SELECTION FOR IMPROVING EGG PRODUCTION IN MANDARAH CHICKENS

4 – DIRECT AND CORRELATED RESPONSE FOR SOME ECONOMIC TRAITS FOR FOUR GENERATIONS OF SELECTION

By

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Abstract: *A Mandarah local strain was selected (SL) for improving egg number (EN) during the 1st 90 days of laying from 2001 to 2006. Genetic changes were estimated as deviations from its unselected control line (CL) per generation. The aim of this study was conducted to determine the influence of selection for four generations on some economic traits (hatch, growth, egg production and egg quality). Selection responses of the EN during the 1st 90 days of laying were 3.11, 3.94, 3.80 and 0.60 eggs for the consecutive four generations. The estimates of the realized heritability of the main trait of selection ranged from 0.24 to 0.55. The results reveled that selection improved growth traits for males and females during the early period, also, fertility and hatchability and non hatched embryos percentages. The selected pullets sexually matured early (ASM) by (4.14 to 7.97 d) through the four generations, produced significantly (P<0.01) more and heavier early eggs and had significantly higher rate of laying (RL%) and more egg mass production (EM) than those of the CL. Selected pullets had better egg quality characteristics (produced eggs with thicker shell, higher shell and yolk percentages, and higher averages of yolk to albumen ratio, yolk index and Haugh units) when compared to the pullets of the CL. Most traits studied affected significantly (P<0.01) by generation.*

After four generations of selection for EN, the cumulative correlated responses for ASM; early egg weight, body weight at sexual maturity and RL% were 2.41 d, -3.38 g, -110.6 g and 13.17%, respectively. However, SL surpassed the CL concerning EM by 422.5 g.. It could be concluded that selection for increasing egg production during the 1st 90 day of laying in

Mandarah strain, enhanced early growth traits, also, hatch and egg production traits, as well as enhanced most of the egg quality characters.

INTRODUCTION

Response to selection is a function of intensity of selection, phenotypic variance and heritability and in theory should decline after continuous selection over generations because additive genetic variance is exhausted (Bulmer, 1971). In the great majority of single trait selection experiments, positive genetic progress for the trait selected, egg number or rate egg production, was presented, while in a few cases, genetic progress was absent or negative (Fairfull and Gowe, 1990). Selection differentials and realized heritability for egg production traits were reported by (Poggenpoel *et al.*, 1996; Sharma et al., 1998; Younis and Abd El-Ghany, 2004; Saleh *et al.*, 2006). Selection criteria in egg production trait are considered as an effective selection program for improving of a certain trait, they have frequently resulted in the occurrence of a correlated response in unselected traits (Marks, 1991; Poggenpoel *et al.*, 1996; Sharma *et al.*, 1998; Toussant and Latshaw, 1999; Emmerson *et al.*, 2002). Selection for part record egg number has decreased and egg weight, and age at sexual maturity (Fairfull and Gowe, 1990; Poggenpoel *et al.*, 1996; Sharma *et al.*, 1998).

The purpose of the current study was to examine the direct selection response of egg number during the 1st 90 days of lay and the correlated responses of some productive and reproductive traits over four generations of selection.

MATERIAL AND METHODS

This study was conducted at El-Sabahia Poultry Research Center, Alexandria, Animal Production Research Institute, Agriculture Research Center through seasons 2001 to 2006. Two lines of Mandarah strain were used: Selected line which selected for egg production was practiced from the 1st egg set up to 90 days of laying using a family index that took into account the individual performance plus sire family average for pullets, and for male were taken according to half sibs mean of egg number. Control line, chicks were randomly chosen and was maintained without conscious selection.

A total of 3126 pedigreed unsexed one day chicks have been hatched over the four generations and used in this study from the two lines (Table1). The chicks were wing banded, weighed at hatch, and 8 wk of age. Growth rate from 0-8 weeks of age was estimated. Chicks were brooded and fed a starter diet (19% crud protein and 2800 Kcal) up to 8 weeks of age, grower diet (15% CP and 2700 Kcal) up to 20 weeks and layer diet (16.5% CP and 2750 Kcal), there after. Feed and water were supplied *ad libitum*.

Sexes were separated at 8 weeks of age and birds were reared to 20 weeks of age under the same condition throughout the four generations. At 20 week of age, pullets from both lines were translated to individual cages to record egg production throughout the 1st 90 days of laying, after that, the pullets were placed in floor pens and the sire family were performed (8-10 pullets and one sire each).

Age and weight (g) at the first egg set, and egg number through the first 90 days of laying were recorded. Egg weight (g) was recorded daily through the 1st 90 days of laying. Rate of laying (%) and egg mass (g) for the same period were estimated.

Egg quality traits were recorded at 42-46 weeks of age from 696 examined eggs over all generations. The egg quality traits were: yolk, albumin and shell weights and percentages and shell thickness. Egg shape index was estimated as the percentage of egg width to egg length. Yolk index was estimated as the percentage of yolk height to yolk width. Haugh units were calculated according to the formula of Haugh (1937) as follow

$$\text{Haugh units (HU)} = 100\text{Log}\,(H + 7.57 - 1.7W^{0.37})$$

where H = Albumin height (mm), W= Egg weight (g)

Hatching eggs were set 10 days apart in two hatches per generation. The fertility was determined on day 18 post-setting and chicks removed on day 21. Percentages of fertility, hatchability were calculated on total egg-set bases (THE), and fertile-egg basis, (HFE)]. Non-hatched (NHE) and pipped (Pip) embryos percentages were estimated. Direct selection response of egg number at the 1st 90 days of laying and correlated responses of some productive and reproductive traits over 4 generations of selection were also. estimated.

