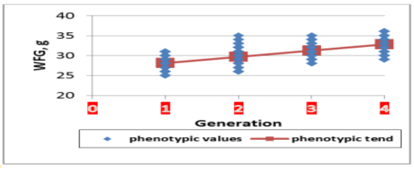

Fig. 1-C

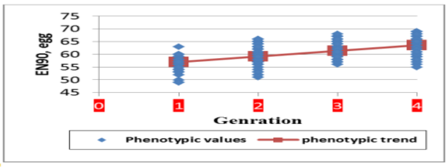

Fig. 1-D

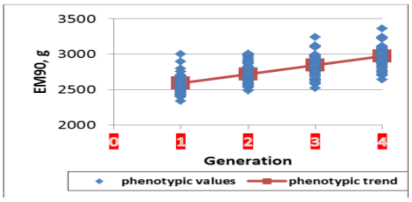

Fig. 1-E

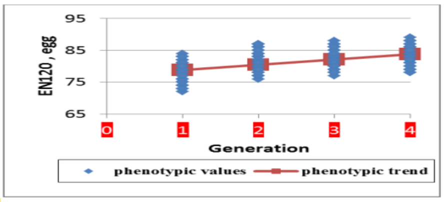

Fig. 1-F

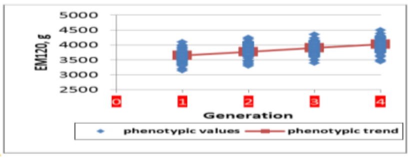

Fig. 1-G

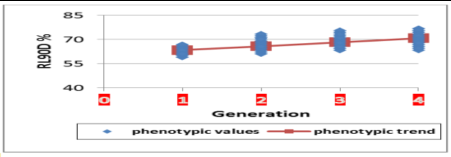

Fig. 1-H

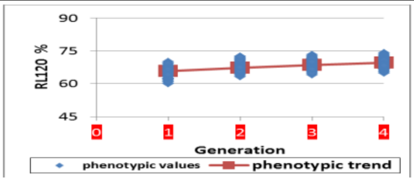

Fig. 1-I

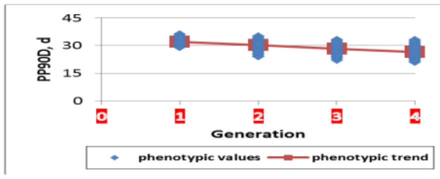

Fig. 1-J

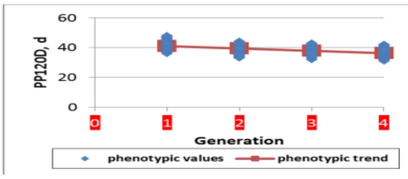

Fig. 1-K

Where : 1= control population 2 = first selected generation 3 = second selected generation 4 = third selected generation

Figure (2): Genetic trend for egg production traits across the selected generations.

