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Direct and Correlated Responses from Long-Term Selection for Water Consumption in Japanese Quail

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ABSTRACT

A total number of 330 birds at 6 weeks of age were taken from the third generation of the base population to construct the generation number zero for selection. The birds were randomly assigned to two mating groups, the first group was established by selection for high water consumption (HWC_{4-6}) and the second was maintained as a random bred control line (RBC) to study the direct and correlated responses for selection for water consumption. The present study was started from generation four to generation seven. The results obtained can be summarized as follow: 1- Water consumption was highly significantly ($P\leq0.01$) increased in the selected line (HWC_{4-6}) from 12.80 cm at generation four to 14.05cm at the seventh generation of selection. On the other hand, water consumption in the control line fluctuated randomly from generation to another, however, there was no significant increase and/or decrease between the mean of generation four (10.45cm^3) and that of the seventh generation (12.05cm^3). 2- Heritabilities computed from the sire component (h^2_S) ranged between 0.21 and 0.33 among the four generations of selection and that computed from the dam components (h^2_D) are generally higher than those computed from the sire components, it ranged between 0.42 and 0.58. while, heritabilities computed from full-sib components (h^2_{S+D}) ranged between moderate and high in magnitude (0.36 - 0.49). The realized heritability were ranged between 0.48 and 0.81. 3- Correlated responses for other traits when selection was applied for WC_{4-6} were as follow: a- Growth traits: Body weight and body weight gain traits in the HWC_{4-6} line: BW_0, BW_2, BW_4 and BW_6 were increased significantly ($P\leq0.05$) from 9.78, 40.01, 93.86 and 160.46g in the fourth generation to 10.66, 44.15, 101.69 and 173.78g after four generations of selection. However, ADG_{0-2}, ADG_{2-4}, ADG_{4-6} and ADG_{0-6} were increased significantly ($P\leq0.05$) from 2.38, 5.21, 1.56 and 3.52g/day in the fourth generation to 3.22, 6.08, 1.99and 4.04g/day after four generations of selection. On the contrary, the corresponding values for the control line among weights and gains were not significant. b- Egg production and reproductive traits: Egg weight (EW) was increased significantly ($P\leq0.05$) from 9.78g in the fourth generation to 11.04g after four generations of selection and ASM was increased significantly ($P\leq0.05$) from 54.01day to 58.92 day of selection, while TEN_{10}, TEW_{10} and DEM were increased significantly ($P\leq0.05$) from, 48.88 egg, 454.81g and 9.00 g/day to 53.20egg, 462.55g and 9.66g/day .However, reproductive traits i.e. FR% and HA% were increased significantly ($P\leq0.05$) from 77.06 and 64.49% in the fourth generation to 80.48 and 71.04% after four generations of selection, while EEM%, LEM% and TEM% were decreased significantly ($P\leq0.05$) from 6.63, 14.37 and 21.00% to 8.25, 15.80 and 24.05%. On the contrary, the corresponding values for the control line among egg production and reproductive traits studied were not significant c- Carcass traits: Meat, bone, giblets and dressing % traits were increased significantly ($P\leq0.05$) from 45.68, 7.31, 14.22 and 60.98% in the fourth generation to 50.97, 8.11, 16.82 and 62.64% after four generations of selection. On the contrary, the corresponding values for the control line among carcass traits studied were not significant.

Key words: Generation, Heritability, Water Consumption in Japanese Quail

Introduction

Genetic studies on Japanese quail in Egypt will enable breeders to design suitable improvement

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programs for this bird,therefore reliable estimates of genetic parameters (heritabilities and correlations) are necessary to predict the direct and indirect selection responses. The direct response or the genetic gain in a selected trait could be determined in standard deviation units (Harvey and Bearden, 1962) or by the difference between the mean of the selected group and population mean (Falconer, 1981).

Selection programs in poultry places much emphasis on rapid early growth rates and increases in body size which result in a significant reduction in the number of days required to grow birds to market weight with indirect improvement in feed conversion. Genetic variations, manifested in the variability of tissue composition and metabolic processes between strains, provide means of evaluating such physiological developmental changes due to genetic selection (Stewart and Washburn, 1983).

