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Genetic evaluation for egg production traits in Japanese quail.

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A B S T R A C T

The main objective of this work was to evaluate the means and genetic parameters for egg production traits of random population of Japanese quail including average egg weight, egg number and egg mass. The second generation had the highest significant value for egg numbers, egg weights and egg masses for most weeks from beginning egg production. All heritability estimates for egg numbers were high except values at first and third week of egg production in the second generation were low (0.09 and 0.003; respectively). All heritability estimates for egg weights were medium values except values for second week of egg production in the first generation was low (0.02).

Keywords: Japanese quail, Egg production, Egg weight, Egg number, Egg mass, Heritability.

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1. INTRODUCTION

Quail is reared for its excellent meat and egg characteristics due to its numerous nutritive and economic benefits (Odugbo, 2004). Quail grows rapidly to maturity as the *coturnix* quail matures sexually of six weeks after hatching. Its mating activity is at its maximum between 70 and 210 days of age (Sefton and Siegel, 1973). Quail has short incubation period and high rate of egg production as the quail may lay more than 300 eggs in their first year of production (Wilbor et. al., 1961). There were many nutrient benefits of quail eggs as good sources of protein, fat, vitamin E, and minerals (nitrogen, iron and zinc). Thus, we should educate or transfer knowledge to people for good nutrient benefits of quail eggs as good nutritional foods and may be the alternative resolving problem of people in some or all nutritional nutrients necessary for human health in developing countries and may be a good potential to resolve "World Food Problem" (Tunsaringkarn et. al., 2013). Genetic studies on Japanese quail in Egypt will enable breeders to design suitable improvement programs for this bird. Therefore, reliable estimates of genetic parameters (heritability and correlations) are necessary to predict the direct and indirect selection responses (Harvey and Bearden, 1962).

The aim of this study was to evaluate the means and genetic parameters for egg production traits in random mating population of Japanese quail including average egg weight, egg number and egg mass.

2. MATERIAL AND METHODS

2.1. Management of the birds

2.1.1. Flock Managements of the birds

Base generation was randomly allotted to 57 sire families and labeled each bird by colored wing band and sire families were housed in wire cages (25 x 25x 25 cm) with sex ratio 1 male: 2 female. Sixteen hours lighting period was adjusted during the laying period. Chicks were floor brooded at 36 °C at the bird level. Temperature was decreased gradually by 3 °C weekly till reach 24°C at the fourth week. Lighting was provided 24 hours daily till 4th week of age then reduced to 14 hours of light and 19 hours of darkness.

Table (A): Each number of hatches and number of sire families of generation.

Generation	Number of hatches	Number of sire families
Base	-	57
First	3	57
Second	3	28

2.1.2. Feeding management

Birds were fed ad libtium on diet containing 21 laying and 29% growing crude protein and 2975.8 Kcal ME/kg of feed.

2.1.3. Egg Incubation and hatching

Eggs were collected daily after complete sexual maturity. Eggs tagged according to their sire families then stored at 18 °C for a week. Pedigreed eggs were set in the setting trays according to their sire families in a forced draft incubator at 37.5 °C and 60-70% relative humidity (RH). Eggs were turned automatically every three hours. At the 14th day of incubation eggs were transferred in pedigree baskets to the hatchers where the temperature was 37.5 °C and RH was 70%.

2.2.*Studied traits and Estimations for base, first, second generation*

2.2.1. *Egg number*

Total egg numbers were recorded for each sire family on a weekly basis after sexual maturity.

2.2.2. *Egg weight*

Total egg weights were recorded to the nearest grams weekly after sexual maturity.

2.2.3. *Egg mass*

The average egg weight (g) for each family multiplied by the egg number was weekly calculated (North and Bell, 1990).

2.2.4. *Genetic parameters*

Heritability estimate

It was calculated from sire component of variance per generation according to the following formula Becker (1985):

$$h^2 = \frac{4\sigma_s^2}{\sigma_s^2 + \sigma_w^2}$$

Where:

σ_S^2 = Sire variance components.

