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Research Article
Selection for Weight of Early Eggs in Japanese Quail: Correlated Response and Heritability

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Abstract
The experiment aimed to measure the correlated response of selection for high egg weight of the first 10 eggs laid at the beginning of egg production period (EW_{10}) and its correlated responses with growth performance in Japanese quail through three generations of selection. The overall mean of EW_{10} for selected lines has higher value (11.63 g) than that for control lines (11.16 g) with a significant difference among generations and between lines. Body weight at hatch, 2, 4 and 6 weeks of age has highly significant differences among generations and between lines. However, the differences between sexes were significant for only BW_6. The selection for EW_{10} has positive effect on BW_0 of both sexes in Japanese quail. The selection for EW_{10} in Japanese quail has different magnitude on BW_4, positive effect on male and negative effect on females. The selection for EW_{10} in Japanese quail has positive trend on BW_6 of both sexes. The overall means of growth rate during 0-2 and 2-6 weeks of age for males were 132.56 and 113.01%, respectively. The corresponding values for females were 133.86 and 113.35%, respectively. The heritability estimate of body weight of males had higher values at hatch and 2 weeks of age than the corresponding estimates for females. Then the females had the superiority in the respect at 4 and 6 weeks of age. In conclusion increasing of body weight at different age as a correlated response can be obtained by direct selection for increase egg weight.

Key words: Quail, selection, correlated response, heritability, growth, performance

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Growth is a trait of prime interest to the poultry industry and the Japanese quail may serve a useful role in studied involving body weight. Quails are considered a good and economical source for producing animal protein (Singh *et al*., 1981). Egg weight is the most important factor affecting chick weight at hatch in Japanese quail (Saatci *et al*., 2006). Direct response to selection is the change of the line means that produced by selection. In other words, it is the difference between the offspring phenotypic mean of selected trait and the corresponding value of their selected parents of the previous generation. The phenomena of growth is usually measured by observing differences in body weight recorded at different ages and/or in body gain obtained during different growth periods (Cole, 1966). Growth is the most important trait for evaluating different livestock species especially in meat production. The literature showed that BW of Japanese quail increased straightly from hatching to 6 weeks and sex differences between body weight of male and female were significant. Aboul-Seoud (2008) found correlated responses when divergent selection was applied TEW_{10} in line selected for high TEW_{10} ($HTEW_{10}$). On the other hands, effect of sex on body weight was studied by Shokoohmand *et al*. (2007) and Alkan *et al*. (2010). They found that females of Japanese quails were heavier than males in their studies. Observed values of heritability for body weight in Japanese quail were published by El-Deen (1994), Resende *et al*. (2005), Magda *et al*. (2010), Momoh *et al*. (2014) and Manaa *et al*. (2015).

The main objectives of the present study was 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 growth performance in Japanese quail through three generations of selection.

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 generation . The experiment aimed to measure the correlated response of selection for high egg weight of the first 10 eggs laid at the beginning of egg production period. The data on body weight were used in order to evaluate their response to selection for high egg weight of the first 10 eggs laid at the beginning of egg production period. Details of this selection experiment were published by El-Deen *et al*. (2015). 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. 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. All birds were fed *ad-libitum* with diet contained 24.03% crude protein and 2896 Kcal. Metabolizable Energy ME kg^{-1} feed until 5 weeks of age, then they received a diet contained 20.06% crude protein and 2901 Kcal ME kg^{-1} feed during the production period.

The data were collected from 146 , 382 sires , were mating with 292 and 764 dams of control and selected parents of Japanese quail respectively during three generations. Four hatches for each generation which produces 894 and 2002 chicks from control and selected parents respectively.

Studied traits

Body Weight (BW): Biweekly body weight was recorded for every individual bird to the nearest 0.1 g From hatch to 6 weeks of age (BW_0, BW_2, BW_4 and BW_6).

