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Effect of Selection for Weight of Early Eggs on Egg Production Traits in Japanese Quail

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ABSTRACT

The present study aimed to measure the direct response of selection for high egg weight of the first 10 eggs laid at the beginning of egg production period in Japanese quail through three generations of selection. The egg weight of the first 10 eggs (EW_{10}) as direct response increased in the selected line when compared with control line from 10.43 g in the base generation to 12.52 g in the second generation after selection with rate of 0.69 g per generation. The Age at Sexual Maturity (ASM) trait increased in the selected line from 49.47 days in the base generation to 52.63 days in the second generation after selection for EW_{10} with rate of 1.05 days per generation. The Body Weight at Sexual Maturity (BWSM) trait increased, after selection in the selected line from 240.09 g in the base generation to 251.45 and 243.67 g in the first and second generation, respectively. Egg number during the first 45 days of production was significantly higher in selected line than the control line throughout the 3 generations of selection. The overall mean of egg weight through the first 45 days of laying period were11.27, 12.01 and 12.29 g for the base, 1st and 2nd generation while it was 11.51 and 12.13 g for control and selected lines, respectively, with a significant difference among generations and between line. Average feed consumption was 31.50 and 29.03 g/female/day for the control and selected line, respectively. The females in selected line had better Feed Conversion Ratio (FCR) than the control females. Selection for EW_{10} in Japanese quail improved egg number, egg weight and FCR during the first 45 days of laying.

Key words: Quail, selection, egg production, feed conversion ratio

INTRODUCTION

Many investigators studied the effect of selection to improve egg production for quail flocks, mostly manipulated egg number and weight laid through different periods of production. Moreover, this include the selection for daily egg mass, fertility and hatchability percentages while there is a lack of information in the literature concerning the selection for quail egg weight laid per hen among a certain period. Kocak *et al*. (1995) found that the quail egg weight of the first 10 days of egg production was 10.44 g. Camci *et al*. (2002) studied the relationship between the age at sexual maturity and the performance traits in Japanese quail. They found that the average egg weight for the first 10 days were 11.05, 10.80 and 10.54 g for three groups according to their age at sexual maturity (36-42, 43-49 and 50-56 days after hatching, respectively). Soliman (2009) found that the means of ASM for low, medium and high BW groups were 60.64, 53.73 and 49.45 days, respectively, with overall mean was 53.48 days. Sakunthaladevi *et al.* (2010) reported that the average of Egg Production (EP) was 30.85 and 73.02 eggs up to 16 and 30 weeks of age, respectively, for black and brown strains of Japanese quails. Hassan (2011) studied the egg weight in Japanese quail at 14 weeks of age with three groups (light, medium and heavy weights) according to their body weight at 6 weeks of age and reported that the egg weight was 12.38, 12.98 and 13.52 g in these groups, respectively. The author indicated that Egg Weight (EW) increased significantly with increasing body weight at 6 weeks of age.

Therefore, the main objectives of the present study were to measure the direct response of selection for high egg weight of the first 10 eggs laid at the beginning of egg production period and its correlated responses with other egg production traits in Japanese quail through three selection generations.