σ_w^2 = within sire residual variance components.

Correlations

a. Phenotypic correlation: "r_P"

Calculated according to the following formula Becker (1985):

$$r_P = \frac{\text{cov } s + \text{cov } w}{\sqrt{\left[(\sigma_s^2(x) + \sigma_w^2(x)\right]\left[(\sigma_s^2(y) + \sigma_w^2(y)\right]}}$$

Where:

Cov_s = sire covariance components.

Cov_W= within sire covariance components.

$\sigma_{s(x)}^2$ = sire variance components for trait (x).

$\sigma_{s(y)}^2$ = Sire variance components for trait (y).

$\sigma_{w(x)}^2$ = within sire variance components for trait (x).

$\sigma_{w(y)}^2$ = within sire variance components for trait (y).

b. Genetic correlation: "rG"

Calculated according to the following formula Becker (1985):

$$r_G = \frac{COVs}{\sqrt{\sigma_S^2(x)\, x\, \sigma_S^2(y)}}$$

Where:

COV_s = Sire covariance components.

$\sigma_{s(x)}^2$ =Sire variance components for trait.

$\sigma_{s(y)}^2$ = Sire variance components for trait (y)

2.3.*Data handling and statistical analysis*

Statistical analysis was carried out using SAS statistical analysis system package software (SAS, 2002) according to the following models.

- *Means for all traits under investigation*

$$X_{ij} = \mu + G_i + + e_{ij}$$

Where:
Xij = the Xth observation of the ith generation.
μ= overall mean.
gi = effect of ith generation (i = 0, 1, 2).
eij = random error.

- *Heritability and correlations*

$$X_{ij} = \mu + S_i + e_{ij}$$

Where:
Xij = the trait.
μ= population mean.
Si = effect of i^{th} sire.
eij = uncontrolled environmental and genetic deviations.

Variance and covariance components for heritability and correlation were determined by SAS program, using Proc Nested and proc Var Comp (SAS, 2002).

3. RESULTS

The second generation had the highest significant value for eggs' numbers at 1st, 2nd, 3rd and 4th week. The first generation showed higher significant value for eggs' numbers than the first generation at 5th and 6^{th} week. The values at 7^{th} and 8^{th} week were recorded for the base generation only (Table 1). The second generation had the highest significant egg weight at 1^{st}, 2^{nd}, 3^{rd} and 4^{th} week. The first generation recorded higher value for eggs' weights than the first generation at 5^{th} and 6^{th} week. The values at 7^{th} and 8^{th} week were recorded for the base generation only (Table 2).

The second generation had the highest significant eggs mass at 1^{st}, 2^{nd}, 3^{rd} and 4^{th} week. The first generation showed higher significant value for eggs' masses than the first generation at 5^{th} and 6^{th} week. The values at 7^{th} and 8^{th} week were recorded for the base generation only (Table 3).

Tables (4 and 5), Heritability estimates for egg numbers at different weeks from beginning laying in the first and the second generation were summarized in tables (4 and 5). All heritability estimates were high values except values for first and third week of egg production in the second generation were low and also were medium for 7^{th} week of egg production in the first generation.

Phenotypic correlations in the first generation for egg number recorded positive and negative values. Positive values were for 1^{st} with 2^{nd}, 1^{st} with 3^{rd}, 1^{st} with 4^{th}, 1^{st} with 6^{th}, 1^{st} with 8^{th} , 2^{nd} with 3^{rd}, 2^{nd} with 6^{th}, 2^{nd} with 8^{th}, 3rd with 6^{th}, 3^{rd} with 7^{th}, 3^{rd} with 8^{th}, 4^{th} with 7^{th}, 4th with 8^{th}, 5^{th} with 7^{th} and 6^{th} with 7^{th} weeks from egg production. Negative values were for 1^{st} with 5^{th}, 1^{st} with 7^{th}, 2^{nd} with 4^{th}, 2^{nd} with 5^{th}, 2^{nd} with 7^{th}, 3^{rd} with 4^{th}, 3^{rd} with 5^{th}, 4^{th} with 5^{th}, 4th with 6^{th}, 5^{th} with 6^{th}, 5^{th} with 8^{th}, 6^{th} with 8^{th} and 7^{th} with 8^{th} weeks from egg production (Table 4).