Selection experiments provide the framework for the study of the inheritance of complex traits and allow the evaluation of theoretical predictions by testing observations against expectations. Depending on the time scale, short-term experiment can be used to estimate genetic variances and covariance to test their consistency from different sources of information and estimate the magnitude of the initial rates of response to selection (Varkoohi and Kaviani, 2014).

Japanese quail, despite their small body size, have an important place in commercial production because of their high egg and meat production capacity. Quails are generally reared for egg production in the Far East and Asian countries, and primarily for meat production in European and American countries (Minvielle, 2004).

Water consumption is the most important nutrient consumed by an animal. It is involved in many aspects of poultry metabolism including the control of body temperature, digestion and absorption of feed, transportation of nutrients and the elimination of by-products from the body. In spite of the importance of water for the poultry as vital nutrients, very few researches have been carried out concerning the genetic bases of water consumption and the possible use of this trait in improving the production performance and the thermoregulation capacity of poultry especially in the subtropical areas (Saleh *et al.,* 2009).

The present work was designed to estimate the direct responses to selection for increased WC_{4-6} and correlated responses with some productive and reproductive traits from generation 4 to generation 7 of selection.

Materials and Methods

Birds, management, breeding plan and feeding of the flock were described in previous article (Aboul-Hassan *et al*., 2016 In press), where data of the present study were collected on the flock of Japanese quail (*Coturnix coturnix japonica*) maintained by the Department of Animal Production, Faculty of Agriculture, Al-Azhar University, Nasr city, Cairo, Egypt, during the period from August 2013 until December 2014.

Statistical analysis:

Statistical analysis were conducted using the General Linear Models (GLM) procedure of base SAS software (SAS Institute, 1988).Differences between each two means were done according to Duncan's Multiple Range Test. Data of the selected trait (HWC_{4-6}) were analyzed using mixed model (Harvey, 1987, model type 5) including each of generation, line and sex as a fixed effects and sire and dam within sire as a random effects. The following model was adopted:

$Y_{ijklmn} = \mu + G_i + L_j + S_k + D_{lk} + x_m + e_{ijklmn}$, where:

Y_{ijklmn} = the observation of ijmkln th bird.

μ = the overall mean, common element to all observations.

G_i = the fixed effect of ith generation. (i=4,5……7)

L_j = the fixed effect of jth line. (i= 1,2)

S_m = the fixed effect of mth sex. (m=1,2)

S_k = the random effect of kth sire.

D_{lk} = the random effect of lth dam nested within a random effect of kth sire.

e_{ijmkln} = the random error term.

Henderson Method 3 (Henderson, 1953) was utilized to estimate the genetic variance components for the different traits studied.

Results and Discussion

Direct response:

The actual means of HWC_{4-6} among four generations of selection in the selected and control lines are presented in (Table, 1). Water consumption was highly significantly ($P \leq 0.01$) increased in the selected line (HWC_{4-6}) from 12.80cm^3 at generation four to 14.05cm^3 at the seventh generation of selection. On the other hand, water consumption in the control line fluctuated randomly from generation to another, however, there was no significant increase and/or decrease between the mean of generation four (10.45cm^3) and that of the seventh generation (12.05cm^3). However, after four generations of selection for HWC_{4-6} the birds of selected line consumed more feed by 16.60% compared with those of control line. The birds of selected line consumed more water by 9.77% after four generations of selection. . The same trend for positive direction was reported by Aboul-Hassan (1997) and El-Fiky (2005) when they selected Japanese quail for increased BW_6 and El-Bourhamy (2004) when he selected for increased feed consumption and Saleh *et al.,* (2009) and Abu-Mosallam (2014) when they selected for increased water consumption and by Meabed (2015) when she selected for increased and decreased shank length at 28 days of age.

Table 1: Actual means, standard deviations (S.D) and coefficients of variation (C.V%) for water consumption (cm^3) in the selected and control lines among generations of selection.