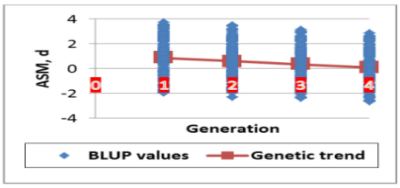

Fig.2-A

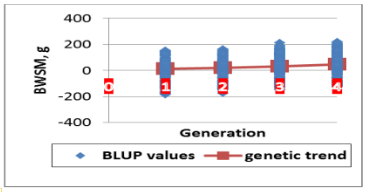

Fig.2-B

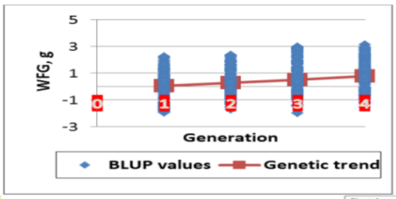

Fig.2-C

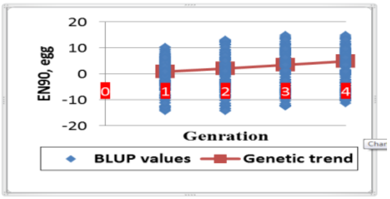

Fig.2-D

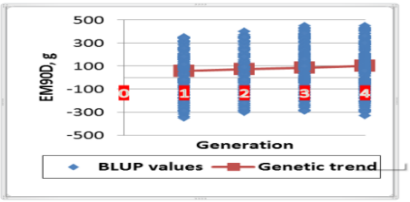

Fig.2-E

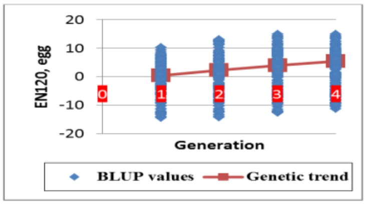

Fig.2-F

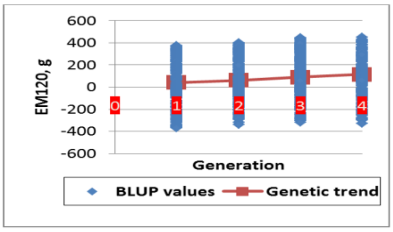

Fig.2-G

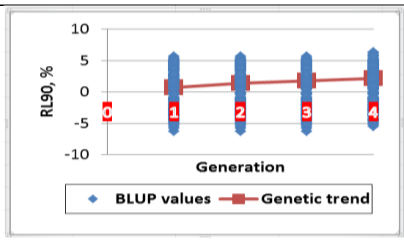

Fig.2-H

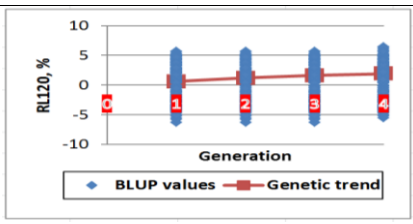

Fig.2-I

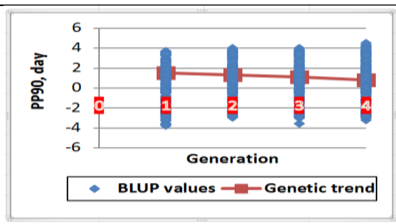

Fig.2-J

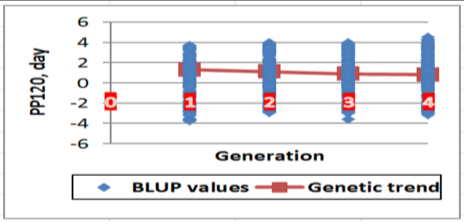

Fig.2-K

Where : 1= control population, 2 = first selected generation, 3 =second selected generation, 4 = third selected generation

REFERENCES

Abd El-Ghany, F. A.1996 . Influences of body weight and strain on productive and reproductive performance of some new developed Egyptian chickens. Egyptian Poultry Science; 16 (III): 601 – 612.

Abd El-Ghany, F. A. 2005. Selection for improving some economic traits in developed Inshas chickens strain. Journal of productivity and development, 10: (2):195-210.

Abd El-Ghany, F.A. 2006. Genetic studies for growth traits in Inshas strain. J. Agric. Sci. Mansoura Univ., 31 (2): 1301-1313.

Abdel A'al, H. A. 2016. Mapping of qantative trait loci affecting performance of some productive traits in purebreds and crossbreds of chickens. Ph.D. Thesis, Faculty of Agriculture at Moshtohor, Benha University, Egypt.

Abou- Elewa, Eman M. 2004. Selection for general immune response and its relation to some economic traits in chickens. M.Sc. Thesis, Minufiya Univ., Egypt.

Abou El-Ghar, R. Sh. and Debes. A. A. 2013. Prediction of breeding values and selection for egg mass in a closed flock of White Leghorn. International Journal of Livestock Production Research. 1, (2): 16 – 25.

Abou El-Ghar, R.Sh.; Abdou, F.H.; Gebriel, G.M. ; Enab, A. A. and Mahmoud, T. H. 2003. Combining ability and genetic gain of some economic traits in Norfa chickens. Egyptian Poultry Science, 23:687-704.

Aly, O. M. ; Ghanem, Hanan H.; Afifi ,Yousria K.; Abou El-Ella, Nazla Y. and Balat, Magda M. 2010a. Selection for improving egg production in Mandarah chickens. 4- Direct and correlated response for some economic traits for four generations of selection. Egyptian Poultry Science, 30: 137-156.

Aly, O. M.; Mosaad, Nema A.; Abou El-Ella, Nazla Y. and Afifi, Yousria K. 2010b. Improving the productivity of Bahij chickens through crossing. Effect of upgrading on B-Egg production, egg quality and hatch traits. Egyptian Poultry Science, 30: 1151- 1170.

Amin, E. M. 2015. Genetic components and heterotic effect in 3x3 diallel crossing experiment on egg production and hatching traits in chickens. Egyptian Poultry Science, 35: 735 - 765.