Growth Rate (GR): Growth rate through the same period's daily body weight gain rate was calculated according the following formula Brody (1945):

$$GR = \frac{W2-W1}{1/2\ (W2+W1)} \times 100$$

Where:
W1 = Initial weight (g)
W2 = Final weight (g)

Heritability estimate (h^2s): Heritability estimates were calculated according to the following formula Becker (1985):

h^2s = 4 var (S)/[var(S)+var(E)]
var(S) = Sire variance components
var (E) = within sire residual variance components

Statistical analysis

Model of analysis: Data were analyzed using SAS (2004) for statistical analysis program. All percentages data were transformed to their corresponding arcsine angles values according to Snedecor and Cochran (1980) 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 data of body weight at different ages and growth rate at different periods were analyzed using the following model:

$$Y_{ij} = \mu + G_i + P_j + S_k + (GP)_{ij} + (GS)_{ik} + (PS)_{jk} + (GPS)_{ijk} + e_{ij}$$

where, Y_{ij} is the observation on the jth individual, μ is the overall mean, G_i is the generation effect, P_j is the line effect, S_k is the sex effect, $(GP)_{ij}$ is the interaction between generation and line, $(GS)_{ik}$ is the interaction between generation and sex effect, $(PS)_{jk}$ is the interaction between line and sex effect, $(GPS)_{ijk}$ is the interaction between generation, line and sex effect and e_{ij} is the random error.

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 the selected and control over lines are presented in (Table 1). The differences among generations, between lines or the interaction effect between them were highly significant ($p \leq 0.01$).

In the base generation, there were no significant differences between means of egg weight for control and selected lines. However, in the second selected generation there were significant differences between means of egg weight for control (11.7 g) and selected (12.52 g) lines. The result of these studies for egg weight is in agreement with Kocak *et al*. (1995), Camci *et al*. (2002) and El-Dlebshany (2014).

Correlated responses

Hatch weight (BW_0): Least-square means for BW_0 of Japanese quail during three generations of selection for EW_{10} are presented in (Table 2). The means of BW_0 for the both sexes

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

	X±SE		
Line generations	Control	Selected	Generation overall mean
Base	10.41±0.11^{d}	10.43±0.07^{d}	10.42±0.06^{C}
1st	11.39±0.07^{c}	11.93±0.05^{b}	11.74±0.04^{B}
2nd	11.70±0.13^{b}	12.52±0.11^{a}	12.11±0.09^{A}
Line overall mean	11.16±0.06^{b}	11.63±0.04^{a}	11.42
ANOVA			
Lines (Pop.)		**	
Generations (Gen.)		**	
Gen. * Pop.		**	

Means having different letters in each effect are differ significantly ($p \leq 0.05$), ^{a,b,c,d}Interaction line by generation, ^{A,B,C}Among generations, ^{a,b}Between lines, **Significantly at $p \leq 0.01$, X: Least square mean, SE: Standard error

Table 2: Least square means, standard errors and analysis of variance for BW_0 in grams during three generations of selection for EW_{10} with Japanese quail

	X±SE						
	Males			Females			
Pop./Gen.	Control	Selected	Generation overall mean	Control	Selected	Generation overall mean	Generation overall mean for both sexes
Base	-	-	8.00±0.00^{c}	-	-	8.00±0.00^{c}	8.00±0.00^{C}
1st	8.64±0.06	8.89±0.06	8.77±0.05^{b}	8.61±0.06	8.88±0.06	8.74±0.05^{b}	8.75±0.03^{B}
	100.00	102.89		100.00	103.14		
2nd	9.23±0.08	9.46±0.04	9.43±0.03^{a}	9.17±0.08	9.49±0.04	9.45±0.03^{a}	9.44±0.02^{A}
	100.00	102.49		100.00	103.49		
Line	8.81±0.05^{b}	9.22±0.03^{a}		8.76±0.05^{b}	9.25±0.03		
Overall mean	100.00	104.65	9.11±0.03	100.00	105.59	9.10±0.03	9.11
ANOVA							
Generation (Gen.)				**			
Line (Pop.)				**			
Gen. * Pop.				NS			
Sex				NS			
Gen. * Sex				NS			
Pop. * Sex				NS			
Gen. * Pop.* Sex				NS			