Generation	Lines			
	HWC_{4-6} Mean ± S.D	C.V%	RBC Mean ± S.D	C.V%
4	12.80±6.48	50.52	10.45±6.60	63.16
5	12.96±6.08	46.91	12.05±6.27	59.04
6	13.78±5.25	38.10	11.96±6.50	54.35
7	14.05±5.10	36.30	10.62±5.36	44.48
Average	13.40±6.14	42.96	11.27±6.22	55.26

As WC_{4-6} increased in the HWC_{4-6} line, the C.V% of this trait decreased from 50.52% at generation four to 36.30% at the seventh generation (Table, 1). The corresponding estimates obtained in the RBC (Random breed control) line were 63.16 and 44.48%, respectively. The change in C.V% from generation four to generation seven in HWC_{4-6} line was significant ($P \leq 0.01$).These results was in agreement with those reported by Kosba *et al.,* (1996); Aboul-Hassan (1997) , El-Fiky (2005) ,El-Bourhamy (2004) ,Saleh *et al*., (2009) and Abu-Mosallam (2014).

The least-squares means, their standard errors and test of significance for factors affecting water consumption are presented in tables (2 and 3). Results obtained (Table, 2) indicated that among HWC_{4-6} line, water consumption increased significantly ($P \leq 0.05$) from 9.87cm^3 at the fourth generation to 11.66cm^3 at the seventh generation. Females of the selected line (HWC) consumed more water by 12.97% than males. On the other hand, the WC_{4-6} in the RBC line fluctuated randomly from generation to another, however, there was no significant increase and/or decrease between the mean of the fourth and the seventh generation of selection (Table, 2), while females of the control line consumed more water by 19.55% than males. The same trend was reported by Kosba *et al.,* (1996); Aboul-Hassan (1997), El-Fiky (2005), El-Bourhamy (2004) ,Saleh *et al*., (2009) and Abu-Mosallam (2014) when they selected for different traits in Japanese quail .

The least-squares means for water consumption among the four generations of selection varied significantly ($P \leq 0.05$) from generation to another and between the two sexes and the two lines (Table, 2).The sire and the dam had non-significant effect on this trait (Table, 3). The same trend was observed by Aboul-Seoud *et al.,* (2009) when they selected for high egg production and Aboul-Seoud *et al.,* (2013) when they selected for increased feed consumption and Aboul-Hassan *et al.,* (2015) when they selected for increased water consumption.

The dam variance component in HWC_{4-6} were higher than the sire component of variance and consequently percentage of variations due to dam effect were larger than that of the sire effects (31.91 and 32.10% vs 5.42 and 3.69%) as shown table (4). These results were in agreement with those obtained by Aboul Hassan (1997); El-Fiky (2005) and Aboul- Seoud *et al*., (2009) when they selected Japanese quail for increased BW_6 & BW_4 and Saleh *et al.,* (2009) and Aboul-Hassan *et al*., (2015) when they selected for increased water consumption and Aboul-Seoud *et al.,* (2013) when they selected for increased feed consumption.

Table 2: Least-squares means and standard errors (S.E) of water consumption (cm^3) in the selected and control lines among generations of selection.

Items	HWC_{4-6}		RBC	
	No.	Means ± S.E	No.	Means ± S.E
Generation:				
4^{th}	254	9.87 ± 0.66^a	180	9.87 ± 0.92^a
5^{th}	247	10.15 ± 0.70^b	190	9.40 ± 0.55^a
6^{th}	260	10.84 ± 0.55^c	185	10.02 ± 0.79^a
7^{th}	245	11.66 ± 0.62^d	175	9.68 ± 0.47^a
Sex:				
Male	500	9.25 ± 0.47^a	355	8.95 ± 0.45^a
Female	506	10.45 ± 0.48^b	365	10.07 ± 0.60^b

a,b,c = Means in the same column with different superscripts differ significantly.

Table 3: F- ratios and test of significant for factors affecting water consumption.

S.O.V.	d.f	F-ratio
Gen.	3	48.89**
Sire: G.	288	2.67
Dam:(S) : (G)	312	2.13
Line	1	77.61**
Sex	1	67.91**
Remainder	1377	

*** = Significant at 1% level of probability.*

Table 4: Variance components (δ^2) and percentage of variation (V%) estimated for random effects on water consumption.