Statistical analysis:

Data of growth traits were analyzed using fixed models SAS institute (1988):

$$Y_{ijkl} = \mu + G_i + L_j + S_k + (GL)_{ij} + (GS)_{ik} + (LS)_{jk} + (GLK)_{ijk} + e_{ijkl}$$

Where: Y_{ijk}= an observations, μ = overall mean, G_i = the fixed effect of i^{th} generation, L_j = the fixed effect of j^{th} line, $(GL)_{ij}$ = effect of the interaction between generation and line, S_k = the fixed effect of k^{th} sex, and $(GL)_{ij}$. $(GS)_{ik}$, $(LS)_{jk}$ and $(GLS)_{ijk}$ = effects of the interactions between the three factors studied, and e_{ijkl} = random error.

The rest data were analyzed using the following model:

$$Y_{ijk} = \mu + G_i + L_j + (GL)_{ij} + e_{ijk}$$

Where: Y_{ijk}= an observations, μ = overall mean, G_i = the fixed effect of i^{th} generation, L_j = the fixed effect of j^{th} line, $(GL)_{ij}$ = effect of the interaction between generation and line, and e_{ijk} = random error.

Significant differences among means were tested by Duncan Test (1955).

The realized genetic gain per generation was estimated as a deviation of the selected line mean from the control line mean according to the following equation

$$R_t = (S_t - S_{t-1}) - (C_t - C_{t-1})$$

Where: R_t realized gain due to selection in the t^{th} generation and S and C averages performance of the selected and the control populations (Guill and Washburn, 1974).

Actual selection differential was calculated as the difference between average of the selected parent for certain trait and the average of their mean of population (Falconer, 1989).

Standardized selection differential (i)

$$i = S / Sd$$

Where S = the selection differential, Sd = the standard deviation.

Realized heritability estimates of the selected trait (egg number during the 1^{st} 90 days of laying) were obtained for each generation as the ratio of realized response to selection differential (Falconer, 1989).

Density of selection (v) calculated by the following equation (Falconer, 1989)

$$V = \frac{\text{Number of selected pullets}}{\text{Number of all population}}$$

RESULTS AND DISCUSSION

Direct response of selection, for egg number during the 1st 90 days of laying is presented in Table (1). The genetic response per generation in the selected trait was 3.11, 3.94, 3.80 and 0.60 eggs in the 1st, 2nd, 3rd and 4th generations, respectively. This result conducted that the selection for egg number during the 1st 90 days improved egg number by 11.45 eggs after four generations of selection. Results reported herein were higher than that reported by Sharma *et al.* (1998) who found on White Leghorn strain under long-term selection for part period egg production over 16 generations, that realized genetic gain per generation was 2.55 eggs. Estimats reported herein were lower than those found by Younis and Abd El- Ghany (2004) in Silver Montazah and Saleh *et al.* (2006) in Inshas strain who reported that the selection response of egg number was 7.2 and 8.0 eggs for the 1st and the 2nd generation, respectively.

Selection differential was 13.4, 7.78, 7.61, 6.93 and 2.48 eggs in the base, 1st, 2nd, 3rd, and 4th generations, respectively, and its selection intensity was 1.21, 0.73, 0.89, 0.41 and 0.48, respectively. However, density of selection for this trait ranged from 0.40 to 0.48. These values were nearly equal to those reported by Younis and Abd El- Ghany (2004) and Saleh *et al.* (2006).

. The realized heritability (h^2_R) of egg number was 0.40, 0.52, 0.55 and 0.24 in the four generations, respectively. The realized genetic gain per generation was highly significant for egg production (2.55eggs) over 16 generations and h^2_R was much lower in the last 8 than in the first 8 generation (Sharma *et al.* (1998). In addition, Kamali *et al.* (2007) using Iranian native hens subject to 8 successive generations of selection for egg number during the 1st 90 days of the laying period resulting heritability estimate for EN was 0.40.

Correlated response

Hatchability traits: Fertility (F%), hatchability of fertile (HFE) and all eggs set (HAE)), non-hatched (NHE) and pipped embryos (Pip) in selected and control lines after four generations of selection are presented in Table 2. No significant difference was found between both the selected and the control lines for these traits except for fertility where the selected line surpassed (P<0.05) the control one (92.20 vs. 90.37%). Selection resulted in slightly improvement for both HFE, HAE and NHE, but not for Pip .