MATERIALS AND METHODS

The present study was conducted at the Poultry Research Center, Department of Poultry Production, Faculty of Agriculture, Alexandria University during three successfully generations. The experiment aimed to measure the direct response of selection for high egg weight of the first 10 eggs laid at the beginning of egg production period and its correlated responses with egg production, egg quality and reproduction traits in Japanese quail through three selection generations. The base line was established from the birds maintained by random mating without intended selection for three generations. The mating system in the base line was in a ratio of one male to two females. In respect to selection technique, all females with higher egg weight average of the first 10 eggs laid at the beginning of egg production period within each family were selected according to their positive deviation from the line mean (Line S). There were individually selected according to full and half-sister egg number. While, random mating was used in the control line. After recording the eggs laid in the first 45 days of egg production period, the birds distributed randomly in colony cages using 1 male: 2 female as sex ratio. The fertile eggs laid used for incubation to obtain the chicks of the next generation. Direct response of selection trait was estimated among three generations, also the correlated responses for other productive and reproductive traits were estimated when selection was applied. In the control line (line C) all eggs laid by the two females of each family were used to produce the parents for the next generation. Eggs were collected for hatch when females were 10-12 weeks of age, marked, incubated for 15 days then were transferred to the hatchery part for 3 days. At the end of incubation period (18 days), all healthy chicks were removed. At day of hatch, all chicks were permanently identified by wing-banded and placed in floor brooders at a starting temperature of 36°C during the first week after hatching and then decreased 2-3°C each week thereafter. At 5 weeks of age, all birds were sexed according to color and pattern of plumage, females were separated from the males and moved to individual laying cages (20×25×25 cm). At 6 weeks of age, the quail birds randomly assigned to two groups. The first group was practiced to study the effect of selection (Line S) and the second group was maintained as contemporary control (Line C). All birds were housed in the same room in order to keep temperature, humidity, light intensity and other variables uniform as possible. However, environment and management practices were at conventional levels through the whole study. The date of the first egg was recorded for each female. Eggs were also recorded daily and weighed throughout the first 45 days after sexual maturity. The eggs of each female were isolated in a separate plastic net inside the incubator room, marked and incubated for 18 days. Again, all chicks were removed from the hatchery and permanently identified by wing-bands at day of hatch and placed in quail floor brooder. All birds were fed *ad libitum* with diet contained 24.03% crude protein and 2.896 kcal metabolizable energy/kg feed until 5 weeks of age, then they received a diet contained 20.06% crude protein and 2.901 kcal ME/kg feed during the production period. The data were collected from 146 and 382 sires, were mating with 292 and 764 dams of control and selected parents of Japanese quail, respectively.

Studied traits: The average egg weight of the first 10 eggs (EW_{10}) was estimated to the nearest 0.01 g for each female. Age at Sexual Maturity (ASM) was recorded in days for each female, the period from hatching to the day of laying the first egg. Individual female Body Weight at Sexual Maturity (BWSM) was recorded in grams, at the day of laying the first egg. The duration of laying the first 10 eggs (DU_{10}) was calculated as the number of days for each female needed to give its first 10 eggs. Egg Number (EN_{45}) and Weight (EW_{45}) were count for each female during the first 45 days of laying. Feed Conversion Ratio (FCR) in the 2nd generation, feed intake was recorded weekly in grams for each female during 10-12 weeks of age. The FCR was calculated through the same periods, as the unit of feed required to produce a unit of egg mass.

Statistical analysis

Models of analysis: Data was analyzed using SAS (2004). All percentages data was transformed to their corresponding arcsine angles values according to Senecore and Cochran (1981) before analysis. The significant tests for the differences between each two means for any studied trait were done according to Duncan's multiple rang test (Duncan, 1955). The model was:

$$Y_{ij} = \mu+G_i+P_j+(GP)_{ij}+e_{ij}$$

Where:

Y_{ij} = Observation on the jth individual

μ = Overall mean

G_i = Generation effect

P_j = Line effect

Gp_{ij} = Interaction between generation and line and

e_{ij} = Random error

Parameters and measurements of selection: Selection intensity realized (actual) selection differentials and the realized and cumulative values for direct or correlated responses in the present study were obtained according to Falconer (1989).

Selection Differential (SD): The magnitude of the selection differential depends on two factors, the proportion of the line included among the selected group and the phenotypic standard deviation of the character. Selection differential through different generations of selection was obtained according to Falconer (1989) as follows:

$$SD = \overline{X}_P - \overline{X}_o$$

Where:

$\overline{X}_P$ = Selected parents' mean

$\overline{X}_o$ = Stock mean

Selection Intensity (SI): Selection intensity through different generations of selection was calculated according to Falconer (1989) as follows:

$$SI = \frac{S}{\delta_p}$$

Where:

δ_p = Phenotypic standard deviation of the trait

S = Selection differential

Selection Response (SR): The actual response to selection for first means of the 10 eggs laid, from generation to generation in the selected line was estimated from the data in as follows:

In the first generation of selection

$$(G_{S1} - G_{S0}) - (G_{C1} - G_{C0})$$

In the second generation of selection

$$(G_{S2} - G_{S1}) - (G_{C2} - G_{C1})$$

Cumulative response

$$(G_{S2} - G_{S0}) - (G_{C2} - G_{C0})$$

RESULTS AND DISCUSSION

Selection for the weight of the first 10 eggs (EW10): Least-square means for egg weight of the first 10 eggs (EW_{10}) during three generations of selection for this trait and their analysis are presented in Table 1.