Means having different letters in each effect are differ significantly ($p \leq 0.05$), ^{a,b,c,d}Interaction line by generation, ^{A,B,C} Among generations, ^{a,b} Between lines,**Significantly at $p \leq 0.01$, NS: Non significant, X: Least square mean, SE: Standard error

were ranged from 8.00-9.49 g, with overall mean was 9.11 g. These values were nearly equal with the findings by Soliman (2009). Also, the overall mean of BW_0 was 9.10 and 9.11 g for quail females and males, respectively. These values are in agreement with the corresponding values reported by Soliman (2009), El-Shahwy (2010) and El-Dlebshany (2014). Also, the insignificant differences due to sex for BW_0 showed by most authors in literature by Abdel-Mounsef (2005), Abd El-Fattah (2006) and Abdel-Tawab (2006). However, these values are disagree with the findinges by Farghly *et al*. (2015), Raji *et al*. (2014), Islam *et al*. (2015), Daikwo *et al*. (2014) and Momoh *et al*. (2014). On the other hand, the statistical analysis for this trait revealed that only the differences among generations or between lines were highly significant ($p \leq 0.01$) while, the other effects studied were insignificant. Generally, all BW_0 means of selected line for males (ranged from 102.49-102.89%) or females (ranged from 103.14-103.49%) 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} has positive effect on BW_0 of both sexes in Japanese quail.

Two weeks body weight (BW_2): Least-square means for BW_2 of Japanese quail during three generations of selection for EW_{10}, are presented in Table 3. The means of BW_2 for both sexes ranged from 37.49-63.88 g with estimated overall mean was 49.69 g. The overall means of BW_2 showed in the present study for females (50.72 g) or males (48.72 g) are in line with similar findings by Balcioglu *et al*. (2005), Magda *et al*. (2010), Okuda *et al*. (2014) and Raji *et al*. (2014). However, these values are disagree and/lower with the findings by Soliman (2009) and El-Shahwy (2010). Also, the insignificant differences due to sex for BW_2 in the present study (Table 3) showed by Sefton and Siegel (1974), El-Deen (1994) and Badawy (2008). Significant differences for quail BW_2 were reported by Soliman (2009), El-Shahwy (2010), Islam *et al*. (2015) and Daikwo *et al*. (2014).

On the other hand, the statistical analysis for this trait revealed that the differences among generations or between lines were highly significant ($p \leq 0.01$) while, the other effects studied were insignificant. Generally, the BW_2 means of selected line for males or females fluctuated higher values in the first generation (104.68 and 113.26%, respectively) to lower values in the second generation (96.50 and 91.47%) when compared with the corresponding values of control line (100%) throughout the 3 generations of selection for EW_{10}. These results indicated that the selection for EW_{10} has negative effect on BW_2 in Japanese quail.

Four weeks body weight (BW_4): Least-square means for BW_4 of Japanese quail during three generations of selection for EW_{10}, are presented in Table 4. The means BW_4 for both sex were ranged from 97.50-137.15 g with estimated overall mean was 119.16 g. Also, the overall mean of BW_4 for quail males and females was 115.89 and 122.33 g, respectively. These values are around the range findings by Balcioglu *et al*. (2005), Soliman (2009), El-Shahwy (2010), Islam *et al*. (2015) and Okuda *et al*. (2014). The sex differences were insignificant as showed in Table 4. However, the significant

Table 3: Least square means, standard errors and analysis of variance for BW_2 in grams during three generations of selection for EW_{10} with Japanese quail

	X±SE						
	Males			Females			
Pop./Gen.	Control	Selected	Generation overall mean	Control	Selected	Generation overall mean	Generation overall mean for both sexes
Base	-	-	49.88±1.21^{b}	-	-	50.58±1.50^{b}	49.88±1.21^{B}
1st	37.83±0.81	39.60±0.71	38.74±0.54^{c}	37.49±0.74	42.46±0.87	39.81±0.58^{c}	39.28±0.40^{C}
	100.00	104.68		100.00	113.26		
2nd	58.82±1.50	56.76±0.71	57.09±0.64^{a}	63.88±1.45	58.43±0.67	59.23±0.62^{a}	58.09±0.45^{A}
	100.00	96.50		100.00	91.47		
Line	43.66±0.91^{b}	50.78±0.58^{a}		44.33±0.94^{b}	53.66±0.61^{a}		
Overall mean	100.00	116.31	48.72±0.50	100.00	121.05	50.72±0.53	49.69
ANOVA							
Generation (Gen.)				**			
Line (Pop.)				**			
Gen. * Pop.				NS			
Sex				NS			
Gen. * Sex				NS			
Pop. * Sex				NS			
Gen. * Pop.* Sex				NS			