Genetic correlations in the first generation for egg number showed positive and negative values**.** Positive values were for 1^{st} with 2^{nd}, 1^{st} with 3^{rd}, 1^{st} with 4^{th}, 1^{st} with 8^{th} , 2^{nd} with 4^{th}, 2^{nd} with 5^{th}, 2^{nd} with 8^{th}, 3^{rd} with 4^{th}, 3^{rd} with 5^{th}, 3^{rd} with 8^{th}, 4th with 8^{th}, 5^{th} with 6^{th}, 5^{th} with 7^{th} and 6^{th} with 7^{th} weeks from egg production. Negative values were for 1^{st} with 5^{th}, 1^{st} with 6^{th},1^{st} with 7^{th}, 2^{nd} with 3^{rd}, 2^{nd} with 6^{th}, 2^{nd} with 7^{th}, 3^{rd} with 6^{th}, 3^{rd} with 7^{th}, 4^{th} with 5^{th}, 4^{th} with 6^{th}, 4^{th} with 7^{th}, 5^{th} with 8^{th}, 6^{th} with 8^{th} and 7^{th} with 8^{th} weeks from egg production (Table 4).

Phenotypic correlations in the second generation for egg number recorded positive values except were negative for 2^{nd} with 5^{rd}, 2^{nd} with 6^{th}, 3rd with 5^{th}, 3rd with 6^{th} and 4^{th} with 6^{th}, weeks from egg production. Genetic correlations in the second generation for egg number recorded positive values except were negative for 1^{st} with 6^{th}, 2^{nd} with 5^{th}, 2^{nd} with 6^{th} and 4^{th} with 6^{th} weeks from egg production (Table 5).

Tables (6-7) showed heritability estimates for egg weights at different weeks from beginning laying in the first and the second generation. All heritability estimates were medium values except values for second week of egg production in the first generation was low and also was high for 2nd, 4th, 5th and 6th week of egg production in the first generation.

Phenotypic correlations in the first generation for egg weight showed positive and negative values. Positive values were for 1st with 2nd, 1st with 4th, 1st with 6th, 1st with 8th , 2nd with 3rd, 2nd with 4th, 2nd with 6th, 2nd with 7th, 3rd with 6th, 3rd with 7th, 3rd with 8th, 4th with 6th, 5th with 6th, 5th with 7th, 6th with 7th weeks and 7th with 8th weeks from egg production. Negative values were for 1st with 3rd, 1st with 5th, 1st with 7th, 1st with 8th, 2nd with 5th, 2nd with 8th, 3rd with 4th, 3rd with 5th, 4th with 5th, 4th with 7th, 4th with 8th, 5th with 8th and 6th with 8th weeks from egg production (Table 6).

Genetic correlations in the first generation for egg weights showed positive and negative values**.** Positive values were for 1st with 3rd, 1st with 4th, 1st with 5th, 1st with 7th, 1st with 8th, 2nd with 5th, 2nd with 8th, 3rd with 4th, 3rd with 5th, 4th with 5th, 4th with 7th, 4th with 8th, 5th with 8th and 6th with 8th weeks from egg production. Negative were for 1st with 2nd, 1st with 6th, 2nd with 3rd, 2nd with 4th, 2nd with 6th, 2nd with 7th, 3rd with 6th, 3rd with 7th, 3rd with 8th, 4th with 6th, 5th with 6th , 5th with 7th, 6th with 7th and 7th with 8th weeks from egg production (Table 6).

Phenotypic correlations in the second generation for egg weights were positive values except were negative for 3rd with 5th and 3rd with 6th weeks from egg production. Genetic correlations in the second generation for egg weights recorded positive values except were negative for 1st with 2nd and 2nd with 6th weeks from egg production (Table 7).