After the whole period of selection, the results showed that the overall mean of EW_{10} for selected line has higher value (11.63 g) than that for control line (11.16 g) while it being 10.42, 11.74 and 12.11 g for the base, 1st and 2nd generation, respectively. Furthermore, the differences

Table 1: Least square means, standard errors and analysis of variance for egg weight of the first 10 eggs in grams during three generations of selection for this trait with Japanese quail

	$\bar{X} \pm SE$		
Population and generations	Control	Selected	Generation overall mean
Base	10.41±0.11^{d}	10.43±0.07^{d}	10.42±0.06^{C}
	100.00%	100.19%	
1st	11.39±0.07^{c}	11.93±0.05^{b}	11.71±0.04^{B}
	100.00	104.74%	
2nd	11.70±0.13^{b}	12.52±0.11^{a}	12.11±0.09^{A}
	100.00%	107.01%	
Population overall mean	11.16±0.06^{b}	11.63±0.04^{a}	11.42
	100.00%	104.21%	
ANOVA			
Populations	**		
Generations	**		
Gen. * Pop.	**		

Means having different letters in each effect are differ significantly ($p \leq 0.05$), $^{a, b, c, d}$Interaction population by generation, $^{A, B, C}$Among generations, $^{a, b}$Between populations. **Significant at $p \leq 0.01$, $\bar{X}$: Least square means, SE: Standard errors, Gen: Generation, Pop: Population among generations, between lines or the interaction effect between them were highly significant ($p \leq 0.01$). Generally, the EW_{10} as direct response increased in the selected line when compared with control line from 10.43 g (100.19%) in the base generation to 12.52 g (107.01%) in the second generation after selection Table 1 with rate of 0.69 g per generation. On the other words, it increased gradually in selected line through generations and has higher EW_{10} means over that for control line throughout the selection period. Which are in agreement with the corresponding values reported by Kocak *et al*. (1995), Camci *et al*. (2002) and EL-Dlebshany (2014). However, these values reported here were higher than the same results found by Sreenivasaiah and Joshi (1988).

Parameters and measurements of selection

Selection Differential (SD): Least square means and standard errors for the initial means of the 10 eggs laid, Selection Differential (SD), Selection Intensity (SI) and Actual Selection Response (SR) of the selected and control lines during three generations of selection for EW_{10} with Japanese quail, are shown in Table 2. The means of SD were 0.97 and 0.56 g through the base and first generations, respectively. The lower values of SD reported in Table 2, may be attributed to small variation in this traits as represented from the values of standard errors for this trait. The magnitude of SD depends on two factors, the proportion of the line included among the selected group and the phenotypic standard deviation of the character (Falconer, 1981). The SD increases with the decrease of the proportion of the selected group and the increase of phenotypic standard deviation of the character. On the other hand, after 3 generation of selection for quail EW, Abdel-Tawab (2006) reported that the average of expected and actual selection differentials were 0.14 and -0.16 g in the control line and were 2.91 and 3.02 g in the selected line, respectively. Also, he found that the values for cumulative (expected and actual) selection differentials were 2.59 and 2.68 g at generation zero among the selected lines increased to 8.18 and 8.97 g at third generation. After divergent selection for high total egg weight to 10 weeks ($HTEW_{10}$) and low ($LTEW_{10}$), Aboul-Seoud (2008) found that the average of expected and actual selection differentials was -15.85 and -15.17 g in the control line, respectively while the values for cumulative selection differentials were 26.52 and 28.36 g at generation zero for the ($HTEW_{10}$) line increased to 32.25 and 33.92 g at the third generation. The corresponding values for the $LTEW_{10}$ line were -22.65 and -23.21g at generation zero increased to -28.25 and -32.01 g at the third generation. EL-Dlebshany (2014) reported that the average of expected and actual selection differential were 1.38 and 0.83 for base and first generation.