Means having different letters in each effect are differ significantly ($p \leq 0.05$), ^{a,b,c,d}Interaction line by generation, ^{A,B,C}Among generations, ^{a,b}Between lines, **Significantly at $p \leq 0.01$, NS: Non significant, X: Least square mean, SE: Standard error

differences between sex reported in many studies for quail BW_4 by El-Deen (1999), Shebl *et al.* (1996), Soliman (2009) and El-Shahwy (2010). However these values were higher than reported by Momoh *et al.* (2014) and Raji *et al.* (2014).

There were only high significant ($p \leq 0.01$) differences among generations or between lines, as shown in Table 4. The overall means of both sexes for base, 1st and 2nd generation were 126.74, 103.85 and 129.44 g, respectively. Generally, the BW_4 means of selected line for males were higher (107.72 and 102.51% at first and second generation, respectively) when compared with the corresponding values of control line (100%). While the BW_4 means of selected line for females were fluctuated between higher value (113.09%) at the first generation and lower value (96.13%) at the second generation, when compared with the corresponding values of control line (100%). These results indicated that the selection for EW_{10} in Japanese quail has different magnitude on BW_4, positive effect on male and negative effect on females.

Six weeks body weight (BW_6): Least-square means for BW_6 of Japanese quail during three generations of selection for EW_{10}, are presented in Table 5. The means of BW_6 were ranged

Table 4: Least square means, standard errors and analysis of variance for BW_4 in grams during three generations of selection for EW_{10} with Japanese quail

	X±SE						
	Males			Females			
Pop./Gen.	Control	Selected	Generation overall mean	Control	Selected	Generation overall mean	Generation overall mean for both sexes
Base	-	-	123.94±3.59^{a}	-	-	129.54±2.76^{a}	126.74±2.27^{A}
1st	97.50±2.07	105.03±1.84	101.27±1.40^{b}	100.43±2.07	113.58±2.24	106.44±1.56^{b}	103.85±1.05^{B}
	100.00	107.72		100.00	113.09		
2nd	123.64±2.59	126.74±1.44	126.23±1.27^{a}	137.15±3.41	131.84±1.29	132.60±1.21^{a}	129.44±0.88^{A}
	100.00	102.51		100.00	96.13		
Line	105.43±1.80^{b}	120.24±1.15^{a}		110.53±2.03^{b}	127.14±1.10^{a}		
Overall mean	100.00	114.05	115.89±0.99	100.00	115.03	122.33±1.01	119.16
ANOVA							
Generation (Gen.)				**			
Line (Pop.)				**			
Gen. * Pop.				NS			
Sex				NS			
Gen. * Sex				NS			
Pop. * Sex				NS			
Gen. * Pop.* Sex				NS			

Means having different letters in each effect are differ significantly (p 0.05), ^{a,b,c,d} Interaction line by generation, ^{A,B,C} Among generations, ^{a,b} Between lines, **Significantly at $p \leq 0.01$, NS: Non significant, X: Least square mean, SE: Standard error

Table 5: Least square means, standard errors and analysis of variance for BW_6 in grams during three generations of selection for EW_{10} with Japanese quail

	X±SE						
	Males			Females			
Pop./Gen.	Control	Selected	Generation overall mean	Control	Selected	Generation overall mean	Generation overall mean for both sexes
Base			174.16±2.79^{b}			181.50±3.32^{b}	178.05±2.19^{B}
1st	164.84±2.63	171.16±2.11	168.05±1.69^{c}	166.91±2.68	181.64±2.42	173.67±1.87^{c}	170.93±1.27^{C}
	100.00	103.83		100.00	108.83		
2nd	177.58±2.82	185.06±1.32	183.79±1.20^{a}	184.93±3.44	193.78±1.22	192.37±1.17^{a}	188.31±0.85^{A}
	100.00	104.21		100.00	104.79		
Line	168.78±2.05^{b}	182.85±1.12^{a}		172.10±2.21^{b}	192.23±1.10^{a}		
Overall mean	100.00	108.34	178.77±1.02	100.00	111.70	186.17±1.07	179.09
ANOVA							
Generation (Gen.)				**			
Line (Pop.)				**			
Gen. * Pop.				NS			
Sex				**			
Gen. * Sex				NS			
Pop. * Sex				NS			
Gen. * Pop.* Sex				NS			