Line	Variance Component					
	Sire		Dam : Sire		Remainder	
	δ^2s	V%*	δ^2D:s	V%*	δ^2e	V%*
HWC_{4-6}	0.28	5.24	1.65	31.91	3.24	62.67
RBC	0.17	3.69	1.48	32.10	2.96	64.21

** V% : Percentage of variation.*

Selection differential:

Selection differential calculated as expected and actual as well as the ratio between the actual and expected selection differentials (Actual/Expected) are presented in (Table, 5) for HWC_{4-6} line. No significant differences were found between the actual and expected selection differentials from generation four to generation seven. This means that the distribution of WC_{4-6} confirm with the properties of a normal distribution closely enough to allow fairly accurate prediction. The same trend was noticed by Aboul-Hassan (1997) , El-Fiky (2005) and Abu-Mosallam (2014).

Table 5: Actual and expected selection differentials (cm^3) and the ratio of actual to expected selection differentials for HWC_{4-6}.

Generation	Actual	Expected	Actual / Expected
4	2.32±0.31	1.87±0.22	1.24
5	2.58±0.24	2.22±0.26	1.16
6	2.86±0.30	2.56±0.30	1.12
7	2.66±0.23	2.40±0.32	1.11
Average	2.61±0.24	2.26±0.19	1.16

Moreover, Marks and Lepore (1968) among two lines of Japanese quail selected for body weight at 4 weeks of age for six generations calculated the expected selection differentials as 9.8, 10.4g at the first generation and 9.3, 11.2g at the sixth generation. The corresponding values for actual selection differentials were 8.8, 10.4g at the first generation and 8.5, 10.4g at the sixth generation.

The ratio of actual to expected selection differentials (Table, 5) was greater than unity, which suggests that natural selection may had a positive effect on selection for HWC_{4-6} .

Cumulative (actual and expected) selection differentials are presented in table (6). The values for cumulative selection differentials (Actual and Expected) were 10.12 and 10.01cm^3 at generation four among the (HWC_{4-6}) line increased to 14.12 and 13.28cm^3 at generation seven. The same trend was observed by Aboul-Seoud *et al.,* (2009) when they selected for increased BW_4 and TEW_{10} and Abu-Mosallam (2014) when he selected for increased feed consumption.

Table 6: Cumulative (actual and expected) selection differentials (cm^3) for water consumption.

Generation	Cumulative (Actual)	Cumulative (Expected)
4	10.12	10.01
5	11.33	10.89
6	12.66	12.07
7	14.12	13.28
Average	12.06	11.56

Selection response:

The actual and cumulative selection response are presented in (Table, 7). The actual response to selection in the line (HWC_{4-6}) decreased from generation to another through the four generations of selection. The estimated response to selection after the fourth generation of selection was 1.88cm^3 then it decreased gradually as the selection continued to 1.62, 1.40 and 1.28cm^3 after the fifth, sixth and the seventh generation of selection among HWC_{4-6} line.

This regularity of the selection response had been observed in many selection experiments reported in the literature. The cumulative response to selection in the HWC_{4-6} line was 6.28cm after the seventh generation of selection. However, El-Fiky (2005) reported that the actual response to selection for HBW_6 was 2.58g after the first generation of selection and fluctuated to be 1.82g after the fourth generation of selection.

Moreover, Aboul-Seoud *et al.,* (2009) reported that the actual response to selection in the line (HBW_4) was decreased from generation to another through the three generations of selection. The estimated response to selection after the first generation of selection was 3.36g, then it decreased gradually as the selection continued to 3.19 and 2.69g after the second and the third generation of selection among HBW_4 line. Abu-Mosallam (2014) found that the actual response to selection in the line (HWC_{4-6}) was decreased from generation to another through the three generations of selection. The estimated response to selection after the first generation of selection was 1.42cm^3 then it decreased gradually as the selection continued to 1.31 and 1.14cm^3 after the second and the third generation of selection among HWC_{4-6} line.

Table 7: Actual and cumulative selection responses (cm^3) for water consumption.

