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Genetic and phenotypic evaluation of growth traits in selection experiment performed in synthesized Benha chickens

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Abstract

A selection program for four generations (base and three selected generations) was started in 2011 at Benha University, Egypt to improve growth traits in a synthetic line named Benha chickens. A total of 18 cockerels and 180 pullets were selected according to their BLUP values for egg number during 90 days of laying from Benha base population (control). Data of 4916 chicks produced by 69 sires and 484 dams were used to estimate heritabiliets, genetic and phenotypic correlations and BLUP estimates for body weight at 0 (BW0), 4 (BW4), 8 (BW8), 12 (BW12) and 16 (BW16) weeks of age along with daily gains during 0-4 weeks (DG4), 4-8 weeks (DG8), 8-12 weeks (DG12) and 12-16 weeks (DG16). The selection effects, correlated responses and the genetic and phenotypic trends for body weights and daily gains across generations were quantified or clarified applying the updated approach of the animal model program of BLUPF90. Heritability estimates were moderate or high; being 0.52, 0.28, 0.27, 0.33 and 0.31 for BW0, BW4, BW8, BW12 and BW16, respectively. Genetic correlations for growth traits at different ages were positive and ranged from 0.64 to 0.88 among body weights, and from 0.14 to 0.65 among daily gain traits. The ranges in BLUP of most body weights and gains in the control generation were higher than those in the selected generations. Accuracies of BLUP estimates for growth traits in all generations (control and selected) were moderate or high. The three selected generations were superior ($P < 0.05$) in most body weights and daily gains than the base generation and the contrasts among estimates of these generations were significant ($P<0.05$).The phenotypic trend increased from 33 to 34 g, 234 to 256 g, 532 to 650 g, 962 to 1123 g and 1458 to 1635 g for BW0, BW4, BW8, BW12 and BW16, respectively. the genetic trends across the generations clarifying that the initial BLUP estimates for BW0, BW4, BW8, BW12 and BW16 were 0, 1.0, 1.0, 1.4 and 0.1 g in the base population then gradually increased as the generation advanced till reached 0.1, 3.0, 9.5, 11 and 5.1 g in the first selected generation, 0.2, 5.0, 18, 20 and 9 g in the second selected generation, and 0.3, 7.0, 25, 29 and 13 g in the third selected generation, respectively. The accumulative correlated selection responses were 84 g for BW8, 123.6 g for BW12 and 123.6 g for BW16.

Keywords: Benha synthesized chickens, selection, growth traits, genetic and phenotypic trends, correlated responses.

Introduction

Egyptian chicken breeds and strains had low growth rates, poor feed efficiency and less meat yield, since these breeds and strains were not subjected to any intensive selection programs **(Iraqi, 2000)**. These strains cannot meet the highly demand on chicken meats in the market and therefore the lines synthesized by crossbreeding and selection could play an important role in this concept. Selection is the most important tool for achieving genetic gain in poultry since selection has been performed in two directions: (1) to improve egg production and egg quality traits, and (2) to improve body weight and daily gain traits. In Egypt, body weights and gains are the most important selection criteria for genetic improvement programs because these traits are easily measurable and they are correlated with several traits (**Saleh *et al.*, 2008; Abd El-karim and Ashour 2014; Ramadan *et al.*, 2014**). For these selection experiments, several methodologies have been used to estimate the selection response. One of them was based on regressing the estimates of the breeding values on generations and this approach depends on the genetic parameters and the model used. The other methodologies do not depend on the genetic parameters and the model itself, but are dependent on another approach through the usage of a control population, which could be an unselected population. In the concept, multi-trait selection is the most effective selection method among the other methods when several traits are involved in selection programs (**Saleh *et al.*, 2006 and 2008; Ramadan *et al.*, 2014).** In comparison with the programs that used to evaluate selection programs, BLUPF90 is the most updated program (**Misztal *et al.*, 2014**) that introduced in Egypt recently. However, BLUPF90 is an animal model program which is a mixed model program written in Fortran 90 (**Misztal *et al.*, 2014**) and is used to evaluate the selection program since it has many advantages, gives high accuracy level of estimates, simplicity and flexibility.

A selection program for four generations was started in 2011 in the Faculty of Agriculture, Benha University in Egypt to improve a synthetic line named Benha chickens. This line was developed by crossing the Egyptian Golden Montazah with the White Leghorn chickens **(Iraqi *et al*., 2012).** To evaluate this selection experiment, the main objectives of the present study were: 1) to estimate the genetic parameters and BLUP estimates across generations for growth 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 body weights and gains 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 strain of chickens namely Benha line (B) was used in this study. This line has been developed from crossing Golden Montazah with White Leghorns chickens and using the BLUP estimates to select the birds for three generations **(Iraqi *et al*., 2013).**

A total of 18 cockerels and 180 pullets were selected according to their BLUP estimates for egg number during 90 days of laying from Benha base population. Data of 4916 chicks were produced by 69 sires and 484 dams from 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 generation of selection (G_1), consequently selection was practiced further for two generations to produce the 2nd (G_2) and 3rd (G_3) generations of selection. The pedigreed eggs from each individual breeding pen for the three selection generations (G_1, G_2 and G_3) were collected daily for fifteen days and then incubated. The structures of data collected from all generations are presented in Table 1.