It is obvious that generation affected significantly (P<0.01) all hatch traits studied. The fertility enhanced by generation, where least square mean was the least in the 1st generation (87.42%), while estimates in the following generations were improved to be in range (91.20–93.08%). Concerning HFE, estimates were increased from the base and the 1st generation, decreased in the 2nd one, then, they return in development through the 3rd and 4th generations. The HAE followed the same trend as in HFE. However, the highest HFE was realized in generation one (81.93%). Increasing of the embryonic mortality percentages in the 2nd generation for the two lines related to bad environmental effect in the incubator. There were unevenly variety in the estimates of both NHE and Pip embryos percentages. The lowest least squares means were found in generation one for NHE (6.65%), and at the 4th generation with respect to Pip% (1.00%). Interaction effects between generation and line were found concerning fertility percentage ($P<0.05$), HFE, HAE, and NHE ($P<0.01$) while the interaction was not significant for Pip %. The cumulative correlated responses for hatch traits revealed that selection decreased F% by 3.57%; and HFE% by 3.92%, while both NHE% and Pip% were increased by 6.02 and 2.52%, respectively.

In selection for part record egg number, fertility and hatchability percentages remained unchanged (Kolstad, 1980, Sorensen *et al.*, 1980). Estimates of fertility and total egg loss embryos percentages (dead and non hatched embryos piped) were nearly similar, but hatchability for total or fertile eggs in this study were lower than those reported by Amin (2008) and Nawar (2009) on Mandarah strain.

Growth traits:

Least squares means of growth traits (body weight at hatch (BW0), and at 8 weeks of age (BW8) and growth rate from hatch to 8 weeks of age (GR0-8) of chicks for the selected and control lines over four generations are presented in Tables 3 and 4. There were significant differences between both lines in all traits studied except for BW0. All growth traits were improved significantly ($P<0.01$) by generation, where chicks in the 4th generation of selection were the heavier and grew faster than those of the other three generations. Males of chicks surpassed the females in all traits except at hatch, in each generation for both the two lines. The interaction between generation (G) and line (L) had highly significant effect on BW0 and GR0-8, and that between G x Sex affected ($P<0.01$) all traits except BW0, while L x Sex interaction was significant for BW8. Also, selection improved BW8 for males and females by 28.68g, 30.32g, and GR0-8 by 1.31%, and 1.85%, respectively, (Table 7). Results of Emmerson *et al.* (2002) suggested that long-term selection for increased egg production and the correlated decrease in BW increased the relative non additive genetic variation in body weight. The three-way interaction among generation, line, and sex were not significant in the three growth traits.

Egg production traits:

The least squares means of age (ASM) and body weight (BWSM) at sexual maturity, rate of laying (RL), egg weight (EW) and egg mass production (EM) of the two lines at the different generations are shown in Table (5). A sharp decline was observed in ASM after four generations where the overall means were 172.96 and 180.47 days for the selected and the control lines, respectively. The difference between the two lines and those among the different generations were highly significant. A similar marked decline in age at sexual maturity was found by Sharma *et al.* (1998) and Kosba *et al.* (2002). The averages of ASM for the two lines were lower than that reported by Amin (2008) (184.2d) and Nawar (2009) (178.5d) for Mandarah strain.

Body weight at sexual maturity did not change significantly by lines, whereas the differences between the generations were highly significant. The BWSM decreased by 110.6 g after four generations of selection. These results were lower than those reported by Amin (2008) for Mandarah strain. Results of Alvarez and Hocking (2009) suggested that total egg production in broiler breeders was very sensitive to body weight at the onset of egg production, whereas changes in body weight gain after peak rate of laying showed only minor effects on total egg production.

Rate of laying during the 1st 90 days of lay was significantly improved ($p<0.01$), where the selected line had higher least squares means compared to the control one (51.58 vs. 43.11%). The last generation of selection had significantly highest value (52.09%), while the lowest value was found in the base generation (34.76%). These results indicated that selection over four generations for egg number increased RL by 13.7%. Results in this study concerning the two lines were lower than that reported by Amin (2008) in the same strain (0.61%).

Highly significant difference between both the selected and control lines over the four generations for egg weight (EW) was detected. The correlated response for EW was -2.09, -0.67, -1.3 and 0.69 in the 1st, 2nd, 3rd and 4th generations, respectively. These results indicated that selection for egg number decreased EW significantly by -3.38 g after four generations. Improvement ($P<0.01$) was observed in egg mass production (EM) in the selected line than the control by (422.5 g) over the four generations (2085.5g vs 1723.3g). Highly significant differences were found of EM among the four generations where the highest EM was found in the

4^{th} generation (2086.5g). Correlated response of egg mass was 93.7,–35.2, 31.3 and 51g for the 1^{st}, 2^{nd}, 3^{rd}, and 4^{th}generations, respectively. There were significant (P<0.01) interactions between line and generation in all egg production traits in (Table 5) except for ASM was not significant. The cumulative correlated responses for ASM; EW; BWSM and RL% were 2.41 d, -3.38 g, -110.6 g and 13.17%, respectively, after four generations of selection (Table 7). Sharma *et al.* (1998) found that the significant genetic response of 4.46 to 4.72 eggs per generation was realized in the first 8 generations only, which was accompanied by a marked decline in egg weight (-1.67 and -0.79 g per generation). Average of EW of the two lines in this study was higher than that found by Amin (2008) (42.1 g) in Mandarah strain.