Tables (8-9) showed heritability estimates for egg masses at different weeks from beginning laying in the first and the second generation. All heritability estimates of egg masses in the first generation were medium values. Meanwhile, the second generation recorded high heritability values for egg masses except value for first week of egg production was low and also was medium for third week.

Phenotypic correlations in the first generation for egg masses showed positive and negative values. Positive values were for 1st with 2nd, 1st with 3rd, 1st with 4th, 1st with 6th, 2nd with 3rd, 2nd with 4th, 2nd with 6th, 2nd with 7th, 3rd with 6th, 3rd with 7th, 3rd with 8th, 4th with 6th, 4th with 7th, 4th with 8th, 5th with 6th and 7th with 8th weeks from egg production. Negative values were for 1st with 5th, 1st with 7th, 1st with 8th, 2nd with 5th, 2nd with 8th, 3rd with 4th, 3rd with 5th, 4th with 5th, 5th with 7th , 5th with 8th, 6th with 7th weeks and 6th with 8th weeks from egg production (Table 8). Genetic correlations in the first generation for egg masses showed positive and negative values**.** Positive values were for 1st with 5th, 1st with 7th, 1st with 8th, 2nd with 3rd, 2nd with 5th, 2nd with 8th, 3rd with 4th, 3rd with 5th, 4th with 5th, 5th with 7th, 5th with 8th, 6th with 7th, 6th with 8th and 7th with 8th weeks from egg production. Negative values were for 1st with 2nd, 1st with 3rd , 1st with 4th, 1st with 6th, 2nd with 4th, 2nd with 6th, 2nd with 7th, 3rd with 6th, 3rd with 7th, 3rd with 8th, 4th with 6th, 4th with 7th, 4th with 8th and 5th with 6th weeks from egg (Table 8).

Phenotypic correlations in the second generation for egg masses were positive values except were negative for 2nd with 6th, 3rd with 5th , 3rd with 6th and 4th with 6th weeks from egg production. Genetic correlations in the second generation for egg masses recorded positive values except were negative for 1st with 6th, 2nd with 6th weeks and 4th with 6th from egg production (Table 9).

Table (1): Least square means ± standard errors (LSM ± SE) for generation effect on egg number of Japanese quails for two successive generations of random mating population.

Trait	Egg number (Mean ± SE) / Age							
Generation	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week
Base	8.64^{b} ±0.42	8.98^{b} ±0.47	10.32^{c} ±0.42	11.43^{b} ±0.38	11.09^{b} ±0.33	10.59^{b} ±0.29	10.95±0.31	5.90 ±24.75
First	8.00^{b} ±0.67	10.50^{b} ±0.70	12.25^{b} ±0.65	12.63^{b} ±0.66	14.18^{a} ±0.60	14.00^{a}±0.88	-	-
Second	12.63^{a} ±0.65	15.95^{a} ±0.72	17.11^{a} ±0.75	17.33^{a} ±1.17	-	-	-	-

Means of different generations within the same column having different superscripts are significantly different ($p \leq 0.05$).

Table (2): Least square means ± standard errors (LSM ± SE) for generation effect on egg weight of Japanese quails for two successive generations of random mating population**.**

Trait	Egg weight (Mean ± SE) / Age							
Generation	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week
Base	90.27^{b}±4.88	101.52^{b}±5.28	122.23^{b}±4.96	138.30^{b}±4.47	135.44^{b}±3.89	130.74^{a}±3.90	132.44±4.22	280.00±60.77
First	87.71^{b}±7.40	115.83^{b}±8.04	135.43^{b}±7.75	144.17^{ab}±7.90	153.06^{a}±6.86	150.83^{a}±11.70	-	-
Second	113.13^{a}±7.46	148.33^{a}±8.07	160.56^{a}±8.76	168.33^{a}±13.68	-	-	-	-

Means of different generations within the same column having different superscripts are significantly different ($p \leq 0.05$).