Means having different letters in each effect are differ significantly (p0.05), ^{a,b,c,d} Interaction line by generation, ^{A,B,C} Among generations, ^{a,b} Between lines, **Significantly at $p \leq 0.01$, NS: Non significant, X: Least square mean, SE: Standard error

from 164.84-193.78 g, with overall mean was 179.09 g. Also, the overall mean for BW_6 quail males and females was 178.77 and 186.17 g, respectively. These values for both sexes were nearly equal with the findings by Balcioglu *et al.* (2005), Aboul-Seoud (2008), Soliman (2009), Magda *et al.* (2010), El-Dlebshany (2014) and Okuda *et al.* (2014). The surpassed of males over females in BW_6 was reported by many authors by Marks (1990), El-Deen (1994, 1999), Shebl *et al.* (1996), Younis *et al.* (2004), El-Shahwy (2010), Raji *et al.* (2014) and Daikwo *et al.* (2014). They indicated that BW for females quail being heavier than males at different ages. Moreover, Caron and Minvielle (1990) indicated that females grew faster and yielded larger muscles and more abdominal fat than males at the same age.

The differences for all main sources of variance studied (generations, lines or sex) were highly significant ($p \leq 0.01$) while all interactions studied were insignificant (Table 5). The overall means of both sexes for base, 1st and 2nd generation were 178.05, 170.93 and 188.31 g, respectively. The BW_6 means of selected line for males and females were higher (it being 103.83 and 108.83% and 104.21 and 104.79% at first and second generation, respectively) when compared with the corresponding values of control line (100%). These results indicated that the selection for EW_{10} in Japanese quail has positive trend on BW_6 of both sexes.

Generally, this results revealed that increasing in body weight at different ages can be obtained by selection for weight of early eggs in Japanese quail.

Growth Rate (GR): Least-square means for GR_{0-2} during three generations of selection for EW_{10}, are presented in Table 6. The means of this trait were ranged from 121.30-147.90%, with overall mean was 135.98%. These values are in agreement with the corresponding findings by Magda *et al.* (2010). Also, the overall mean for GR_{0-2} for quail males and females was 132.56 and 133.86%, respectively.

The statistical analysis of GR_{0-2} revealed that only the differences among generations or between lines were highly significant ($p \leq 0.01$) while the other effects studied were non-significant Table 6. The overall means of GR_{0-2} for both sexes in base, 1st and 2nd generation were 144.07, 122.92 and 140.95%, respectively.

Least-square means for GR_{2-6} during three generations of selection for EW_{10}, are presented in Table 7. The means of GR_{2-6} were ranged from 100.20-123.24%, with overall mean was 113.18%. Also, the overall mean for GR_{2-6} for quail males and females was 113.01 and 113.35%, respectively.

The analysis of variance results of GR_{2-6} revealed that only the differences among generations or between lines were highly significant ($p \leq 0.01$) while, other effects studied were non-significant, as found in Table 7. The overall means of GR_{2-6} for both sexes in base, 1st and 2nd generation were 113.01, 122.46 and 104.08%, respectively. Highly significant differences for GR (%) during 0-2 and 2-6 weeks of age were in agreement with the findings by Soliman (2009).

In general, the results of growth rate indicated that, growth rate decreased gradually during the growth periods from hatch to 6 weeks of age. These results agree with those obtained by Soliman (2009), Daikwo *et al.* (2014), Okuda *et al.* (2014) and Raji *et al.* (2014).