Egg quality traits:

Egg weight (EW), egg shape index (EShI), yolk (Y%), albumin (Al%), and shell (Sh%) percentages, also, yolk index (YI), yolk/albumin ratio (Y/Al ratio), shell thickness (Sh.Th) and Haugh units (Hu) are presented in Table 6. Significant differences were found between the two lines studied, where eggs produced by the control pullets were heavier compared to those of the selected line (51.8 vs. 49.9 eggs). Also, eggs of the control line had higher averages of Al% (54.5%), YI (46.7), Hu (84.4) compared with those of selected line. The YI and Hu were improved by 2.8 and 1.1, respectively, while AlW was decreased by 0.1g after four generations of selection for egg number (Table 7). These results may be due to the decreasing of the EW after the four generations of selection. Eggs of the selected pullets had higher y/Al ratio than that of the control line (62.9 vs. 60.7). However, although eggs from selected pullets were smaller, they had the largest Y% and Sh% compared to the control eggs.

There were significant differences among the five generations studied. The best averages were estimated for EW in the 2^{nd} generation, EShI in the 1^{st} and 3^{rd}, Y% in the 1^{st} and 2^{nd}, Al% in the base population, Sh% in the 1^{st}, YI in the base and 1^{st} and 4^{th} generations. The averages of y/Al ratio were the best at generations one and two. Eggs of generations one and four were the thickest compared to the others, and eggs of the base, 3^{rd} and 4^{th} generations had the best Hu values. The improvement in the Hugh units in these three generations may be due to the increasing in EW and Al% values.

Significant interactions between G and L were found concerning EShI, YI, and Y/Al ratio (P<0.01), and Y% (P<0.05). Improving of yolk/albumin ratio may be affected hatchability traits. Egg weight, and egg components proportion, in this study are in the range to those reported by Balat *et al.* (1995), Amin (2008) and Nawar (2009) for Mandarah strain. According on averages of the egg shape index, eggs laid by both the lines were oval in shape. Selection for part record egg number decreased egg weight in 20 of 31 cases (Fairfull and Gaue, 1980). On the other hand, Silversides and Budgell (2004) compared between three strains of laying hens, suggested that selection had changed the proportion of the yolk, albumen, and shell and has increased albumen height. The strength of egg shell is determined not just by the amount of shell but also by the quality of shell (Roberts, 2004). More albumen weight of the eggs produced by the control pullets in this study may be attributed to their heavier eggs produced. Eggs produced by the selected pullets had higher yolk percentage (insignificantly) than those of control.

Control pullet eggs exhibited significantly higher values of Haugh unit than those of the selected. Also, yolk index was significantly differ between birds of the two lines ($P<0.01$). Many factors have been reported to affect Haugh units such as strain, storage time, temperature, age of birds, nutrition and disease (Toussant and Latshaw, 1999). Akhtar *et al.* (2007) reported that maximum shell weight, shell thickness and yolk index were observed in the local birds while Haugh unit values were not significantly different amongst the three breeds. The interaction between generation and line was found concerning EShI, and YI, ($P<0.01$) and Y%, Y/Al ratio and Sh.T ($P<0.05$), while no significant effect was found in the rest traits.

Table (1): Means ± standard errors (X ± S.D) of egg number during the first 90 days of laying, realized response to selection (R), selection differential (S), standardized selection differential (i), density of selection (v) and realized heritability (h^2_R) through four generations of selection

Generation	Egg number					R	S	i	v	h^2_R
	Selected line		Control line		Average					
	N	X ± S.D	N	X ± S.D						
0	66	32.00±1.37	70	30.39±1.04	31.17±0.85^D		13.4	1.21		
1	159	44.34±0.84	121	39.62±0.62	42.33±0.63^C	3.11	7.78	0.73	0.45	0.40
2	209	46.90±0.59	71	38.24±0.98	44.71±0.55^B	3.94	7.61	0.89	0.41	0.52
3	81	52.19±0.83	138	39.73±0.57	44.28±0.62^B	3.80	6.93	0.41	0.40	0.55
4	160	53.32±0.25	150	40.26±0.29	46.91±0.42^A	0.60	2.48	0.48	0.48	0.24
Cumulative	**675**	**46.43±0.39**	**612**	**38.80±0.35**	**42.95**	**11.45**				

-The differences among the five generations and between both the selected and control lines studied and the interaction between the two main factors were highly significant (P<0.01).

Table (2): Means and standard errors of fertility, hatchability percentages (for fertile, HFE% and all eggs set, HAE%) non-hatched and pipped embryos percentages in selected and control lines through four generations of selection for egg number