Generation	Actual	Cumulative
3-4	1.88±0.69	1.88
4-5	1.62±0.47	3.50
5-6	1.40±0.88	5.00
6-7	1.28±0.66	6.28
Average	1.55±0.87	-----

Heritability estimates:

1.Components of variance:

Heritability estimates for water consumption computed from the sire component (h^2_S) ranged between 0.21 and 0.33 among the four generations of selection (Table, 8) and that computed from the dam component (h^2_D) are generally higher than those computed from the sire component, it ranged between 0.42 and 0.58. This may be due to the large dam variance components obtained and the non-genetic effects, primarily dominance and maternal, normally result in the h^2_D estimates being considerably larger than h^2_S estimates. While, heritabilities computed from full-sib components (h^2_{S+D}) ranged between moderate and high in magnitude (0.36 - 0.49).

These results were in agreement with those reported by Aboul-Hassan (1997), who estimated h^2_S , h^2_D and h^2_{S+D} as 0.20, 0.45 and 0.32 when selection was applied for BW_6 and Abu-Mosallam (2014) as 0.19-0.30, 0.40-0.52, 0.30-0.40 when he selected Japanese quail for increased water consumption .

Table 8: Heritability estimates computed from sire, dam, sire plus dam components of variance as well as realized heritability for HWC_{4-6}

Heritability				
Generation	Sires h^2_S ±S.E	Dams: Sires $h^2_{D:S}$ ±S.E	Full-sibs h^2_{S+D} ±S.E	Realized h^2±S.E
4	0.28±0.85	0.50±0.46	0.36±0.69	0.81±0.47
5	0.30±0.62	0.42±0.84	0.42±0.47	0.63±0.54
6	0.33±0.32	0.58±0.64	0.49±0.55	0.49±0.32
7	0.21±0.54	0.49±0.54	0.44±0.45	0.48±0.42

2. Realized heritability:

The realized heritability estimated for water consumption as the ratio between response to selection and selection differential (R/S) calculated from the HWC_{4-6} line was presented per generation in (Table, 8). The estimates of the realized heritability for Water consumption decreased from 0.81 at the fourth generation to 0.48 at the seventh generation.

The present estimates were larger than the estimates reported in the literature for the same trait. Where, Aboul-Hassan (1997) and El-Fiky (2005) reported a range of estimates (0.12-0.21) for realized heritability of BW_6, while they agreed with that reported by Aboul-Soud *et al.,* (2013) (0.7-0.78) when they select for HWC_{4-6}.

Correlated responses:

Selection for HWC_{4-6} had consequence for some other traits. The weights and/or the weight gains recorded at different ages and growth periods, egg production, reproductive traits and the carcass traits may be changed. The actual means of the correlated traits associated with selection for HWC_{4-6} are presented in tables from 9-11.

1-Growth traits:

Body weight and body weight gain traits in the HWC_{4-6} line: BW_0, BW_2, BW_4 and BW_6 were increased significantly ($P\leq0.05$) from 9.78, 40.01, 93.86 and 160.46g in the fourth generation to 10.66, 44.15, 101.69 and 173.78g after four generations of selection (Table, 9). However, ADG_{0-2}, ADG_{2-4}, ADG_{4-6} and ADG_{0-6} were increased significantly ($P\leq0.05$) from 2.38, 5.21, 1.56 and 3.52g/day in the fourth generation to 3.22, 6.08, 1.99and 4.04g/day after four generations of selection. On the contrary, the corresponding values for the control line among weights and gains were not significant (Table, 9).

Table 9: Actual means and standard deviations for growth traits studied in both sexes for lines and generations of selection when selection was applied for HWC_{4-6}.