Table 6: Least square means, standard errors and analysis of variance for GR_{0-2} in percentages during three generations of selection for EW_{10} with Japanese quail

	X±SE						
	Males			Females			
Pop./Gen.	Control	Selected	Generation overall mean	Control	Selected	Generation overall mean	Generation overall mean for both sexes
Base			142.76±1.30[a]			145.37±0.11[a]	144.07±1.30[A]
1st	121.55±1.43	123.14±1.25	122.37±0.95[b]	121.30±1.30	125.93±1.30	123.46±0.93[b]	122.92±0.66[B]
	100.00	101.31		100.00	103.82		
2nd	143.49±1.65	139.48±0.85	140.11±0.7[a]	147.90±1.21	140.97±0.75	141.98±0.67[a]	140.95±0.51[A]
	100.00	97.21		100.00	95.31		
Line	127.65±1.28[b]	134.56 ±0.72[a]		128.19±1.21[b]	136.48±0.71[a]		
Overall mean	100.00	105.41	132.56±0.64		106.47	133.86±0.63	135.98
ANOVA							
Generations (Gen.)				**			
Lines (Pop.)				**			
Gen. * Pop.				NS			
Sex				NS			
Gen. * Sex				NS			
Pop. * Sex				NS			
Gen. * Pop.* Sex				NS			

Means having different letters in each effect are differ significantly ($p \leq 0.05$), [a, b, c, d]Interaction line by generation, [A,B,C]Among generations, [a, b]Between lines, NS: Non significant, X: Least square mean, SE: Standard error

Table 7: Least square means, standard errors and analysis of variance for GR_{2-6} in percentages during three generations of selection for EW_{10} with Japanese quail

	X±SE						
	Males			Females			
Pop./Gen.	Control	Selected	Generation overall mean	Control	Selected	Generation overall mean	Generation overall mean for both sexes
Base			112.61±1.61[b]			113.41±1.08[b]	113.01±1.61[B]
1st	123.24±0.99	122.26±0.99	122.66±0.74[a]	123.09±1.09	121.12±1.16	122.27±0.76[a]	122.46±0.53[A]
	100.00	98.28		100.00	99.33		
2nd	100.95±1.85	104.29±0.74	103.76±0.69[c]	100.20±2.33	105.13±0.84	104.38±0.80[c]	104.08±0.53[C]
	100.00	103.31		100.00	104.92		
Line	116.81±1.18[a]	111.54±0.69[b]		117.04±1.18[a]	109.95±0.76[b]	113.35±0.65	
Overall mean	100.00	95.49	113.01±0.60		100.00	93.94	113.18
ANOVA							
Lines (Gen.)				**			
Lines (Pop.)				**			
Gen. * Pop.				NS			
Sex				NS			
Gen. * Sex				NS			
Pop. * Sex				NS			
Gen. * Pop.* Sex				NS			

Means having different small or capital letters are differ significantly ($p \leq 0.05$), [a,b,c,d]Interaction line by generation, [A,B,C]Among generations, [a,b]Between lines, **Significantly at $p \leq 0.01$, NS: Non significant, X: Least square mean, SE: Standard error

Table 8: Heritability estimates of body weight at hatch, 2, 4 and 6 weeks of age for males and females in Japanese quail over three generations of selection

	h^2s ±SE		
Generations	Age (Weeks)	Male	Female
0	0	0.73±0.26	0.54±0.23
	2	0.67±0.20	0.44±0.22
	4	0.39±0.19	0.66±0.27
	6	0.38±0.17	0.67±0.30
1	0	0.55±0.19	0.38±0.21
	2	0.73±0.27	0.66±0.25
	4	0.40±0.19	0.49±0.30
	6	0.41±0.23	0.49±0.17
2	0	0.95±0.34	0.81±0.19
	2	0.86±0.20	0.72±0.22
	4	0.37±0.21	0.45±0.24
	6	0.40±0.16	0.54±0.22

h^2s: Heritability estimates

Heritability estimate: Heritability estimates of body weight at hatch, 2, 4 and 6 weeks of age for male and female are presented in Table 8 the heritability values are around the corresponding values reported in different experiments of selection by Marks (1981), El-Deen (1994), Resende *et al.* (2005), Magda *et al.* (2010), Momoh *et al.* (2014) and Manaa *et al.* (2015).