G	Line	Fertility %	Hatchability HFE %	Hatchability HAE %	non-hatched embryos %	Pipped embryos %
0	SL	90.40±1.72	82.18±3.42	74.58±3.67	13.48±3.29	4.34±1.46
	CL	80.26±5.22	90.65±2.70	72.15±4.53	7.97±2.66	1.38±0.71
Overall mean		**87.42±2.07^{B}**	**84.67±2.61^{A}**	**73.87±2.88^{BC}**	**11.86±2.46^{B}**	**3.47±1.07^{A}**
1	SL	93.06±1.10	88.78±1.62	80.12±2.89	7.08±1.28	1.48±0.52
	CL	93.10±1.06	90.76±1.90	84.63±2.19	6.00±1.32	1.47±0.81
Overall mean		**93.08±0.78^{A}**	**89.58±1.23^{A}**	**81.93±1.95^{A}**	**6.65±0.92^{C}**	**1.48±0.45^{B}**
2	SL	92.56±1.11	78.31±2.54	73.13±2.71	19.81±2.59	1.59±0.46
	CL	87.13±3.14	55.99±5.52	49.84±5.68	42.40±5.80	1.49±0.98
Overall mean		**91.20±1.16^{A}**	**72.73±2.59^{B}**	**67.31±2.73^{C}**	**25.46±2.65^{A}**	**1.57±0.42^{B}**
3	SL	92.70±0.96	86.19±1.55	79.77±1.45	8.08±1.16	3.57±0.86
	CL	90.69±1.59	84.66±2.44	76.94±2.77	9.32±1.44	4.34±1.36
Overall mean		**91.96±0.84^{A}**	**85.63±1.32^{A}**	**78.73±1.37^{AB}**	**8.54±0.90^{BC}**	**3.85±0.73^{A}**
4	SL	91.32±1.61	85.55±1.75	78.57±2.43	10.92±1.22	1.18±0.39
	CL	95.14±1.05	87.55±2.75	83.19±2.61	11.43±2.54	0.74±0.42
Overall mean		**92.83±1.08^{A}**	**86.34±1.50^{A}**	**80.40±1.80^{AB}**	**11.12±1.23^{B}**	**1.00±0.29^{B}**
Overall mean of SL		92.20±0.56^{a}	83.60±1.08	76.88±1.24	12.72±1.06	2.26±0.33
Overall mean of CL		90.37±1.07^{b}	81.61±2.00	74.15±2.07	15.51±1.99	1.96±0.45
Overall means		91.59	82.93	75.96	13.70	2.16
Significance of:						
Line, L		*	NS	NS	NS	NS
G x L		*	**	**	**	NS

- Means within each main factor in each column having similar letter are not significantly different at $p<0.05$.
- G: generation L: line, SL: selected line, CL: control line.
- Generation affected significantly ($P<0.01$) all hatch traits studied.

** significant at $p< 0.01$, * significant at $p< 0.05$, NS non significant.

Table (3): Means ± standerd errors for main factors affected body weight at hatch (BW0), at 8 weeks of age (BW8), and growth rate at 0-8 wks of age, GR (0-8)

Trait / Main factors	BW0 g.	BW 8 g.	GR (0-8) %
Generation (G):			
1	34.96±0.14^{BC}	448.59±5.60^{C}	169.17±0.40^{C}
2	34.65±0.11^{C}	418.39±4.59^{D}	167.41±0.42^{D}
3	35.02±0.13^{B}	499.30±5.40^{B}	172.25±0.25^{B}
4	36.29±0.11^{A}	574.69±3.76^{A}	175.30±0.17^{A}
Line (L):			
Selected	35.45±0.08	511.29±3.35	172.20±0.20
Control	35.33±0.11	484.17±4.25	171.19±0.24
Sex (L):			
Male	35.46±0.10	552.01±4.12^{X}	174.51±0.22^{X}
Female	35.38±0.09	468.85±3.27^{Y}	170.08±0.21^{Y}
Significance of			
G	**	**	**
L	NS	**	**
S	NS	**	**
G x L	**	NS	**
Gx S	NS	**	**
L x S	NS	*	NS

- G: generation. L: line. S: Sex.
- Means within each factor for each trait having similar letter are not significantly differed at $p<0.05$.
- The three-way interaction among generation, line, and sex were not significant.

** significant at $p< 0.01$. * significant at $p< 0.05$. NS non significant.

Table (4): Means and standard errors of body weight at hatch (BW0) and at 8 weeks of age (BW8), and growth rate at 0-8 wks of age, (GR 0-8) for both males and females in selected (SL) and control (CL) lines for the four generations studied

Ge	Line	BW0. g	BW 8. g	GR 0-8 %
		Males		
1	SL	34.79±0.23	508.54±9.83	173.10±0.54
	CL	35.03±0.33	485.34±12.68	171.70±0.76
Overall mean		**34.88±0.19**	**500.27±7.79**	**172.60**
2	SL	34.87±0.21	503.26±8.71	172.37±0.94
	CL	33.82±0.25	485.86±8.66	173.45±0.49
Overall mean		**34.54±0.17**	**497.87±6.55**	**172.70±0.66**
3	SL	35.85±0.26	585.87±11.10	175.76±0.43
	CL	35.01±0.35	527.71±15.39	173.62±0.65
Overall mean		**35.55±0.21**	**565.47±9.15**	**175.50±1.21**
4	SL	35.96±0.24	631.63±8.13	177.62±0.34
	CL	37.42±0.30	579.75±11.14	174.91±0.50
Overall mean		**36.43±0.19**	**615.02±6.70**	**176.74±0.28**
Overall mean of SL		35.44±0.12	565.55±5.15	175.01±0.30
Overall mean of CL		35.50±0.17	524.97±6.61	173.53±0.31
		Females		
1	SL	35.14±0.30	399.82±8.90	165.91±0.81
	CL	34.93±0.31	396.03±9.66	165.70±0.85
Overall mean		**35.04±0.21**	**398.01±6.53**	**165.82±0.58**
2	SL	35.02±0.18	365.90±4.80	163.67±0.51
	CL	33.71±0.26	349.15±7.01	163.67±0.95
Overall mean		**34.73±0.15**	**362.17±4.06**	**163.67±0.45**
3	SL	35.32±0.23	461.30±6.82	170.62±0.39
	CL	34.13±0.24	460.18±10.05	170.68±0.55
Overall mean		**34.79±0.17**	**460.80±5.85**	**170.65±0.33**
4	SL	35.80±0.17	565.64±5.56	175.30±0.27
	CL	36.93±0.23	531.53±7.15	173.24±0.34
Overall mean		**36.18±0.14**	**554.20±4.45**	**174.60±0.21**
Overall mean of SL		35.42±0.11	473.66±4.13	170.25±0.26
Overall mean of CL		35.29±0.14	460.27±5.30	169.78±0.38