Table (3): Least square means ± standard errors (LSM ± SE) for generation effect on egg mass of Japanese quails for two successive generations of random mating population.

Trait	Egg mass (Mean ± SE) / Age							
Generation	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week
Base	896.43^{b} ±86.15	1018.93^{c}± 111.69	1370.89^{b}± 113.94	1635.80^{b} ± 113.49	1541.88^{b}± 100.06	1450.65^{b}± 74.78	1508.48± 84.94	1456.25± 234.13
First	828.75^{b} ±131.09	1442.50^{b} ± 170.31	1782.39^{b}± 177.79	2011.94^{b} ± 200.18	2360.31^{a}± 187.20	2111.67^{a}± 224.35	-	-
Second	1503.13^{a}± 131.59	2476.88^{a}± 171.61	2850.28^{a}± 200.98	3033.33^{a} ± 346.72	-	-	-	-

Means of different generations within the same column having different superscripts are significantly different ($p \leq 0.05$).

Table (4): Heritability (on diagonal), phenotypic correlation (above diagonal) and genetic correlation (below diagonal) for egg numbers of Japanese quails in first generation of random mating population.

Trait	Egg number / Age							
Generation	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week
1st week	0.53	0.20	0.11**	0.59**	-0.68	0.12	-0.43	0.42
2nd week	0.69	0.34	0.87**	-0.02**	-0.50**	0.18	-0.06	*0.16
3rd week	0.61**	-0.83**	0.38	-0.01**	-0.55**	0.01**	0.26**	0.19
4th week	1.41**	0.95**	0.74**	0.53	-0.37**	-0.31**	0.09*	0.51
5th week	-0.08	0.30**	0.40**	-0.45**	0.35	-0.05**	0.06	-0.19**
6th week	-1.81	-0.95	-0.63**	-1.51**	0.81**	1.11	0.01**	-0.64**
7th week	-1.92	-1.19	-1.71	-3.11*	1.14	2.48**	0.10	-0.14**
8th week	1.36	0.63*	0.47	1.32	-0.59**	-1.13**	-2.07**	3.84

* Significant at level (0.05), ** Highly significant at level (0.01).

Table (5): Heritability (on diagonal), phenotypic correlation (above diagonal) and genetic correlation (below diagonal) for egg numbers of Japanese quails in second generation of random mating population.

Trait	Egg number / Age					
Generation	1st week	2nd week	3rd week	4th week	5th week	6th week
1st week	0.09	0.44	0.39	0.37	0.08	0.11
2nd week	0.65	0.89	0.44**	0.33**	-0.06**	-0.18
3rd week	2.97	2.88**	0.003	0.20**	-0.05**	-0.18**
4th week	2.97	1.31**	2.03**	0.49	0.27**	-0.06**
5th week	1.05	-0.007**	2.49**	0.53**	0.86	0.49**
6th week	-0.83	-1.21	1.55**	-0.54**	0.81**	0.60

* Significant at level (0.05), ** Highly significant at level (0.01).

Table (6): Heritability (on diagonal), phenotypic correlation (above diagonal) and genetic correlation (below diagonal) for egg weights of Japanese quails in first generation of random mating population.

Trait	Egg weight/ Age							
Generation	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week
1st week	0.18	0.19	-0.08	0.50	-0.56	0.29	-0.41	0.32-
2nd week	-0.19	0.02	0.87**	0.15**	-0.12**	0.64	0.19**	-0.12**
3rd week	0.08	-0.87**	0.18	-0.20**	-0.27**	0.39**	0.39	0.15
4th week	0.50	-0.15**	0.20**	0.18	-0.004**	0.28**	-0.09	-0.06
5th week	0.56	0.12**	0.27**	0.004**	0.18	0.33**	0.21	-0.31**
6th week	-0.29	-0.64	-0.39**	-0.28**	-0.33**	0.18	0.15**	-0.60**
7th week	0.41	-0.08**	-0.39	0.09	-0.21	-0.15**	0.18	**0.61
8th week	0.32	0.12**	-0.15	0.06	0.31**	0.60**	-0.61**	0.18

* Significant at level (0.05), ** Highly significant at level (0.01).