In general, the heritability estimates of body weight for males had mostly higher values at hatch and 2 weeks of age than the corresponding estimates at 4 and 6 weeks of age.

CONCLUSION

The increasing in body weight at different ages and GR_{2-6} can be obtained by selection for early eggs in Japanese quail while it did not affect the heritability estimates of body weight at different age studied because of the fluctuation from one generation to another. Finally the present study confirmed that quails are alternative birds able to develop for meat this supported by more or/and continues studies.

REFERENCES

Abd El-Fattah, M.H., 2006. Selection for increased body weight and growth rate in Japanese quail. Ph.D. Thesis, Faculty of Agriculture, Fayoum University, Egypt.

Abdel-Mounsef, N.A., 2005. Non genetic factors affecting some productive traits in Japanese quail. M.Sc. Thesis, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.

Abdel-Tawab, S.K., 2006. The effect of selection for egg weight on some productive traits in Japanese quail. M.Sc. Thesis, Faculty of Agriculture, Al-Azhar University, Egypt.

Aboul-Seoud, D.I., 2008. Divergent selection for growth and egg production traits in Japanese quail. M.Sc. Thesis, Faculty of Agriculture, Al-Azhar University, Egypt.

Alkan, S., K. Karabag, A. Galic, T. Karslı and M.S. Balcıoglu, 2010. Determination of body weight and some carcass traits in Japanese quails (*Coturnix coturnix japonica*) of different lines. Kafkas Univ. Vet. Fak. Derg., 16: 277-280.

Badawy, A.Y., 2008. Divergent selection in Japanese quail for body weight under subtropical conditions. M.Sc. Thesis, Faculty of Agriculture, Suez Canal University, Egypt.

Balcioglu, M.S., K. Kizilkaya, H.I. Yolcu and K. Karabag, 2005. Analysis of growth characteristics in short-term divergently selected Japanese quail. S. Afr. J. Anim. Sci., 35: 83-89.

Becker, W.A., 1985. Manual of Quantitative Genetics. 4th Edn., Academic Enterprises, Washington, DC., USA.

Brody, S., 1945. Bioenergetics and Growth. Reinhold Publishing Co., UK., Pages: 1023.

Camci, O., C. Erensayin and S. Aktan, 2002. Relations between age at sexual maturity and some production characteristics in quails. Archiv Geflugelkunde, 66: 280-282.

Caron, N., F. Minvielle, M. Desmarais and L.M. Poste, 1990. Mass selection for 45-day body weight in Japanese quail: Selection response, carcass composition, cooking properties and sensory characteristics. Poult. Sci., 69: 1037-1045.

Cole, H.H., 1966. Introduction to Livestock Production Including Dairy and Poultry. 2nd Edn., W.H. Freeman, San Francisco, CA., pp: 37-63.

Daikwo, S.I., U.A. Dike and N.I. Dim, 2014. Estimation of genetic parameters of weekly bodyweight and growth rates of Japanese quail. Int. Agric. Vet. Sci., 7: 56-62.

Duncan, D.B., 1955. Multiple range and multiple *F* tests. Biometrics, 11: 1-42.

El-Deen, M.B., 1994. Selection indices and crossing as a tool for improvement meat and egg production in Japanese quail. Ph.D. Thesis, Faculty of Agriculture, Alexandria University, Egypt.

El-Deen, M.B., 1999. Inheritance of sexual dimorphism in body weight and its relationship with growth and egg production traits in Japanese quail. Egypt. Poult. Sci., 19: 657-669.

El-Deen, M.B., A.A. Nour, W.S. El-Tahawy and H.A. Fouad, 2015. Effect of selection for weight of early eggs on egg production traits in Japanese quail. Asian J. Poult. Sci., 9: 179-190.

El-Dlebshany, A.E., 2014. Impact of egg weight selection on body weight of japanes quail. Proceedings of the 10th World Congress of Genetics Applied to Livestock Production, August 17-22, 2014, Vancouver, BC., Canada.

El-Shahwy, H.I., 2010. Body weight and its relationship with some economical and physiological traits in Japanese quail. M.Sc. Thesis, Faculty of Agriculture, Alexandria University, Egypt.