Selection Response (SR): Least-square means for the initial means of the 10 eggs laid, Selection Intensity (SI) and actual Selection Response (SR) for the selected and control lines during three

Table 2: Least square means and standard errors for the first means of the 10 eggs laid, selection differential, selection intensity and actual selection response of the selected and control populations during three generations of selection for EW_{10} with Japanese quail

		Selected populations ($\bar{X} \pm SE$)				
Generations	Control population ($\bar{X} \pm SE$)	All population	Selected parents	SD (g)	SI (units)	SR (g)
Base	10.41±0.11	10.43±0.07	11.40±0.15			
N	100	450	200	0.97	0.65	-
1st	11.39±0.07	11.93±0.05	12.49±0.12			
N	90	260	114	0.56	0.69	0.52
2nd	11.70±0.13	12.52±0.11				
N	102	233	-	-	-	0.28
Cumulative response						0.80

$\bar{X}$: Least square means, SE: Standard errors, SD: Selection differential, SI: Selection intensity, SR: Selection response generations of selection for EW_{10} with Japanese quail, are shown in Table 2. The estimated actual response to selection after the first generation of selection was 0.52 g and then it decreased gradually as the selection continued to 0.28 g after the second generation of selection, respectively.

In the present experiment, the actual response to selection for first means of the first 10 eggs laid, from generation to generation in the selected line was estimated from the data presented in Table 2 as follows:

In generation 1:

$$(G_{S1}-G_{S0})-(G_{C1}-G_{C0}) = (11.93-10.43)-(11.39-10.41)$$
$$= 1.50-0.98 = 0.52$$

In generation 2:

$$(G_{S2}-G_{S1})-(G_{C2}-G_{C1}) = (12.52-11.93)-(11.70-11.39)$$
$$= 0.59-0.31= 0.28$$

Cumulative response:

$$(G_{S2}-G_{S0})-(G_{C2}-G_{C0}) = (12.52-10.43)-(11.70-10.41)$$
$$= 2.09-1.29 = 0.80$$

These fluctuations of SR showed in the present study were obvious due to the significant differences among generations in the mean of EW_{10} for the control lines. This irregularity of the selection response had been observed by Falconer (1954), showed that it might be due to many causes of genetically or environmental nature. Differences in natural selection differential, fertility and/or genetic-environment interaction on egg weight might be causing such irregularity in selection response especially in such small numbers of generations. Also, Larner (1958) reported that selection programs depend on the amount of genetic variability presents in the line. On the other hand, Abdel-Tawab (2006) reported that the actual response to selection for high egg weight was 1.22 g at the first generation and fluctuated to be 0.68 g at the third generation. Aboul-Seoud (2008) showed that the actual response to selection for ($HTEW_{10}$) was 12.24 g at the first generation and then it decreased gradually as the selection continued to 11.59 and 10.06 g at the second and third generation, respectively. While, the actual response to selection for $LTEW_{10}$ was -9.54 g at the first generation, then it decreased gradually as the selection continued to -7.95 and -6.52 g at the second and the third generation of selection, respectively. The cumulative response to selection after three generations of selection in the $HTEW_{10}$ and $LTEW_{10}$ lines were 33.89 and -24.01 g, respectively. EL-Dlebshany (2014) reported that the selection response for three generation were 0.82.

Correlated response to selection

Egg production traits

Age at Sexual Maturity (ASM): Least-square means for ASM during three generations of selection for EW_{10}, are shown in Table 3. The overall means of ASM were 52.61 and 50.45 days for control and selected lines while it being 49.61, 50.78 and 54.77 days for the base, 1st and 2nd

Table 3: Least square means, standard errors and analysis of variance for age at sexual maturity in days during three generations of selection for EW_{10} with Japanese quail

	$\bar{X} \pm SE$		
Population and generations	Control	Selected	Generation overall mean
Base	50.09±0.58	49.47±0.35	49.61±0.30[B]
	100.00	98.76	
1st	51.18±0.87	50.58±0.53	50.78±0.46[B]
	100.00	104.74	
2nd	56.89±1.64	52.63±1.67	54.77±1.18[A]
	100.00	107.01	
Population overall mean	56.61±0.06[a]	50.45±0.37[b]	51.16
	100.00	95.89	
ANOVA			
Populations	**		
Generations	**		
Gen. * Pop.	NS		

Means having different letters in each effect are differ significantly ($p \leq 0.05$). [A,B,C]Among generations, [a,b]Between populations, **Significant at $p \leq 0.01$, NS: Non significant, $\bar{X}$: Least square means, SE: Standard errors, Gen: Generation, Pop: Population

generation, respectively. Also, the differences among generations or between lines were highly significant ($p \leq 0.01$) while the interaction effect between them was insignificant (Table 3).