El -kommy, A. E.; Alfarmawy, A. M. and Ghanem, H. H. 2014. Genetic evaluation of the impact of mating between commercial laying hens (LSL) with some local Egyptian strains chicken and its effects on some productive and physiological parameters. International Journal of Agricultural Research 9 (6): 271- 283.

El-Attrouny, M. M. 2011. Estimation and evaluation of genetic and non-genetic parameters for some productive traits in chickens. M. Sc. Thesis, Faculty of Agriculture at Moshtohor, Benha University, Egypt.

El-Attrouny, M. M. 2017. Genetic improvement for egg production and quality traits in a synthesized line of chickens. Ph. D. Thesis, Faculty of Agriculture at Moshtohor, Benha University, Egypt.

El-Attrouny, M.M.; Iraqi, M.M.;Khalil, M.H. and El-Moghazy, Gihan M. 2017. Genetic and phenotypic evaluation of growth traits in selection experiment performed in synthesized Benha chickens. Annals of Agric. Sci., Moshtohor, 51 (1): 33-42.

El–Hadad, E. 2003. Efficiency of selection in laying hens by using supplementary information on feed consumption. Ph.D. Thesis, Fac. Agric. Minufiya Univ., Egypt.

El-Labban, A. F. 2000. Genetic Study of egg laying performance in four locally developed strains of chickens. J. Agric. Sci. Mansoura Univ., 25 (6) 3187 - 3195.

El-Labban, A. M.; Iraqi, M. M.; Hanafi, M. S. and Hassan, Heba A. 2011. Estimation of genetic and non-genetic parameters for egg production traits in local strains of chickens. Livestock Research for Rural Development23(1)2011(http://www.1rrd.org/1rrd23/1/ella)

El-Weshahy, O. A. 2010. Genetic improvement of some economic traits in Norfa chickens. Ph.D. Thesis, Fac. Agric. Minufiya Univ., Egypt.

Falconer, D. S. and Mackay, F. C. 1996. Introduction to Quantative Genetics.″4th Edition″ Longman Group Ltd, England.

Flock, D. K. 1998. Genetic aspects of feed efficiency in laying hens.World's. Poult. Sci. J; 54:225-239.

Hassan, G. M.; Farghaly, M.; Soliman, F. N. and Hussain, H. A. 2000. The influence of strain and dietary protein level on egg production traits for different local chicken strains. Egyptian Poultry Science, 20 (I): 49-63.

Hassan, Heba A. 2008. Estimation of heterosis and predicated breeding values for traits of egg production in chickens using Multi-trait Animal Model. M.Sc. Thesis, Fac. of Agric., Banha. Univ., Egypt.

Henderson, C. R. 1975. Best linear unbiased estimation and prediction under a selection model. Biometrics 31 (2): 423 - 47.

Iraqi, M. M. 2008. Estimation of crossbreeding effects for egg Production traits in a crossbreeding experiment involving two local strains of chickens. Egyptian Poultry Science, 28 (III): 867-882.

Iraqi, M. M.; EI-Labban, A. F.; Hanafi, M. S. and Hassan, Heba A. 2011. Estimation of genetic and non-genetic parameters for egg production traits in local strains of chickens. Livestock Research for Rural Development 23 (10).

Iraqi, M. M.; Khalil, M. H. and El-Atrouny, M. M. 2012. Estimation of crossbreeding parameters for egg production traits in crossing Golden Montazah with White Leghorn chicken. Livestock Research Rural Development. 24 (4).

Iraqi, M.M., Khalil, M.H. and El Attrouny M. M. 2016. The phenotypic and productive characterization of Benha-line chicken under Egyptian condations. Egypt. Poult. Sci. Vol (36) (III): 685-693.

Jobin, J. 2013. Evaluation of production traits in two strains of layer chickens under relaxed selection. Ph. D. Thesis, Faculity of Agricultural Ahmadu Bello Univ., Zaria. Nigerian.

Kennedy, B. W. 1989. Animal model BLUP - Crasmus intensive graduate Course. University of Guelph, Dublin.

Khalil, M. H.; AL-Homidan, A. H. and Hermes, I. H. 2004. Crossbreeding components in age at first egg and egg production for crossing Saudi chickens with White Leghorn. Livestock Research for Rural Development. 16. (1).

**Kosba, M. A.; Farghaly, M. H.; Bahie EL-Deen, M.; Iraqi, M. M.; El-

Labban, A. F. M. and Abd El-Halim, H. A. 2006. Genetic trends and evaluation for some productive traits in Alexandria chickens. Egyptian Poultry Science, 26: 1497 - 1513.