Table 1. Numbers of sires, dams and pullets used in the selection experiment in different generations of Benha line

Generation	No. of sires	No. of dams	No. of Pullets	No. of chicks produced
Base (control) population	17	113	180	898
1st generation of selection	18	119	180	1034
2nd generation of selection	17	117	180	1434
3rd generation of selection	17	135	216	1550
TOTAL	69	484	756	4916

Management:

On hatching day, chicks produced from all generations were wing - banded and reared in floor brooder, then transferred to the floor pens. Chicks produced from all generations were fed at libitum during growing (from hatch up to 8 weeks of age), rearing (from 8-20 weeks of age) and laying (more than 20 weeks of age) periods on diets containing 21% protein and 2950 kcal/kg, 18% protein and 2850 kcal/kg, and 16% protein and 2700 kcal/kg, respectively. 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

Individual body weight (BW) of 4916 chicks were recorded at 0, 4, 8, 12 and 16 weeks of age, while the daily gains in weight for these chicks were calculated during the periods of 0-4 (DG4), 4-8 (DG8), 8-12 (DG12) and 12-16 (DG16) weeks of age. The REML variance components of the random effects were estimated using the AIREMLF90 software (**Misztal *et al*., 2014**). Multi-trait animal model (in matrix notation) used for analyzing growth traits (as characters of the chick) was as follows:

$$\mathbf{y = Xb + Za + e}$$

Where: y= n×1 vector of observation of the chick, n = number of records; X= design matrix of order n×p, which is related to the fixed effects of generation (four levels) and sex (two levels), b= p×1 vector of the fixed effects of generation and sex, a= vector of random effects (additive genetic) of the birds, X and Z are the incidence matrices relating to the fixed effects and the additive genetic effects, respectively and e = vector of random residual effects. The common environmental effects were neglected in the model since the common environment reduced the additive variance value, which had negatively effect on the genetic parameters estimated. Heritabilties for growth traits were computed as: $h^2_a = \frac{\sigma^2_a}{\sigma^2_a + \sigma^2_e}$; where: σ^2_a and σ^2_e are the variances due to the effects of direct additive genetic and random error, respectively. The genetic (r_g) and phenotypic (r_p) correlations among growth traits were also estimated.

Estimation of BLUP:

The BLUP were estimated using BLUPF90 program (**Misztal *et al*., 2014**). Bird 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, d_j = 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 differences between the four generations of selection were obtained by generalised 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}) (σ_{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 two traits X and Y, respectively, r_{GXY} is the genetic correlation between two traits and σ_{PY} is the standard deviation of phenotypic value of trait Y.

Results and discussion

Actual means and variations:

Actual means, their standard derivations (SD) and percentages of variation (V%) for body weights at 0, 4, 8, 12 and 16 weeks of age and daily gains during intervals of 0-4, 4-8, 8-12 and 12-16 weeks of age in Benha chickens are shown in Table (2).

The actual means of body weights were 33.7, 247, 601, 1055 and 1561 g for chicks at hatch, 4, 8, 12 and 16 weeks of age, respectively (Table 2). In Dokki-4 chickens, **Iraqi *et al.* (2002)** reported that means of body weights were 31.6, 168, 428, 744 and 1059 for BW0, BW4, BW8, BW12 and BW16, respectively. **Kosba *et al*. (2006)** using Alexandria low line, Alexandria high line and Fayomi chickens found that means of body weight were 31.3, 31.7 and 27.2 g for BW0 and 374.4, 518.2 and 354.6 g for BW8.

The means of daily gains in Benha chicks were 19.5, 31.0, 25.2 and 32.5 g during the periods from DG04, DG48, DG812 and DG1216 weeks of age, respectively (Table 2). However, the daily gain tends to increase with the advance of age and the highest value was noticed during the period of 12-16 weeks. These means fall within the ranges for the strains of chickens raised under the Egyptian conditions **(e.g. Iraqi *et al.*, 2002; El-Dlebshany *et al.*, 2013; Iraqi *et al.*, 2013)**. **Kosba *et al*. (2006)** reported that means of DG08 was 51.5, 52.5 and 49.8 g in Alexandria low line, Alexandria high line and Fayomi chickens, respectively.

Table 2. Actual means and their standard deviations (SD) and percentages of variation (V%) for body weights and daily gains (g) at different ages in Benha chickens.

traits	Symbol	NO	Mean	SD	V%
Body weights:					
Hatch	BW0	4916	33.7	3.6	10.8
4 weeks	BW4	4576	247	42	16.8
8 weeks	BW8	4370	601	122	20.2
12 weeks	BW12	4155	1055	177	16.8
16 weeks	BW16	3883	1561	272	17.4
Daily body gains:					
0-4 weeks	DG04	4576	7.6	1.5	19.5
4-8 weeks	DG48	4370	12.6	3.9	31.0
8-12 weeks	DG812	4155	16.2	4.1	25.2
12-16 weeks	DG1216	3910	18.1	5.9	32.5

The percentage of variation (V%) in Benha chickens ranged from 10.8 to 20.2 % for body weight traits and from 19.5 to 32.5% for daily gain traits (Table 2). These estimates tended to increase generally as the chick advanced in age **(Khalil *et al.*, 1993; Khatab 2014). Iraqi *et al*. (2002)** reported that the estimate of V% for body weight traits ranged from 9.7 to 17.7 % and from 9.7 to 17.7 for daily gains traits in Dokki-4 chickens. **Kosba *et al*. (2006)** found that the estimates of V% for BW0 were 6.7, 7.1 and 9.3 %, while they were 29.8, 27.7 and 29.6 % for BW8 and were 22.3, 18.9 and 25.6 % for DG08 in Alexandria low line, Alexandria high line and Fayomi chickens, respectively.