Table (5): Means ± standard errors for age (ASM) and body weight (BWSM) at sexual maturity, rate of laying (RL), egg weight (EW) and egg mass production (EM) in selected (SL) and control (CL) lines through four generations of selection for egg number

Generation	Line	ASM, days	BWSM, g	RL, %	EW, g	EM, g
0	SL	166.05±1.33	1469.39±22.41	35.56±1.51	44.02±0.32	1402.5±59.6
	CL	176.43±1.67	1406.21±22.04	33.99±1.15	40.68±0.26	1240.4±43.8
Overall mean		**166.76±1.07^{C}**	**1436.88±15.89^{CD}**	**34.76±0.94^{D}**	**42.30±0.25^{C}**	**1319.7±37.3^{D}**
1	SL	170.62±1.47	1698.81±14.67	49.27±0.92	45.27±0.39	2008.5±41.6
	CL	174.76±1.38	1757.42±43.92	44.09±1.01	44.02±0.25	1752.7±43.5
Overall mean		**172.41±1.03^{B}**	**1724.14±20.75^{A}**	**47.03±0.70^{C}**	**44.73±0.25^{B}**	**1898.0±31.1^{C}**
2	SL	170.73±0.90	1427.87±11.01	50.11±0.66	45.09±0.31	2035.1±30.9
	CL	175.83±1.59	1364.15±16.42	45.40±1.33	44.51±0.27	1814.5±52.6
Overall mean		**172.02±0.79^{B}**	**1411.71±9.35^{D}**	**48.92±0.61^{B}**	**44.95±0.24^{B}**	**1979.2±27.2^{B}**
3	SL	191.13±0.68	1452.73±13.31	57.98±0.92	45.37±0.22	2367.4±39.3
	CL	198.20±0.84	1463.25±12.10	44.15±0.63	46.14±0.16	1833.8±27.6
Overall mean		**195.62±0.63^{A}**	**1459.41±9.08^{BC}**	**49.20±0.69^{B}**	**45.86±0.13^{A}**	**2028.7±28.5^{A} ^{B}**
4	SL	171.94±0.36	1471.35±8.86	59.25±0.28	44.48±0.17	2370.2±14.2
	CL	179.91±0.27	1518.78±10.94	44.51±0.32	44.56±0.17	1785.6±15.3
Overall mean		**174.35±0.27^{B}**	**1494.78±7.11^{B}**	**52.09±0.47^{A}**	**44.52±0.12^{B}**	**2086.5±9.6^{A}**
Overall means of SL		172.96±0.54	1509.12±7.22	51.58±0.44	44.92±0.14	2085.5±19.2
Overall means of CL		180.47±0.66	1523.00±12.46	43.11±0.39	44.34±0.11	1723.3±17.2
Overall means		**176.31**	**1514.70**	**47.72**	**44.66**	**1922.4**
Significance of:						
Generation (Gn)		**	**	**	**	**
Line (L)		**	NS	**	**	**
Gn x L		NS	**	**	**	**

Means within each column having similar letter are not significantly different at $p<0.05$.
Gn: generation L: line.
** significant at $p< 0.01$. NS non significant.

Table (6): Means ± standerd errors for internal and external egg quality traits in selected (SL) and control (CL) lines through four generations of selection for egg number