Gen.			HWC4-6			RBC		
Trait	4	5	6	7	4	5	6	7
BW_0	9.78±0.69	10.15±0.55	10.24±0.75	10.66±0.82	9.39±0.71	8.90±0.84	9.88±0.78	9.20±0.66
BW_2	40.01±4.22	41.54±4.82	43.41±5.77	44.15±5.90	36.08±4.45	36.99±4.94	35.950±4.20	36.65±4.90
BW_4	93.86±12.51	97.66±15.46	100.14±16.61	101.69±17.42	93.05±14.23	94.10±12.05	91.06±13.77	92.80±15.33
BW_6	160.46±16.55	165.98±15.15	170.48±16.00	173.78±18.08	160.08±17.14	157.84±16.02	154.59±18.10	157.75±16.80
ADG_{0-2}	2.38±0.44	2.69±0.49	3.09±0.58	3.22±0.61	2.55±0.68	2.60±0.70	2.29±0.41	2.38±0.61
ADG_{2-4}	5.21±0.39	5.51±0.22	5.89±0.41	6.08±0.54	5.09±0.75	5.18±0.69	4.98±0.60	5.22±0.57
ADG_{4-6}	1.56±0.45	1.78±0.50	1.89±0.67	1.99±0.82	1.52±0.71	1.48±0.85	1.57±0.66	1.43±0.64
ADG_{0-6}	3.52±0.77	3.68±0.95	3.90±0.84	4.04±0.70	3.78±0.64	3.44±0.87	3.60±0.98	3.88±0.59

Abu-Mosallam (2014) when he selected for increased water consumption reported that: body weight and body weight gain traits in the HWC_{4-6} line: BW_0, BW_2, BW_4 and BW_6 were increased significantly ($P \leq 0.05$) from 9.12, 39.18, 86.71 and 156.82g in the first generation to 9.75, 43.54, 945.45 and 170.42g after three generations of selection. However, ADG_{0-2}, ADG_{2-4}, ADG_{4-6} and ADG_{0-6} were increased significantly ($P \leq 0.05$) from 2.24, 5.00, 1.38 and 3.45g/day in the first generation to 2.68, 5.62, 1.78 and 4.01g/day after three generations of selection. On the contrary, the corresponding values for the control line among weights and gains were not significant (Table 9).

2-Egg production and reproductive traits:

Egg weight (EW) increased significantly ($P \leq 0.05$) from 9.78g in the fourth generation to 11.04g after four generations of selection (Table, 10) and ASM increased significantly ($P \leq 0.05$) from 54.01 to 58.92 day, while TEN_{10}, TEW_{10} and DEM were increased significantly ($P \leq 0.05$) from, 48.88 egg, 454.81g and 9.00 g/day in the fourth generation to 53.20egg, 462.55g and 9.66g/day after four generations of selection (Table, 10). However, reproductive traits i.e. FR% and HA% were increased significantly ($P \leq 0.05$) from 77.06 and 64.49% in the fourth generation to 80.48 and 71.04% after four generations of selection (Table, 10), while EEM%, LEM% and TEM% were decreased significantly ($P \leq 0.05$) from 6.63, 14.37 and 21.00% in the fourth generation to 8.25, 15.80 and 24.05% after four generations of selection. On the contrary, the corresponding values for the control line among egg production and reproductive traits studied were not significant changeds (Table, 10). The same trend was noticed by Abdel-Tawab (2006) when he selected Japanese quail for increased egg weight.

Table 10: Actual means and standard deviations for egg production and reproductive traits studied in females for lines and generations of selection when selection was applied for HWC_{4-6}.

Gen.	HWC_{4-6}				RBC			
Trait	4	5	6	7	4	5	6	7
EW	9.78±7.57	10.88±9.18	10.90±11.22	11.04±14.27	10.22±15.60	10.09±12.44	10.44±17.40	10.31±16.05
ASM	54.01±9.10	56.05±8.66	58.92±9.84	60.80±10.17	55.05±8.45	53.44±8.92	52.94±8.15	54.66±8.48
TEN_{10}	48.88±8.20	51.84±7.55	50.18±8.19	53.20±7.18	55.90±6.91	55.05±6.61	54.78±7.10	56.28±6.78
TEW_{10}	454.81±16.20	460.55±18.50	452.55±19.00	462.54±18.72	470.81±17.68	472.88±17.60	463.81±16.51	471.99±14.15
DEM	9.00±7.42	9.40±7.84	9.18±8.87	9.66±8.40	9.18±7.22	9.47±6.72	9.37±7.06	9.51±7.66
FR%	80.48	81.44	79.61	83.06	86.31	84.55	85.45	84.42
HA%	71.04	67.99	67.21	7.49	70.52	72.25	75.80	72.08
EEM%	6.63	6.94	7.25	7.25	6.80	5.88	6.24	6.84
LEM%	14.37	15.35	15.84	15.80	15.45	15.42	15.86	15.23
TEM%	21.00	22.29	23.09	23.05	22.25	21.30	22.10	22.07