In breeding researches, ASM is very important trait, since egg production traits are affected by age at sexual maturity in chickens and quails (Ghanem, 1995; Camci *et al*., 2002; Meky, 2007). The overall mean for ASM showed in this study was 51.16 days (ranged from 49.47-56.89 days), this finding is in agreement with the findings reported by Shalan (2002), Abdel-Tawab (2006) and Meky (2007). However, it were found to be disagree and/or higher with those obtained by Aboul-Seoud (2008), Badawy (2008), Soliman (2009), Magda *et al*. (2010), Sakunthaladevi *et al*. (2011), Momoh *et al*. (2014), Okuda *et al*. (2014) and Islam *et al*. (2015). In general, the respect ASM trait as correlated response increased in the selected line from 49.47 days in the base generation to 52.63 days in the second generation after selection for EW_{10} (Table 3) with rate of 1.05 days per generation. However, all ASM means of selected line (92.51-98.83%) were lower than that for control line (100%) throughout the 3 generations of selection. These results indicated that the selection for EW_{10} decreased ASM in Japanese quail.

Body Weight at Sexual Maturity (BWSM): Least-square means for BWSM during three generations of selection for EW_{10}, are shown in Table 4. The overall means of BWSM were 245.99 and 243.67 g for control and selected populations while it being 239.62, 244.55 and 252.51 g for the base, 1st and 2nd generation, respectively. The analysis results showed that only the differences among generations were highly significant ($p \leq 0.01$) while the effects for between lines or interaction were insignificant (Table 4). The overall mean for BWSM was 244.44 g (ranged from 238.12-353.55 g). These values were nearly equal with finding by Soliman (2009), however, it was higher than the range from 144.8-228.8 g. found by Meky (2007), Okenyi *et al*. (2013), Bothaina *et al*. (2014), Bulbul *et al*. (2014), Ipek and Dikmen (2014), Momoh *et al*. (2014) and Islam *et al*. (2015).

In general, the BWSM trait increased, after selection for EW_{10} as correlated response, in the selected line from 240.09 g in the base generation to 251.45 and 243.67 g in the first and second generation, respectively (Table 4). However, the BWSM means of selected line during first and second generation were lower (99.58 and 99.17%, respectively, than that for control line (100%). These results indicated that the selection for $EW_{10,}$ regardless their fluctuations among generations, decreased BWSM in Japanese quail.

Table 4: Least square means, standard errors and analysis of variance for body weight at sexual maturity in grams during three generations of selection for EW_{10} with Japanese quail

Population and generations	$\bar{X} \pm SE$ Control	Selected	Generation overall mean
Base	238.12±2.63	240.09±1.58	239.62±1.35[C]
	100.00	98.76	
1st	245.25±2.05	244.21±1.43	244.55±1.17[B]
	100.00	104.74	
2nd	253.55±3.18	251.45±3.45	252.51±2.34[A]
	100.00	99.17	
Population overall mean	245.99±1.51	243.67±1.04	244.44
	100.00	99.06	
ANOVA			
Populations	NS		
Generations	**		
Gen. * Pop.	NS		

Means having different letters in each effect are differ significantly ($p \le 0.05$), [A, B, C]Among generations, **Significant at $p \le 0.01$,NS: Non Significant, $\bar{X}$: Least square means, SE: Standard errors, Gen: Generation, Pop: Population

Table 5: Least square means, standard errors and analysis of variance for the duration of laying the first 10 eggs (DU_{10}) during three generations of selection for EW_{10} with Japanese quail