G	L	EW	EShI	Y%	Al%	Sh%	YI	Y/Al ratio
0	SL	47.9±0.9	74.1±0.7	32.2±0.6	56.4±0.7	11.7±0.3	47.1±0.7	57.7±1.8
	CL	49.6±0.7	76.6±0.5	32.5±0.4	56.0±0.5	11.8±0.3	48.3±0.7	58.3±1.1
Overall mean		**48.8±0.6** ^{D}	**75.3±0.5** ^{B}	**32.3±0.4** ^{C}	**56.2 ±0.4** ^{A}	**11.8±0.2** ^{C}	**47.7±0.5** ^{A}	**58.0±1.1** ^{C}
1	SL	49.1±0.4	76.3±0.4	34.6±0.4	51.5±0.4	13.9±.0. 2	47.2±0.4	67.8±1.3
	CL	50.8±06	76.8±0.7	32.3±0.6	53.7±0.6	13.9±0.3	48.6±0.6	60.7±1.8
Overall mean		**49.5±0.4** ^{CD}	**76.4±0.3** ^{A}	**34.0±0.4** ^{A}	**52.1±0.4** ^{D}	**13.9±0.1** ^{A}	**47.6±0.3** ^{A}	**65.9±1.1** ^{A}
2	SL	51.4±0.6	76.1±0.4	34.3±0.4	52.6±0.4	13.1±0.2	41.5±0.4	65.4±1.2
	CL	54.0±0.4	73.6±0.5	33.5±0.3	54.0±0.3	12.4±0.2	46.6±0.5	61.5±1.3
Overall mean		**52.9±0.4** ^{A}	**74.8±0.3** ^{C}	**33.8±0.2** ^{AB}	**53.4±0.3** ^{C}	**12.7±0.2** ^{B}	**44.3±0.4** ^{B}	**63.2±0.8** ^{AB}
3	SL	50.7±0.7	76.5±0.6	32.8±0.4	54.3±0.6	13.0±0.3	41.6±0.8	61.4±1.4
	CL	51.1±0.6	75.6±0.5	32.5±0.5	53.9±0.6	13.5±0.3	44.1±0.6	60.9±1.5
Overall mean		**50.9±0.5** ^{B}	**76.2±0.4** ^{AB}	**32.7±0.3** ^{C}	**54.1±0.4** ^{B}	**13.2±0.2** ^{B}	**42.5±0.6** ^{C}	**61.2±1.1** ^{B}
4	SL	49.8±0.5	74.3±0.3	33.9±0.. 3	55.1±0.5	11.9±0.2	48.1±0.4	60.5±1.1
	CL	51.4±0.5	76.0±0.7	33.3±0.5	55.1±0.6	11.7±0.2	46.5±0.8	61.1±1.7
Overall mean		**50.4±0.4** ^{CB}	**75.2±0.3** ^{BC}	**33.1±0.3** ^{BC}	**55.1±0.3** ^{B}	**11.8±0.2** ^{C}	**47.5±0.4** ^{A}	**60.7±0.9** ^{BC}
Overall mean of SL		49.9±0.3	75.6±0.2	33.4±0.2	53.8±0.2	12.8±0.1	45.4±0.3	62.9±0.7
Overall mean of CL		51.8±0.3	75.4±0.3	32.5±0.2	54.5±0.2	12.6±0.1	46.7±0.3	60.7±0.6
Sig of								
Generation (G)		**	*	**	**	**	**	**
Line (L)		**	NS	NS	*	NS	**	*
G x L		NS	**	*	NS	NS	**	*

Means within each column having similar letter are not significantly different at $p<0.05$.
G: generation L: line.
** significant at $p< 0.01$. * significant at $p< 0.05$. NS non significant.

- EW: egg weight. EShI: egg shell index. Y%. Al%. Sh%: yolk, albumin and shell percentages. YI: yolk index. Y/Al ratio: yolk/albumin ratio..

Cont. Table 6

G	L	Sh.Th	HU	YW	AlW	ShW	YC
0	SL	29.0±0.8	84.8±1.5	15.4±0.4	27.1±0.8	5.6±0.2	11.8±0.2
	CL	28.5±0.8	87.2±1.0	16.1±0.3	27.8±0.4	5.9±0.2	12.2±0.3
Overall mean		28.8±0.1 D	85.9±0.9 A	15.2±0.2 C	27.4±0.4 A	5.7±0.1 B	11.9±0.2 A
1	SL	35.8±0.3	80.6±1.0	17.0±0.2	25.3±0.3	6.8±0.1	12.7±0.2
	CL	33.5±0.7	81.9±1.5	16.4±0.4	27.3±0.4	7.1±0.1	12.4±0.4
Overall mean		**35.2±0.3 A**	**80.9±1.9 C**	**16.8±0.2 B**	**25.8±0.3 B**	**6.9±0.1 A**	**12.6±0.2 A**
2	SL	32.8±0.5	80.2±1.7	17.5±0.2	27.1±0.5	6.7±0.1	9.7±0.2
	CL	33.6±0.4	82.9±1.2	18.2±0.2	28.9±0.5	6.6±0.1	13.6±1.4
Overall mean		**33.3±0.3 B**	**81.8±1.0 BC**	**17.9±0.2 A**	**28.1±0.4 A**	**6.7±0.1 A**	**11.5±0.1 A**
3	SL	31.7±0.4	82.3±1.1	16.6±0.3	27.6±0.5	6.6±0.2	6.7±0.3
	CL	32.6±0.7	86.1±1.0	16.6±0.3	27.6±0.5	6.9±0.1	6.7±0.3
Overall mean		**32.0±0.4 C**	**83.7±0.8 AB**	**16.6±0.2 B**	**27.6±0.4 A**	**6.7±0.1 A**	**6.7±0.2 B**
4	SL	34.6±0.4	83.4±0.8	16.3±0.2	27.6±0.4	5.9±0.1	7.3±0.4
	CL	34.4±0.5	84.7±1.4	17.0±0.3	28.4±0.5	6.0±0.1	7.8±0.5
Overall mean		**34.5±0.3 A**	**83.9±0.8 AB**	**16.6±0.1**	**27.8±0.3 A**	**5.9±0.1 B**	**7.6±0.3 B**
Overall mean of SL		33.4±0.2	82.2±0.3	16.6±0.1	26.9±0.2	6.4±0.1	10.0±0.2
Overall mean of CL		32.8±0.3	84.4±0.5	17.1±0.1	28.2±0.2	6.5±0.1	10.8±0.4
Sig of Generation (G)		**	**	**	*	**	**
Line (L)		NS	**	NS	**	NS	*
G x L		*	NS	NS	NS	NS	**

Means within each column having similar letter are not significantly different at $p<0.05$. G: generation L: line.