Heritabilities:

Estimates of heritability for body weights are given in Table 3. The estimates were moderate or high; being 0.52, 0.28, 0.27, 0.33 and 0.31 for BW0, BW4, BW8, BW12 and BW16, respectively. The estimates could be encouragement for the Egyptian breeders to practice genetic selection at early ages in local strains. Also, the estimates showed that heritability for body weight decreased with the advancement of age. So, rapid improvement in body weights could be achieved without waiting to later ages to save money, time and effort **(Iraqi *et al*., 2002)**. These results are in agreement with **Iraqi *et al*. (2002)** who demonstrated that estimates of heritability (h^2) in a crossbreeding experiment using multi-trait animal model for body weight at hatch, 4, 8, 12 and 16 weeks of age were 0.58, 0.21, 0.15, 0.20 and 0.14, respectively. **Kosba *et al*. (2006)** showed that the estimate of h^2 for BW0 was 0.30, 0.62 and 0.36, while it was 0.32, 0.29 and 0.17 for BW8 in Alexandria low line, Alexandria high line and Fayomi chickens, respectively. **Abd El-Ghany and Abd El-Ghany (2011)** reported that the estimates of h^2 for BW0, BW4, BW8 and BW12 in selected line of Mandara chickens were 0.13, 0.32, 0.58 and 0.61, respectively.

Table 3. Estimates of heritability ± SE (on diagonal) and genetic correlation ± SE (below diagonal) and phenotypic correlation ± SE (above diagonal) for body weight and daily gain traits at different ages in Benha chickens.

Traits	Body Weights				
	BW0	BW4	BW8	BW12	BW16
BW0	**0.52±0.02**	0.12±0.02	0.14±0.02	0.13±0.02	0.11±0.02
BW4	0.14±0.04	**0.28±0.02**	0.44±0.21	0.40±0.21	0.34±0.21
BW8	0.18±0.05	0.64±0.12	**0.27±0.02**	0.76±0.21	0.58±0.17
BW12	0.22±0.11	0.55±0.13	0.88±0.06	**0.33±0.02**	0.81±0.20
BW16	0.31±0.06	0.24±0.18	0.36±0.07	0.31±0.02	**0.31 ±0.02**
	Daily body gains				
	DG04	DG48	DG812	DG1216	-
DG04	**0.30±0.03**	0.35±0.01	0.13±0.02	0.34±0.13	-
DG48	0.41±0. 01	**0.23±0.03**	0.55±0.01	0.75±0.01	-
DG812	0.14±0.03	0.65±0.01	**0.19±0.03**	0.79±0.01	-
DG1216	0.14±0.05	0.45±0.08	0.57±0.08	**0.24±0.02**	-

Heritability estimates for daily gains were moderate, being 0.30, 0.23, 0.19 and 0.24 for DG04, DG48, DG812 and DG1216, respectively (Table 3). It seems that the heritability estimate tends to decrease with the advancement of age. **Iraqi *et al*. (2002)** found that the estimates of h^2 in Matrouah and Mandara chickens increased with the advance of age and the estimates were 0.22, 0.24, 0.35 and 0.44 for daily gains during the periods from 0-4, 4-8, 8-12 and 12-16 weeks of age, respectively.

Genetic and phenotypic correlations:

Genetic correlations among body weights at different ages were positive (Table 3). Moreover, the estimates among BW4, BW8, BW8, BW12 weeks were high and ranged from 0.64 and 0.88. Genetic correlations among daily gain traits were positively moderate or high and ranged from 0.14 and 0.65. **Iraqi *et al.* (2000)** showed that the genetic correlations (r_G) among body weight traits at different ages in Dokki-4 chickens were positive and ranged from 0.17 to 0.77, while they ranged from 0.11 to 0.65 for daily gain traits. **Kosba *et al.* (2006) and Balat *et al.* (2008)** found that the estimates of genetic correlation between BW0 and BW8 was 0.17 in Mandara chickens. In selected line of Mandara chickens, **Abd El-Ghany and Abd El-Ghany (2011)** reported that the genetic correlations among BW0, BW4, BW8 and BW12 were low or moderate and ranged from 0.16 to 0.29, while the estimates between BW4 and BW8 or BW12 were high (0.89 and 0.71)

Estimates of phenotypic correlation were positive and moderate between BW4 & BW8 (0.44), BW4 & BW12 (0.40) and BW12 & BW16 (0.34) as shown in Table (3). In addition, the estimates were positive and high between BW8 & BW12 (0.76), BW8 & BW16 (0.58) and BW12W & BW16 (0.81). **Iraqi *et al.* (2002)** found that the phenotypic correlations among daily gains were 0.27, 0.10 and 0.20 among DG04, DG812 and DG1216, respectively.