Table (7): Heritability (on diagonal), phenotypic correlation (above diagonal) and genetic correlation (below diagonal) for egg weights of Japanese quails in second generation of random mating population.

Trait	Egg weight / Age					
Generation	1st week	2nd week	3rd week	4th week	5th week	6th week
1st week	0.20	0.47	0.43	0.34	0.09	0.23**
2nd week	-0.33	0.52	0.49**	0.27**	0.09*	0.07
3rd week	2.21	1.69**	0.19	0.14**	-0.009**	-0.09**
4th week	2.23	1.90**	2.48**	0.63	0.37**	0.10*
5th week	1.89	0.84*	1.53**	1.04**	0.91	0.53**
6th week	0.80**	-0.008	1.07**	1.23*	1.60**	0.40

* Significant at level (0.05),** Highly significant at level (0.01).

Table (8): Heritability (on diagonal), phenotypic correlation (above diagonal) and genetic correlation (below diagonal) for egg masses of Japanese quails in first generation of random mating population**.**

Trait	Egg mass / Age							
Generation	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week
1st week	0.18	0.25	0.006*	0.33*	-0.69	0.43	-0.41	0.35-
2nd week	-0.25	0.18	0.67**	0.10**	-0.23**	0.73	0.11**	0.16*-
3rd week	-0.005*	0.67**	0.18	-0.19**	-0.42**	0.27**	0.54	0.32
4th week	-0.33*	-0.10**	0.19**	0.18	-0.27**	0.17**	0.05*	0.10
5th week	0.69	0.23**	0.42**	0.27**	0.18	0.07**	-0.004	0.24**-
6th week	-0.43	-0.73	-0.27**	-0.17**	-0.07**	0.18	-0.06**	0.49**-
7th week	0.41	-0.11**	-0.54	-0.05*	0.003	0.06**	0.18	0.84**
8th week	0.35	0.16*	-0.32	-0.10	0.24**	0.49**	0.84**	0.18

* Significant at level (0.05), ** Highly significant at level (0.01).

Table (9): Heritability (on diagonal), phenotypic correlation (above diagonal) and genetic correlation (below diagonal) for egg masses of Japanese quails in second generation of random mating population.

Trait	Egg mass/ Age					
Generation	1st week	2nd week	3rd week	4th week	5th week	6th week
1st week	0.002	0.47	0.39	0.34	0.07	0.16
2nd week	0.45	0.59	0.37**	0.25**	0.03**	-0.002
3rd week	0.75	1.27**	0.22	0.14**	-0.05**	-0.19**
4th week	0.36	1.76**	0.04**	0.31	0.29**	-0.02**
5th week	1.43	0.38**	0.97**	1.05**	0.82	0.45**
6th week	-2.19	-1.39	0.68**	-0.46**	1.23**	0.24

* Significant at level (0.05),** Highly significant at level (0.01).

4. DISCUSSION

The results of egg number agreed with Taha (2009) which ranged from 51.97 to 61.93, 48.02 to 59.53 and 57.66 to 72.83 for the base, first and second generations; respectively and also agreed with Okenyi et. al. (2013) who found that the mean egg production for 30 days in the base generation, first generation and second generation were 25.34, 27.60 and 29.46; respectively.

Similar result of egg weights was obtained by Magda et al., (2010) who reported that the second generation was the highest significant value at first and fifth weeks for egg weights (12.42 and 12.91 g; respectively).

Results of egg mass agreed with Magda et al., (2010) who found that the highest significant was the second generation (524.67).

Similar results of heritability of egg number were obtained by Bahie El-Deen (1991), El-Fiky (1991) and Bahie El-Dean et al., (2008).

Results of correlation of egg number and egg weight were similar to results recorded by Abdel-Mounsef (2005).

Results of heritability of egg weight and egg mass agreed with those obtained by Bahie El-Dean (1994), El-Full (2001) and Megeed and Younis (2006).

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