** significant at $p< 0.01$. * significant at $p< 0.05$. NS non significant.

- Sh.T: shell thickness. Hu: Haugh units. YW. AlW. ShW: yolk, albumen and shell weights and YC: yolk color.

Table (7): Correlated response of unselected traits

Generation / Trait	1	2	3	4	Cumulative
ASM	6.24	-0.96	-1.97	-0.9	2.4
BWSM	-257	122.33	-74.24	-36.9	-110.61
RL%	3.6	-0.47	9.2	0.91	13.17
EW	-2.09	-0.67	-1.3	0.69	-3.38
EM	93.7	-35.2	31.3	51.	422.5
F%			-3.42	-5.83	-3.57
HFE	-3.9	24.3	-20.79	-3.53	-3.92
HAE	-6.94	27.8	-20.46	-7.45	-7.05
NHE	-4.43	-23.67	21.35	0.73	-6.02
PIP	-2.95	0.09	-0.85	1.21	-2.52
BW8 (M)	-	-5.8	40.76	-6.28	28.68
BW8 (F)	-	12.96	-15.63	32.99	30.32
GR (M)	-	-2.48	3.22	0.57	1.31
GR (F)	-	-0.21	-0.06	2.12	1.85
YI	-0.2	-3.7	2.6	4.1	2.8
Hu	1.1	-1.4	-1.1	2.5	1.1
Alw	-1.3	0.2	1.8	-0.8	-0.1

ASM: age at sexual maturity. BWSM: body weight at sexual maturity. RL%: rate of lay. EW: egg weight. EM: egg mass production. F%: fertility. HFE and HAE: hatchability for fertile and all eggs set. NHE and PIP: non-hatched and piped embryos. BW8 (M) and BW8 (F): body weight at 8 wks of age for males and females. GR (M). GR (F): growth rate from 0 to 8 wk for males and females. YI: yolk index. Hu: Haugh unite. and Alw: albumin weight.

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الملخص العربى

الانتخاب لتحسين إنتاج البيض فى دجاج المندرة

II. الاستجابة المباشرة و المرتبطة

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معهد بحوث الإنتاج الحيوانى – مركز البحوث الزراعية- وزارة الزراعة – الدقى

تم إجراء انتخاب لسلالة دجاج المندرة المحلية لتحسين إنتاج البيض خلال التسعين يوم الأولى من وضع أول بيضة خلال الفترة من ٢٠٠١ إلى ٢٠٠٦. تم حساب التغيرات الوراثية الناتجة بمقارنة الخط المنتخب بخط الكنترول فى كل جيل. وقد أجريت هذه الدراسة لتحديد تأثير الانتخاب لتحسين إنتاج البيض خلال أربعة أجيال متتالية على بعض الصفات (الفقس –النمو – إنتاج البيض و جودة البيض). أوضحت النتائج أن الاستجابة للانتخاب فى عدد البيض بلغت ٣.١١ ، ٣.٩٤ ، ٣.٨٠ و ٠.٦٠ بيضة خلال الأربعة أجيال المتعاقبة. وقد تراوحت قيم المكافئ الوراثى المحقق بين ٠.٢٤ إلى ٠.٥٥. و أدى الانتخاب لعدد البيض إلى تحسينا جوهريا فى صفات النمو خلال مرحلة النمو المبكرة لكل من الذكور والإناث ، وكذلك تحسينا جوهريا فى جميع صفات إنتاج البيض ، حيث بلغت الدجاجات المنتخبة جنسيا مبكرا (٤.١٤ إلى ٧.٩٧ يوما) خلال الأربعة أجيال، كما حدث تحسينا معنويا فى كل من عدد ووزن البيض وكذلك معدل إنتاج البيض ، وكتلة إنتاج البيض مقارنة بالدجاجات الغير منخبة. كما أدى الانتخاب إلى تحسين أغلب صفات جودة البيض مثل نسبتى كل من القشرة والصفار، سمك القشرة ، و نسبة الصفار إلى البياض. ووحدات هو ، وقد اختلفت معظم الصفات التى تم دراستها بين الأجيال المختلفة معنويا.

كذلك أوضحت نتائج الدراسة أن الاستجابة المرتبطة خلال الأجيال الأربع من الانتخاب بالنسبة للعمر عند أول بيضة، وزن البيض المبكر ووزن الدجاجات عند النضج الجنسي ، ومعدل الوضع هى ٢.٤١ يوم ، - ٣.٣٨ جم ، - ١١٠.٦ جم، و١٣.١٧% على التوالى. أيضا زادت كتلة البيض الناتج عن الدجاجات المنتخبة بمقدار ٤٢٢.٥ جم بالمقارنة بتلك الغير منتخبة، يمكن القول أن الانتخاب لتحسين إنتاج البيض أدى إلى تحسين صفات إنتاج البيض الأخرى وصفات النمو بالمرحلة المبكرة من عمر الطيور ، أيضاً أدى إلى تحسين صفات الفقس وكذلك معظم صفات جودة البيض.