Kosba, M. A.; Farghaly, M. H.; El-Deen, M.B, M. and Abd El-Halim, H. A. 2002. Selection and genetic analysis of some egg production traits in local chickens. Egyptian Poultry Science, 22: 681-696.

Misztal, I.; Lourenco, D.; Aguilar, I.; Legarra, A. and Vitezica, Z. 2014. Manual for BLUPF90 family of programs. University of Georgia, Athens, USA. First released May 12, 2014 Last Edit June 18, 2015.

NRC 1994. National Research Council Nutrient Requirement of Poultry. Ninth Revised Ed. National Academy Press Washington DC, USA.

Ramadan, G. S.; Moghaieb, R. E.; El-Ghamry, A. A.; El-Komy, E. M.; Nassar, F. S.; Abdou, A. M.; Ghaly, Mona M. and Stino, F. K. 2014. Effect of selection for high live body weight on slaughter performance of briolers breeds. Egyptian Poultry Science, 34: 289-304.

Saleh, K.; Younis, H. H.; Abd El-Ghany, F.A. and Hassan, Enayat A. 2006. Selection and correlated response for egg production traits in Inshas and Silver Montazah strains of chickens. Egyptian Poultry Science, 26: 749-770.

Samak, H. R. 2001. Evaluating and improving the productive performance in some local chickens .Ph.D. Thesis, Fac. of Agric., Zagazig. Univ., Benha branch, Egypt.

Shalan, Hedaia M.; Zweil, H.S.; El-Wekeel, H. and Abd-Ella, M. M. 2012. Selection and correlated response for age at sexual maturity in Baheij strain. Egyptian Poultry Science, 32: 339 - 350.

Soltan, M. E. 1997. Performance of selected – Sinai fowl in comparison with Fayoumi and Baladi fowls standard Egyptian local breeds. II. Egg quality. Minofiya . Agric . Res. 17 (2): 53 – 526.

Soltan, M. E. and Ahmed, B. 1990. Performance of selected Sinia fowl in comparison with Fayoumi and Baladi fowls standard Egyptian local breeds. 1- Egg production .World Rev. Anim. Produ.25: 17 – 26.

Soltan, M. E.; Abd El-Rahman, F. H.; Abdou, H. and Ashour, Rasha. 2009. Correlated selection responses in Sinia fowl as a results of selection for feed efficiency for egg production Conf. of applied researches in Minofiya. University.

Taha, A. E. and Abd El-Ghany, F. A. 2013. Improving production traits for El-Salam and Mandarah chicken strains by crossing. I-Estimation of crossbreeding effects on egg production and egg quality traits. World Academy of Science Engineering and Technology, International Journal of Biological Science and Engineering 7 (10).

Younis, H. H. and Abd EL-Ghany, F. A. 2004. Direct and correlated response to selection for egg number in Silver Montazah chickens. Egyptian Poultry Science, 24: 701-718.

Younis, H. H.; Abd El-Ghany, F. A. and Awadein, Nasra B. 2014. Genetic improvement of egg production traits in Dokki-4 strain. 1- Correlated response, heritability, genetic and phenotypic correlations for egg production and egg quality traits. Egyptian Poultry Science, 34:345-362.

Selection - egg production traits - genetic and phenotypic trends - correlated responses.

Yousefi, Z. A.; Alijani, S.; Mohammadi, H.; Rafat, A and Daghigh, K. H. 2013. Estimation of genetic parameters for productive and reproductive traits in Esfahan native chickens. Journal of Livestock Science and Technologies, 1:34-38.

الملخص العربي

التقييم الوراثي والمظهري لصفات إنتاج البيض في تجربة انتخاب على دجاج بنها

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[1]قسم الإنتاج الحيوانى كلية الزراعة بمشتهر – جامعة بنها - مصر