BLUP estimates across generations:

The ranges in BLUP estimates in different generations are presented in Table 4. The ranges in BLUP for most body weights and gains were moderate or high in all generations; the ranges in the control, 1st, 2nd, and 3rd generations being 2.1, 1.9, 1.9 and 1.9 g for BW0, 33, 21, 37 and 35 g for BW4, 129, 99, 110 and 104 g for BW8, 140, 123, 125 and 118 g for BW12, and 41, 48, 48 and 48 g for BW16, respectively. For daily gains, the ranges deviated from 1.4 to 3.6 g for DG04, 1.8 to 3.1 g for DG48, 2.2 to 3.7g for DG812 and 2.3 to 3.2 g for DG1216 in the base, 1st, 2nd and 3rd generation, respectively. **Iraqi *et al.* (2000b)** reported that the ranges in estimates of predicted breeding values for body weight traits in Golden Montazah, Silver Montazah and Mandara strain ranged from 4 to 121 g, 4.7 to 178 g and 4 to 289 g, respectively, while the respective estimates for daily gain traits ranged from 1.1 to 9.5 g, 0.5 to 4.2 g and 1.8 to 8.7 g. **Khatab (2014)** reported that the ranges in estimates of predicted breeding values in

Mandara chickens ranged from 12 to 259 g for body weight traits and 1.9 to 4.6 for daily gains, while the respective estimates ranged from 12 to 314 g for body weights and 2.2 to 3.8 g for daily gains in Matrouah chickens.

Accuracies of BLUP estimates for growth traits in all generations (control and selected) were moderate or high (Table 4); ranging from 0.47 to 0.73 for body weight traits and from 0.34 to 0.60 for daily gain traits in the base population, from 0.60 to 0.74 for body weights and 0.41 to 0.62 for daily gains traits in the first selected generation, from 0.47 to 0.61 for body weights and 0.41 to 0.59 for daily gains traits in the second selected generation, and from 0.47 to 0.63 for body weights and 0.48 to 0.54 for daily gains in the third selected generation. **Iraqi *et al.* (2000b)** reported that the accuracy of estimates of predicted breeding values for body weight traits in Golden Montazah, Silver Montazah and Mandara strain were high and ranged from 0.46 to 0.64, 0.56 to 0.68 and 0.58 to 0.69, respectively, while the respective estimates for daily gain traits ranged from 0.62 to 0.73, 0.65 to 0.66 and 0.66 to 0.73. In Dokki-4 chickens**, Iraqi *et al.* (2000a)** found that the accuracies of the estimates of the breeding values were high and ranged from 0.72 to 0.87 for body weight traits and 0.71 to 0.83 for daily gain traits. **Khatab (2014)** reported that the accuracies in predicted breeding values in Mandara chickens ranged from 0.24 to 0.95 for body weight traits and 0.19 to 0.89 for daily gains, while the respective accuracies ranged from 0.40 to 0.95 for body weights and 0.40 to .89 for daily gains in Matrouah chickens.

Table 4. Ranges in BLUP estimates (g) and their standard errors (SE) and accuracy of prediction (r_A) estimated by multi-trait animal model for growth traits in the base and selected generations in Benha chickens.

Traits	Ranges in BLUP	SE	Accuracy	Ranges in BLUP	SE	Accuracy
	Base population			**First selected generation**		
BW0	2.1	0.2	0.73	1.9	0.1	0.60
BW4	33	4.4	0.58	21	2.1	0.65
BW8	129	11.6	0.47	99	22	0.69
BW12	140	16.6	0.65	123	19.	0.71
BW16	41	5.4	0.69	48	7.6	0.74
DG04	1.4	0.1	0.60	2.1	0.8	0.62
DG48	3.6	0.8	0.45	3.1	0.7	0.53
DG812	2.8	0.7	0.44	3.1	0.9	0.51
DG1216	3.3	1.1	0.34	1.8	0.4	0.41
	Second selected generation			**Third selected generation**		
BW0	1.9	0.17	0.60	1.9	0.2	0.60
BW4	37	4.3	0.47	35	4.6	0.47
BW8	110	10.2	0.53	104	19	0.52
BW12	125	22.6	0.48	118	25	0.50
BW16	48	8.6	0.61	48	9.7	0.63
DG04	2.2	0.9	0.59	2.3	0.9	0.54
DG48	3.7	0.7	0.43	3.1	0.8	0.48
DG812	2.6	0.7	0.41	3.2	0.6	0.53
DG1216	3.3	0.9	0.53	2.8	0.6	0.51

Selection effect and generation contrasts:

Estimates of the three generations of selection obtained by generalized least squares using BLUPF90 were superior (P <0.05) for most body weights and daily gains than the base population (Tables 5, 6). Based on BLUPF90, the contrasts among estimates of these generations were significant (P<0.05).The third generation showed superiority in weights and gains compared to the average of the first and second generations**. Aly *et al*. (2010)** found that BW0 and BW8 averaged 35.4 and 511 g in the selected line, while they averaged 35.3 and 484 g in the control Matrouah chickens, respectively. **Abou El-Ghar and Abd El-Karim (2016)** found that BW0 averaged 32.7, 35.5 and 33.6 g and averaged 851, 915 and 738 g for BW12 in the selected line of Inshas chickens, while averaged 33, 33 and 34 g for BW0 and averaged 833, 856 and 833 g for BW12 in the control line.