Population and generations	$\bar{X} \pm SE$ Control	Selected	Generation overall mean
Base	13.75±0.59[c]	13.63±0.28[c]	13.65±0.26
	100.00	99.13	
1st	15.07±0.63[a]	14.47±0.38[b]	14.67±0.33
	100.00	96.02	
2nd	14.97±1.08[a]	14.31±1.17[b]	14.64±0.80
	100.00	95.59	
Overall mean	14.76±0.46	14.11±0.26	14.32
	100.00	95.60	
ANOVA			
Populations	NS		
Generations	NS		
Gen. * Pop.	**		

Means having different letters in each effect are differ significantly ($p \le 0.05$), [a, b, c, d]Interaction population by generation, **Significant at $p \le 0.01$, NS: Non significant, $\bar{X}$: Least square means, SE: Standard errors, Gen: Generation, Pop: Population

Duration of laying the first 10 eggs (DU_{10}): Least-square means for the duration of laying the first 10 eggs (DU_{10}) during three generations of selection for EW_{10}, are shown in Table 5. The results of this trait showed that the differences among generation and between lines were insignificant, it ranged from 13.63-15.07 days. However, the interaction results observed to has highly significant ($p \le 0.01$) differences. The overall mean for DU_{10} was 14.32 days. Generally, all DU_{10} means of selected line (ranged from 13.63-14.47 days) were lower than that for control line (ranged from 13.75-15.07 days) throughout the 3 generations of selection for EW_{10}. In percentages, the overall means of DU_{10} were 100 and 95.60% for control and selected lines, respectively. These results indicated that the selection for EW_{10}, regardless their fluctuations among generations, decreased DU_{10} in Japanese quail. Result of the present study is in harmony with previous study reported by Bothaina *et al.* (2014).

Egg number through the first 45 days of laying (EN_{45}): Least-square means for egg number through the first 45 days of laying during three generations of selection for EW_{10} are shown in Table 6. The differences among generations in that respect were non-significant (ranged from 37.07-37.30 eggs) but the differences between lines and the interaction effect were highly significant ($p \le 0.01$).

Table 6: Least square means, standard errors and analysis of variance for egg number through the first 45 days of laying (EN_{45}) during three generations of selection for EW_{10} with Japanese quail

	$\bar{X} \pm SE$		
Population and generations	Control	Selected	Generation overall mean
Base	37.18±0.96[a]	37.34±0.44[a]	37.30±0.40
	100.00	100.43	
1st	35.18±0.91[b]	38.10±0.63[a]	37.07±0.52
	100.00	108.30	
2nd	35.64±1.16[b]	37.82±1.18[a]	37.19±0.83
	100.00	108.92	
Population overall mean	35.77±0.60[b]	37.88±0.37[a]	37.18
	100.00	105.90	
ANOVA			
Populations	**		
Generations	NS		
Gen. * Pop.	**		

Means having different letters in each effect are differ significantly ($p \leq 0.05$), [a, b]Between populations, **Significantly at $p \leq 0.01$ NS: Non significant, $\bar{X}$: Least square means, SE: Standard errors, Gen: Generation, Pop: Population

The overall mean of selected line has significantly higher EN_{45} (37.88 eggs) over the corresponding value for control line (35.77 eggs). The overall mean was 37.18 eggs, similarly the results obtained by Bahie El-Deen (1994), Shebl *et al.* (1996), Kosba *et al.* (2003), Debes (2004), Bahie El-Deen and Shalan (2005), Meky (2007) and Okuda *et al.* (2014) are in consistently with the present results. However, it was found to be disagreeing with those obtained by Abdel-Tawab (2006), Aboul-Seoud (2008), Soliman (2009) and Okenyi *et al.* (2013). Egg production in Japanese quail is influence by several factors other than additive genetic effects such as: Age at sexual maturity, managerial and climatic conditions (Shamma, 1981) age, body weight, lean mass adiposity and skeletal size (Broady *et al.*, 1984; Brody *et al.*, 1980; Krapu, 1981).

Generally, all EN_{45} means of selected line (ranged from 100.43-108.92%) were higher than that for control line (100%) throughout the 3 generations of selection for EW_{10}. These results indicated that the selection for EW_{10} increased EN_{45} in Japanese quail.