[2]المركز الإقليمى للأغذية والاعلاف – مركز البحوث الزراعية – مصر

بدأ برنامج انتخابي لأربعة اجيال (الكنترول وثلاث أجيال انتخابية) في عام 2011 بكلية الزراعة جامعة بنها وأجري هذا البرنامج الانتخابي بغرض تحسين صفات إنتاج البيض في دجاج بنها المستنبط. تم انتخاب 18 ديك و180 دجاجه طبقا لقيم أحسن متنبئ خطى غير متحيز BLUP لصفة عدد البيض عند اول 90 يوم من الإنتاج من جيل الاساس (الكنترول) . تم تقدير أثر الانتخاب والاستجابة المرتبطة عبر الاجيال والاتجاهات الوراثية والمظهرية لصفات إنتاج البيض في دجاج بنها بإستخدام نموذج الحيوان المعروف بإسم BLUPF90 Program . آخذت بيانات 756 دجاجه ناتجه من 69 أب و 484 أم لتقدير المكافئ الوراثي – الارتباط الوراثي والمظهري وقيم أحسن متنبئ خطى غير متحيز BLUP لصفات إنتاج البيض والتي تمثلت في صفة العمر والوزن عند النضج الجنسي، وزن أول بيضة، عدد البيض وكتلة البيض عند 90 يوم الأولى من الإنتاج، عدد وكتلة البيض الكلى عند 120 يوم الأولى من بداية الإنتاج، معدل وضع البيض اليومي خلال 90 و120 يوم الأولى من بداية الإنتاج . كانت قيم المكافئ الوراثي متوسطة أو عالية حيث كانت 0.27 ، 0.32 ، 0.42 ، 0.31 ، 0.34 ، 0.28 ، 0.33 ، 0.14 و 0.19 لصفات العمر عند النضج الجنسي، الوزن عند النضج الجنسي، وزن أول بيضة، عدد البيض عند 90 يوم الأولى من الإنتاج، كتلة البيض عند 90 يوم الأولى من الانتاج، عدد البيض الكلى عند 120 يوم الأولى من الانتاج، كتلة البيض الكلى عند 120 يوم الاولى من الانتاج، معدل وضع البيض اليومي خلال 90 يوم الاولى من الإنتاج، معدل وضع البيض خلال 120 يوم الأولى من الإنتاج على التوالي . كانت تقديرات المدى لقيم BLUP لمعظم صفات إنتاج البيض متوسطة وعالية في جميع الاجيال. كانت درجات الدقة في قيم BLUP لصفات إنتاج البيض عبر كل الأجيال متوسطة إلي عالية الدقة .أظهرت الأجيال الثلاثة للانتخاب تفوق معنويا في صفات إنتاج البيض مقارنة بجيل الكنترول كما أظهرت التضادات المستقلة Contrasts بين الأجيال المختلفة اختلاف معنوي بين هذه الأجيال. أظهر الاتجاه المظهري ازديادا في القيم المظهرية لصفات إنتاج البيض قيمته من 1642 إلى 1759 جرام ، من 28 إلى 32.8 جرام ، من 57 إلى 64 بيضة ، من 79 إلى 84 بيضة ، من 2593 إلى 2977 جرام ، من3651 إلى 4027 جرام ، وكذلك ارتفعت قيم الاتجاهات الوراثية من 12 إلى 45 جرام ، 0.7 إلى 0.8 جرام ، 0.9 إلى 4.8 بيضة ، 0.5 إلى 5.5 بيضة ،57 إلى 102 جرام و 38 إلى 114 جرام لصفات الوزن عند النضج الجنسي، وزن أول بيضة، عدد البيض عند 90 يوم الأولى من الإنتاج، كتلة البيض عند 90 يوم الأولى من الإنتاج، عدد البيض الكلى عند 120 يوم الأولى من الإنتاج، كتلة البيض الكلى عند 120 يوم الاولى من الإنتاج، بينما انخفضت الاتجاهات المظهرية من 163 إلى 160 يوم وكذلك انخفضت الاتجاهات الوراثية من 0.84 إلى 0.1 يوم لصفة عمر النضج الجنسي. أظهرت الاستجابة الانتخابية المحققة والمصاحبة بعد ثلاث أجيال من الانتخاب تبكيراً في عمر النضج الجنسي (2.48 -) يوم، ازدياداً في وزن الجسم عند عمر النضج الجنسي (140.5 جرام) ،ازدياداً في وزن أول بيضة (1.99 جرام) ، ازدياداً في عدد البيض الكلى عند 120 يوم الأولى من بداية الإنتاج (5.45 بيضة) ، ازدياداً في كتلة البيض عند 90 يوم الأولى من الإنتاج (418 جرام) ، ازدياداً في كتلة البيضة عند 120 يوم الأولى من بداية الإنتاج (371 جرام) ، ازدياداً في معدل وضع البيض اليومي خلال 90 يوم الأولى من بداية الإنتاج (7.5 %) ومعدل وضع البيض اليومي خلال 120 يوم الأولى من بداية الإنتاج (4.2 %).