Table 5. Generalized least-square estimates for body weights (g) in different generations along with their generations contrasts and standard errors (± SE) in Benha chicks.

Generation	BW0	BW4	BW8	BW12	BW16
Control (C)	33.2±0.15[c]	231±1.9[c]	548±5.5[c]	970±6.5[c]	1455±5.5[c]
1st generation (G_1)	33.5±0.16[b]	246±2.2[b]	570±6.5[b]	1027±7.7[b]	1558±5.8[b]
2ndgeneration (G_2)	33.5±0.17[b]	248±2.4[b]	566±7.1[b]	1021±8.3[b]	1563±5.7[b]
3rd generation(G_3)	34.0±0.18[a]	252±2.7[a]	642±7.8[a]	1095±9.1[a]	1593±6.0[a]
C VS G_1	-0.3±0.17	-15 ±2.0*	-22 ±5.6*	-57 ±7.0*	-103 ±7.0 *
C VS G_2	-0.3±0.18	-17 ±2.3*	-18 ±6.3*	-51 ±7.7*	-109 ±7.0*
C VS G_3	-0.8±0.19*	-21 ±2.5*	-94 ±7.0*	-125 ±8.5*	-139 ±7.3*
G_1 VS G_2	0.0±0.16	-2 ±1.8	4 ±5.0	7 ±6.3	-6 ±6.3
G_1 VS G_3	-0.5±0.17*	-6 ±2.1*	-72 ±5.9*	-68 ±7.3*	-36 ±6.6*
G_2 VS G_3	-0.5±0.14*	-4 ±1.7*	-76 ±4.7*	-74 ±5.9*	-30 ±5.2*

a, b, c, d Estimates with the same letters within each trait are not significantly different (P<0.05).
* Generation effect significantly different from 0, α = 0.05.

Table 6. Generalized least-square estimates for daily body gains (g/d) in different generations along with their generation contrasts and standard errors (± SE) in Benha chicks.

Generation	DG04	DG48	DG812	DG1216
Control (C)	7.0±0.07[c]	11.3±0.17[c]	15.0±0.14[c]	17.3±0.18[c]
1st generation (G_1)	7.5±0.08[b]	11.6±0.20[b]	16.2±0.16[b]	18.6±0.21[a]
2nd generation (G_2)	7.6±0.08[b]	11.4±0.22[b]	16.3±0.16[b]	18.7±0.23[a]
3rd generation (G_3)	7.7±0.09[a]	14.0±0.24[a]	16.3±0.17[a]	19.8±0.25[b]
C VS G_1	-0.5±0.07*	-0.3±0.18	-1.2±0.17*	-1.3±0.20*
C VS G_2	-0.6±0.08*	-0.1±0.20	-1.3±0.18*	-1.4±0.22*
C VS G_3	-0.7±0.09*	-2.7±0.22*	-1.3±0.19*	-2.5±0.24*
G_1 VS G_2	-0.1±0.06	0.2±0.16	-0.1±0.19	-0.1±0.18
G_1 VS G_3	-0.2±0.07*	-2.4±0.19*	-0.1±0.17	-1.2±0.21*
G_2 VS G_3	-0.1±0.06	-2.6±0.15*	-0.0±0.14	-1.1±0.17*

a, b, c, d Estimates with the same letters within each trait are not significantly different (P<0.05).
* Generation effect significantly different from 0, α = 0.05.