Aboul-Hassan *et al*., (1999) reported negative correlated responses in egg production traits when selection was applied for increase BW_6, however, ASM was significantly ($P \leq 0.05$) increased from 45.11 days at the first generation to 49.88 days after three generations and the females of the selected line reached the ASM by 5.71 days later than the control females. While, TEN_{10}, TEW_{10}, DEM were significantly ($P \leq 0.05$) decreased from 56.92 eggs, 480.11 g, 9.21 g/day at the first generation to 50.01 eggs, 458.65 g, 7.42 g/day after three generations and the females of selected line produced TEN_{10},

TEW_{10}, DEM lower by 7.16 eggs, 15.22 g, 1.14 g/day than the control females. However, both FR and HA% significantly ($P \leq 0.05$) decreased from 80.15, 73.91% at the first generation to 72.58, 63.54% after three generations and the females of selected line had lower FR, HA% estimates by 6.04, 5.92% than the control females, respectively. When selection was applied for increasing TEN_{10} produced during the first ten weeks of laying, Aboul-Hassan (2001b) reported positive correlated responses in some egg production traits. However, TEW_{10}, DEM were significantly ($P \leq 0.05$) increased from 454.8g, 8.2 g/day in the first generation to 498.2g, 9.4 g/day, while ASM, BWSM were decreased from 54.2 days, 210.2 g in the first generation to 49.8 days, 192.1 g after three generations.

Furthermore, Abu-Mosallam (2014) selected Japanese quail for increased water consumption among the first 3 generations of selection and reported that: Egg weight (EW) was increased significantly ($P \leq 0.05$) from 9.42g in the first generation to 10.21g after three generations of selection and ASM was increased significantly ($P \leq 0.05$) from 52.31day to 55.12 day, while TEN_{10}, TEW_{10} and DEM were increased significantly ($P \leq 0.05$) from, 54.82 egg, 468.11g and 9.42 g/day sto 58.10 egg, 482.66g and 10.02g/day. However, reproductive traits i.e. FR% and HA% were increased significantly ($P \leq 0.05$) from 78.12 and 70.72% to 89.81 and 75.32%, while EEM%, LEM% and TEM% were decreased significantly ($P \leq 0.05$) from 5.31, 16.36 and 21.67% in the first generation to 5.00, 13.86 and 18.86% after three generations of selection. On the contrary, the corresponding values for the control line among egg production and reproductive traits studied were not significantly changeds.

3-Carcass traits:

Meat, bone, giblets and dressing % traits were increased significantly ($P \leq 0.05$) from 45.68, 7.31, 14.22 and 60.98% in the fourth generation to 50.97, 8.11, 16.82 and 62.64% after four generations of selection (Table, 11). On the contrary, the corresponding values for the control line among carcass traits studied were not significant (Table, 47).

The same findings were reported by Abu-Mosallam (2014) when he selected Japanese quail for increased water consumption among the first 3 generations of selection, where the carcass traits in the HWC_{4-6} line: meat, bone, giblets and dressing % traits were increased significantly ($P \leq 0.05$) from 44.28, 7.11, 13.72 and 61.12% in the first generation to 47.31, 8.16, 15.32 and 64.18% after three generations of selection. On the contrary, the corresponding values for the control line among carcass traits studied were not significant.

Table 11: Actual means and standard deviations for carcass traits studied in both sexes for lines and generations of selection when selection was applied for HWC_{4-6}.

Gen.	HWC_{4-6}				RBC			
Trait	4	5	6	7	4	5	6	7
Meat%	45.68	47.87	49.99	50.97	45.81	46.29	45.22	46.01
Bone%	7.31	7.66	7.20	8.11	7.92	7.70	8.26	7.95
Giblets%	14.22	14.79	15.92	16.32	14.55	14.12	15.66	14.32
Dressing%	60.98	61.87	62.10	62.64	60.88	61.32	61.52	60.99

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