Farghly, M.F.A., K.M.A. Mahrose and D.E. Abou-Kassem, 2015. Pre and post hatch performance of different Japanese quail egg colors incubated under photostimulation. Asian J. Poult. Sci., 9: 19-30.

Islam, M.S., S. Faruque, H. Khatun and M.N. Islam, 2015. Comparative production performances of different types of quail (*Coturnix coturnix japonica*). Agriculturists, 12: 151-155.

Kocak, C., O. Altan and Y. Akbas, 1995. Japon bildircinlarinin cesitli verim Ozellikleri uzerinde arastirmalar. Turk. J. Vet. Anim. Sci., 19: 65-71.

Magda, I.A.S., M.M. Sharaf and S.A. Hemeda, 2010. Phenotypic and genetic estimates of some productive and reproductive traits in Japanese quails. Egypt. Poult. Sci. J., 30: 875-892.

Manaa, E.A., K.M. El-Bayomi and G.A. Sosa, 2015. Genetic evaluation for growth traits in Japanese quail. Benha Vet. Med. J., 28: 8-16.

Marks, H.L., 1981. Selection environment influences on feed and water intake of Japanese quail following long-term selection for 4-week body weight. Poult. Sci., 60: 2572-2580.

Marks, H.L., 1990. Abdominal fat and testes weights in diverse genetic lines of Japanese quail. Poult. Sci., 69: 1627-1633.

Momoh, O.M., D. Gambo and N.I. Dim, 2014. Genetic parameters of growth, body and egg traits in Japanese quails (*Cotournix cotournix japonica*) reared in Southern Guinea Savannah of Nigeria. J. Applied Biosci., 79: 6947-6954.

Okuda, E.U., M. Orunmoyi, I.A. Adeyinka, E.D. Eze, A.J. Shoyombo and U. Louis, 2014. Estimation of genetic parameters of egg production and reproductive traits in Japanese quails. Agric. Adv., 3: 19-27.

Raji, A.O., S.T. Mbap and J. Aliyu, 2014. Comparison of different models to describe growth of the Japanese quail (Coturnix Japonica). Trakia J. Sci., 12: 182-188.

Resende, R.O., E.N. Martins, P.C. Georg, E. Paiva and A.C.M. Conti *et al*., 2005. Variance components for body weight in Japanese quails (*Coturnix japonica*). Rev. Bras. Ciencia Avicola, 7: 23-25.

SAS., 2004. SAS/STAT User's Guide: Statistics. SAS Institute, Cary, NC., USA.

Saatci, M., H. Omed and I.A. Dewi, 2006. Genetic parameters from univariate and bivariate analyses of egg and weight traits in Japanese quail. Poult. Sci., 85: 185-190.

Sefton, A.E. and P.B. Siegel, 1974. Inheritance of body weight in Japanese quail. Poult. Sci., 53: 1597-1603.

Shebl, M.K., M. Bahie El-Deen and M.A. Kosba, 1996. Selection for 6 weeks body weight in Japanese quail-direct and correlated responses. Egypt. Poult. Sci. J., 16: 703-723.

Shokoohmand, M., N.E.J. Kashan and M.A.E. Maybody, 2007. Estimation of heritability and genetic correlations of body weight in different age for three strains of Japanese quail. Int. J. Agric. Biol., 9: 945-947.

Singh, R.P., B. Panda, S.D. Ahaja, S.K. Agarwal, M.P. Babu, A.K. Shrivastava and O.P. Butta, 1981. Development of quails for meat and egg. Central Avian Research Institute, Izatnagar, India.

Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods. 7th Edn., Iowa State University Press, Iowa, USA., ISBN-10: 0813815606, Pages: 507.

Soliman, A.S., 2009. Inheritance of some productive traits and their relationships with some blood constituents in Japanese quail. M.Sc. Thesis, Faculty of Agriculture, Alexandria University, Egypt.

Younis, H.H., K.M. Saleh, R.Y. Nofal and A.M. Abd El-Ghany, 2004. Effect of crossing two Japanese quail lines selected seven generation for meat and egg production on growth traits agricultural research. J. Suez Canal Univ., 3: 1-14.