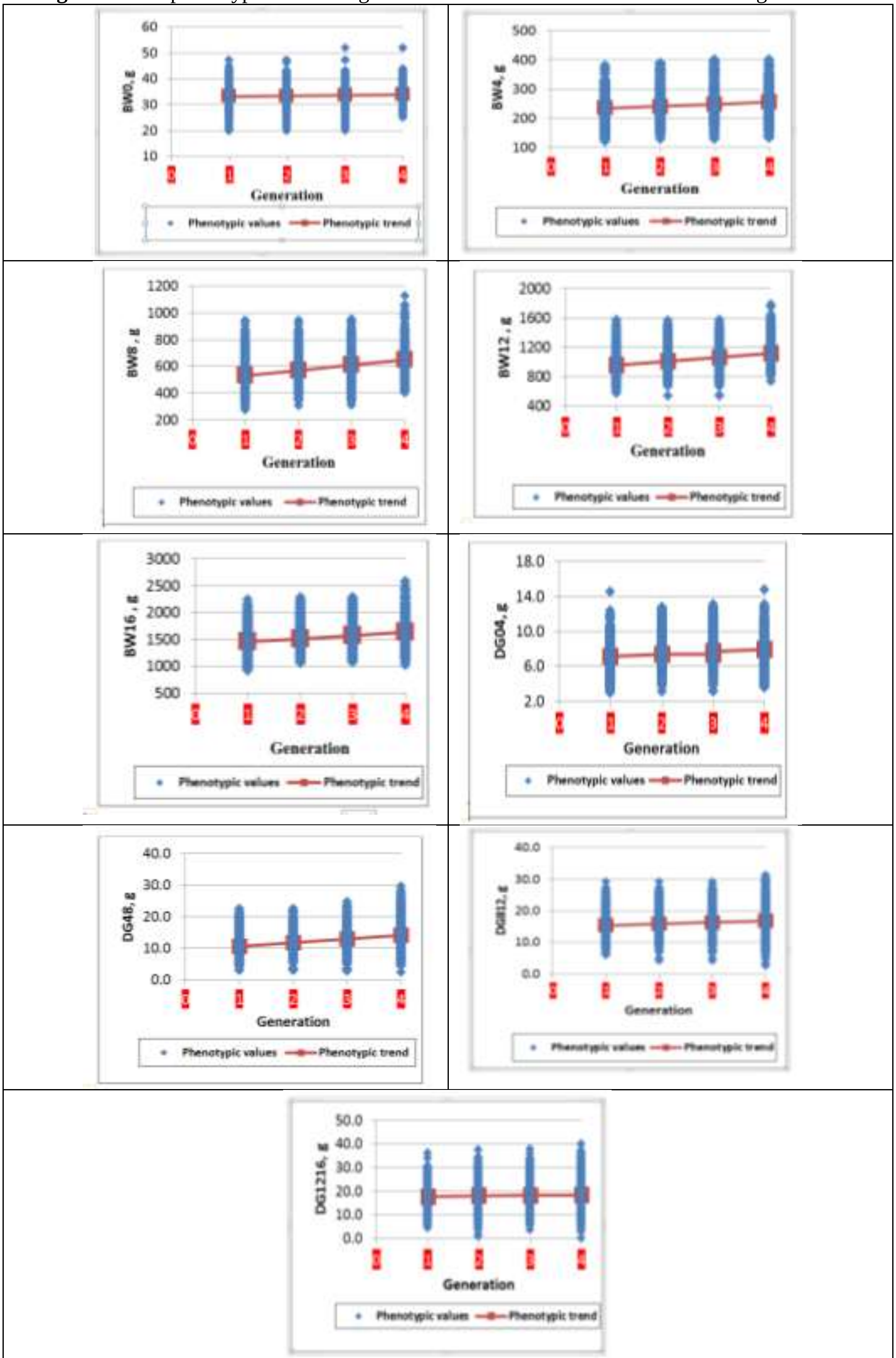
The phenotypic trends across generations:

For body weight traits, the phenotypic trends across the generations showed that the initial phenotypic values for BW0, BW4, BW8, BW12 and BW16 were 33, 234, 532, 962 and 1458 g in the base population, gradually increased as the generation advanced till reached 33, 241, 571, 1016 and 1517 g in the first generation of selection, 34, 248, 616, 1069 and 1576 g in the second selected generation and 34, 256, 650, 1123 and 1635 g in the third selected generation, respectively (Figure 1). These results indicated that selection over three generations for egg number was associated with an increasing in the phenotypic values of body weights and daily gains. For daily gains traits, the initial phenotypic values for DG04, DG48, DG812 and DG1216 were 7, 11, 15 and 17.6 g in the base population, respectively, reached 7, 12, 16 and 18 g in the first selected generation, 8, 13, 16 and 18 g in the second selected generation and 8, 14, 17 and 18.3 g in the third selected generation, respectively (Figure 1). **Younis *et al*. (2013)** found that the phenotypic values for BW0, BW4, BW8 and BW12 were 32.3, 210.7, 510.7 and 763 g in base generation, respectively, reached 32.8, 226.8, 542 and 810 g in 1st selected generation and 32.5, 237, 569 and 845 g, respectively in 3rd selected generation, respectively in Dokki-4 chickens. **Abd El-Karim and Ashour (2014)** reported that the phenotypic values for BW8 was 800 g in base generation, reached 861 g in 2nd selected generation and increased till reached 1043 g in 2nd selected generation, respectively in El-Salam strain.

The genetic trends across generations:

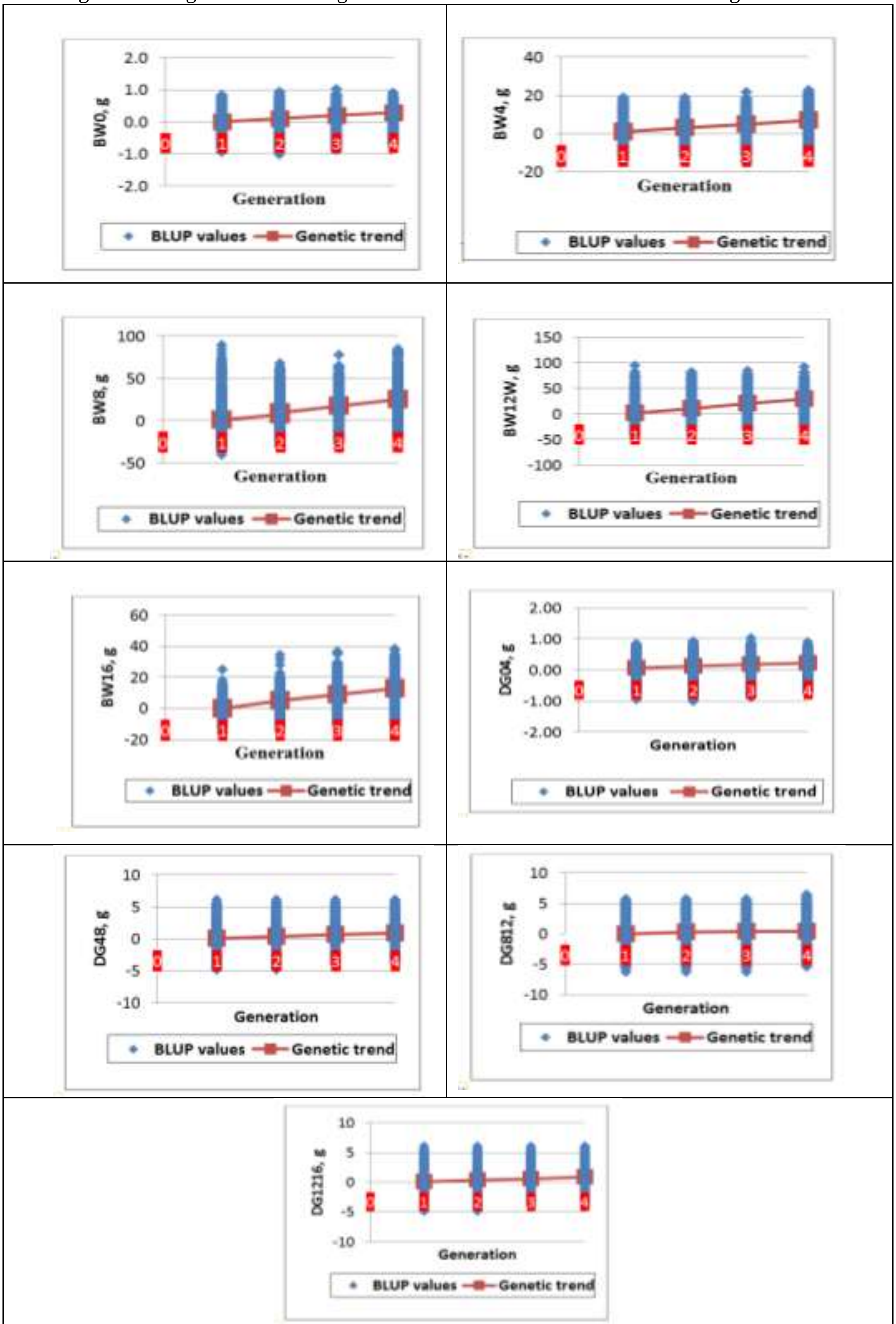
For body weights, the genetic trends across the generations clarifying that the initial BLUP estimates for BW0, BW4, BW8, BW12 and BW16 were 0, 1.0, 1.0, 1.4 and 0.1 g in the base population then gradually increased as the generation advanced till reached 0.1, 3.0, 9.5, 11 and 5.1 g in the first selected generation, 0.2, 5.0, 18, 20 and 9 g in the second selected generation, and 0.3, 7.0, 25, 29 and 13 g in the third selected generation, respectively (Figure 2). A similar genetic trend for body gains were recorded where the initial BLUP estimates for DG04, DG48, DG812 and DG1216 were constant to be 0.1, 0.1, 0.1 and 0.1 in the base population then gradually increased as the generation advanced till reached 0.13, 0.4, 0.3 and 0.4 g in the first selected generation, 0.2, 0.7, 0.4 and 0.6 g in the second selected generation and 0.2, 0.9, 0.4 and 0.9 g in the third selected generation, respectively (Figure 2). Contradicted trend was reported by **Kosba *et al.* (2006)** who indicate that the genetic trend increased for BW8 and reached soon at the 2nd generation of the study, then the trend decrease slowly down to show the minimum point (but positive) at the 4th generation and converted upward to show new trend at the 5th generation and converted down thereafter for Alexandaria high line.

Figure 1: The phenotypic trend for growth traits across the control and selected generations



Where : 1= Control population, 2 = First selected generation, 3 =Second selected generation, 4 = Third selected generation, BW0 = Body weight at hatch, BW4 = Body weight at 4 weeks, BW8 = Body weight at 8 weeks, BW12 = Body weight at 12 weeks, BW16 = Body weight at 16 weeks

Figure 2: The genetic trend for growth traits across the control and selected generations.



Where : 1= Control population, 2 = First selected generation, 3 =Second selected generation, 4 = Third selected generation, BW0 = Body weight at hatch, BW4 = Body weight at 4 weeks, BW8 = Body weight at 8 weeks, BW12 = Body weight at 12 weeks, BW16 = Body weight at 16 weeks

Correlated selection responses

The correlated selection responses were positive for all body weights at different ages (Table 7). The responses in the 1st, 2nd and 3rd generation of selection were 20.2, 3.4 and 60.4 g with acumulative response of 84 g for BW8, 49.2, 5.7 and 68.7 g with acumulative response of 123.6 g for BW12 and 95.3, 4.9 and 26.8 g with acumulative response of 123.6 g for BW16, respectively. These responses indicating that selection for egg number was associated with an increase in body weight at different ages. A similar trend was observed for daily body gains (g/d) in chicks at different age intervals. **Saleh *et al.* (2008)** reported that the cumulative realized response was 90 and 104 g for BW8 and BW16 over three selected generations in El-Salam chickens. **Abd El-Ghany and Abd El-Ghany (2011)** found that the realized correlated response after two selected generations were 1.23 g in BW0 and 20.27 g in BW4 in Mandara chickens. **Younis *et al.* (2013)** found that the cumulative realized and expected response were 26, 58 and 82 for body weight at 4, 8 and 12 weeks of age, 0.92, 1.14 and 0.94 for daily weight gains after two selected generations in Dokki-4 chickens.