Egg weight through the first 45 days of laying (EW_{45}): Least-square means for EW through the first 45 days of laying (EW_{45}) during three generations of selection for EW_{10} are shown in Table 7. The results showed highly significant ($p \leq 0.01$) differences for all effect studied. The overall means of EW_{45} were 11.27, 12.01 and 12.29 g for the base, 1st and 2nd generation and 11.51 and 12.13 g for control and selected lines, respectively. The overall mean for EW_{45} was 11.86 g (ranged from 11.21-12.85 g), these findings are in agreement with the results obtained by EL-Dlebshany (2014), Ipek and Dikman (2014) and Farghly *et al.* (2015) in their studies at different ages studied. Higher value showed by Abdel-Azeem *et al.* (2005), the mean of egg weight during 6-11 weeks of age in Japanese quail was 12.14 g. Lower value reported by Abdel-Tawab (2006), Okenyi *et al.* (2013) and Momoh *et al.* (2014). Generally, all EW_{45} means of selected line (ranged from 101.07-109.64%) were higher than that for control line (100%) throughout the 3 generations of selection for EW_{10}. These results indicated that the selection for EW_{10} increased EW_{45} in Japanese quail.

Feed Conversion Ratio (FCR): Least square means of feed consumption and FCR in the 2nd generation of selection for EW_{10} with Japanese quail are shown in Table 8. Feed consumption through 10-12 weeks of age averaged 31.50 and 29.03 g/female/day for the control and selected line, respectively. The average FCR was 3.11 and 2.41 unit (kg feed/kg egg) for the control and selected

Table 7: Least square means, standard errors and analysis of variance for egg weight through the first 45 days of laying (EW_{45}) in grams during three generations of selection for EW_{10} with Japanese quail

	$\bar{X} \pm SE$		
Population and generations	Control	Selected	Generation overall mean
Base	11.21 ± 0.12^c 100.00	11.33 ± 0.07^c 101.07	11.27 ± 0.06^C
1st	11.61 ± 0.07^b 100.00	12.23 ± 0.05^{ab} 105.34	12.01 ± 0.05^B
2nd	11.72 ± 0.11^b 100.00	12.85 ± 0.10^a 109.64	12.29 ± 0.08^A
Population overall mean	11.51 ± 0.06^b 100.00	12.13 ± 0.04^a 105.39	11.86
ANOVA			
Populations	**		
Generations	**		
Gen. * Pop.	**		

Means having different letters in each effect are differ significantly ($p \leq 0.05$), [a, b, c, d]Interaction population by generation, [A, B, C]Between generations, [a, b]Between populations, **Significancy at $p \leq 0.01$, $\bar{X}$: Least square means, SE: Standard errors, Gen: Generation, Pop: Population

Table 8: Least square means, standard errors and analysis of variance for feed consumption (g/female/day) and feed conversion ratio (unit) in the 2nd generation of selection for EW_{10} with Japanese quail

	Traits ($\bar{X} \pm SE$)	
Populations	Feed consumption	Feed conversion ratio
Control	31.50	3.11^a
Selected	29.03	2.41^b
ANOVA		
Populations	NS	**

Means having different small letters are differ significantly ($p \leq 0.05$), [a, b]Between populations, **Significantly at $p \leq 0.01$, NS: Non significant, $\bar{X}$: Least square means, SE: Standard errors

lines, respectively. Also, the females in selected line had better FCR than that in control. The differences between lines for feed consumption were non-significant, it being highly significant ($p \leq 0.01$), as shown in Table 8. These results were agreement with the values reported by Abdel-Azeem *et al.* (2005), Meky (2007), Khaldari *et al.* (2010) and Bulbul *et al.* (2014). The present results indicated that the selection for EW_{10} with Japanese quail improved feed conversion ratio for egg production as a correlated response by the rate -22.51% (77.49 vs. 100% for selected and control lines, respectively).

CONCLUSION

Response of selection for high egg weight of the first 10 eggs laid at the beginning of egg production period in Japanese quail through three selection generation increased in selected line compared with control line. Furthermore, improved FCR and egg production traits (age at sexual maturity, egg number and egg weight during the first 45 days of laying).

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