Table 7. Correlated selection responses in body weights and gains through three generations of selection for egg number at the first 90-days of laying in Benha chickens.

Traits	Correlated selection response as a result of selection for egg number at 90 day of laying (EN90D)			
	1st generation	2nd generation	3rd generation	Cumulative
BW0	0.29	0.05	0.38	0.7
BW4	17	1.8	3.1	21.9
BW8	20.2	3.4	60.4	84
BW12	49.2	5.7	68.7	123.6
BW16	95.3	4.9	26.8	127
DG04	0.4	0.1	0.1	0.6
DG48	0.2	0.1	1.9	2.3
DG812	0.9	0.1	0.1	1.1
DG1216	1.1	0.1	0.9	2.1

Conclusions

1) The high estimates of BLUP for growth traits in the control and selected generations indicate that improvement of growth performance in Benha chickens could be achieved through more generations of selection.
2) Superiorities in the selected generations indicated that selection for egg number during the first 90 days of laying in Benha chickens was associated with an improvement in body weights and daily gains
3) The genetic trends were slightly positive for all traits indicating that the selection program was performed correctly. For all traits, the phenotypic trends showing improvement trends indicating the presence of appropriate environment especially for nutritional level.

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التقييم الوراثى والمظهرى لصفات النمو فى تجربة إنتخاب لخط دجاج بنها المستنبط

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بدأ برنامج إنتخابى لإربعة اجيال (الكنترول وثلاث أجيال انتخابية) فى عام 2011 بكلية الزراعة جامعة بنها وأجري هذا البرنامج الإنتخابي بغرض تحسين صفات النمو فى دجاج بنها المستنبط. تم إنتخاب 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 أوتوضيح أثر الإنتخاب والإستجابة المرتبطه عبر الاجيال والإتجاهات الوراثية والمظهرية لصفات وزن الجسم والزيادة اليومية فى دجاج بنها بإستخدام نموذج الحيوان المعروف بإسم BLUPF90 Program . إخذت بيانات 4916 كتكوت ناتجه من 69 ذكر و 484 دجاجة لتقديير المكافئ الوراثى – الإرتباط الوراثى والمظهرى وقيم أحسن متنبئ خطى غير متحيزBLUP لصفات وزن الجسم عند عمر يوم ، 4 ،8 ،12 و 16 أسبوع من العمر بالإضافه إلى صفات الزيادة اليومية من عمر 0- 4 ، 4 - 8 ،8- 12 و 12 – 16 أسبوع. كانت قيم المكافئ الوراثى متوسطه أوعاليه حيث كانت 0.52 ، 0.28 ،0.27 ،0.33 ، 0.31 لصفات وزن الجسم عند عمر يوم ، 4 ، 8 ، 12 و 16 أسبوع من العمر. وكانت قيم الإرتباط الوراثى بين صفات وزن الجسم عند الأعمار المختلفة تتراوح بين 0.64 – 0.88 لصفات وزن الجسم وبين 0.14 – 0.64 لصفات الزيادة اليومية. كانت تقديرات المدى لقيم BLUP لصفات وزن الجسم والزيادة اليومية فى جيل الكنترول أعلى من الإجيال الإنتخابية. كانت درجات الدقة فى قيم BLUP لصفات النمو عبر كل الأجيال متوسطة أو عالية الدقه .أظهرت الأجيال الثلاثة للإنتخاب تفوق معنويا فى وزن الجسم والزيادة اليومية مقارنة بجيل الكنترول كما أظهرت التضادات المستقلة Contrasts بين الإجيال المختلفة أختلاف معنوي بين هذه الإجيال. أظهر الإتجاه المظهرى إزدياد القيم المظهرية من 33 إلى 34 ، 234 إلى 256 ، 532 إلى 650 ،962 إلى 1123 و 1458 إلى 1635 جرام وكذلك إرتفعت قيم الإتجاهات الوراثية من 0 إلى 0.29 ، 1 إلى 7 ،1 إلى 25 ، 1.4 إلى 29 و0.14 إلى 31 جرام لصفة وزن الجسم عند عمر يوم ،4 ،8 ،12 و 16 أسبوع على التوالى. وجد أن الإستجابة الإنتخابية المحققة والمصاحبة بعد ثلاث أجيال من الإنتخاب لصفة عدد البيض عند 90 يوم الأولى من الإنتاج صاحبها زيادة تراكمية فى وزن الجسم مقدارها 21.9 جرام عند 4 أسابيع ،84 جرام عند 8 أسابيع ،123.6 جرام عند 12 أسبوع ،127 جرام عند 16 أسبوع.