SINAI Journal of Applied Sciences 9 (2) 2020 207-224

Available online at www.sinjas.journals.ekb.eg

SCREENED BY iThenticate Professional Plagiarism Prevention

SINAI Journal of Applied Sciences

Print ISSN 2314-6079
Online ISSN 2682-3527

ARU-EGYPT SJAS Trust Science | It Creates

EFFECT of SHORT-TERM DIVERGENT SELECTION for BODY WEIGHT at 4 weeks of AGE in JAPANESE QUAIL UNDER NORTH-SINAI CONDITIONS

B- EFFECT ON GROWTH TRAITS AT 4 WEEKS OF AGE

Basma A. Yousha[1*]; M.A. Abdel Ghaffar[1]; A.M. Ali[1] and H.M. Sabri[2]

1. Dept. Animal and Poult. Prod., Fac. Environ. Agric. Sci., Arish Univ, Egypt.

2. Dept. Animal Prod., Fac. Agric., Suez Canal Univ., Ismailia, Egypt.

ARTICLE INFO

Article history:
Received: 21/04/2020
Revised: 02/05/2020
Accepted: 02/05/2020
Available online: 02/05/2020

Keywords:
Japanese quail,
Selection,
Divergent,
Growth,
Relative growth rate,
weight gain.

Check for updates

ABSTRACT

Base population of the evaluated Japanese quail was derived from a randomly mated flock. This flock was used for subsequent divergent body weight selection at 4 weeks of age to produce the next three generations (G1, G2, and G3). The resultant investigational birds during the period from November 2016 to November 2017 were produced and raised at the experimental farm, Department of Animal and Poultry Production, Faculty of Environmental Agricultural Sciences, Arish University, Al-Arish, North Sinai, Egypt. Individual selection for body weight at 4 wk of age was applied. The upmost 2/3 ranked birds were considered, the high body weight line (HL), while the lowest 1/3 ranked ones were considered, the low body weight line (LL). At 5 wk of age, the selected birds were transferred to cages (1 male and 2 female assigned at random from the same selection category along with avoiding sib mating). The same trend of body weight selection intensity was applied at each generation within each line. The used experimental diet was a corn-soybean growing diet in a mash form with approximately 23% crude protein and 2850 kcal ME/kg. Feed and water were offered *ad libitum*. The results indicated that the interaction between body-weight-selection-type and sex was significant on most evaluated growth traits. Furthermore, line effect had highly significant ($P \leq 0.0001$) on most evaluated growth traits. Also, the Relative Growth Rate (RGR) decreased with the advancing in age, and higher values were recorded for both sexes and lines for RGR_{0-2} and reduced gradually by increasing age, also the high females was higher than males at most studied periods. However, the higher values for Weight gain (WG) were obtained for females in both selected lines where the HL showed higher values than the LL.

INTRODUCTION

Japanese quail is considered as an ideal laboratory bird for its rapid growth, early sexual maturity, short generation interval and relatively high egg production (**Wilson *et al.*, 1961; Reese and Reese, 1962**).

Selection is an important tool for changing gene frequencies for better fit individuals for one or more particular breeding purpose(s). **Falconer and Mackay (1996)** stated that artificial selection produces its changes of gene frequency by separating the adult individuals of parent generation into two groups, the selected and the discarded that differ in gene frequencies. Natural selection produces its effect through differences in fertility (*i.e.* longevity and fertility among the parents or viability among their progeny). The divergent selection can be used when the researchers are interested in producing two lines selected in opposite directions, and also to avoid the low accuracy of measuring

*** Corresponding author: E-mail address:** basmaeby@gmail.com
https://doi.org/10.21608/SINJAS.2020.86512

the response resulting from using the control line as unselected line because the use of control necessitates a reduction in population size of the selected line, quadruples the sampling variance of the response measured as a deviation from control and so doubles the standard error (**Falconer and Mackay, 1996**), so the divergent selection can be used to improve the accuracy of measuring the response where each selected line acts as a control line for the other and the response is measured as the divergence between the two lines

During the early embryonic development of chicks, growth is primarily the result of hyperplasia; after hatching, growth of most tissues is largely, and in some cases totally, due to hypertrophy. Animal growth has been defined also by **Moran (1977)** as the sum of the growths of the component parts of the carcass, *i.e.* meat, bone, and skin. **Jones and Hughes (1978)** cleared that Japanese quail surpassed the Bobwhite in growth rate up to 6 wk of age. They also revealed that Japanese quail reached the maximum average daily gain (4.89 g) at the third week of age and decreased thereafter to the sixth week of age.

Growth may be expressed in many ways such as absolute growth rate (AGR), relative growth rate (RGR) and the cumulative growth rate at limited area of time. **Marks (1993)** reported that means of weekly relative growth rate for the period from hatch through six wk of age [*i.e.* (GR_{0-1}), GR_{1-2}, GR_{2-3}, GR_{3-4}, GR_{4-5}, and GR_{5-6}] were decreased as age of the birds increased.

El-Sayed *et al.* (1995) reported that growth rate during the second generation increased for the HL and control, while it was decreased for the LL compared with the 1st one. However, growth rate at 14 days of age for the selected high and low lines in addition to the unselected control line during the second generation was decreased for HL and LL, while it was increased for control line. **Shalan (1998)** reported that the overall mean of RGR_{0-2} for combined sexes and lines over three generations of selection was 147.32%, and the means of RGR_{2-4}, RGR_{4-6}, and RGR_{0-6} for females were higher than males.

While, **Bahie El-Dean and El-Sayed (1999)** reported that the average relative growth rates (RGR) were 138.85, 66.81, and 48.57% for RGR_{0-2}, RGR_{2-4}, and RGR_{4-6}, respectively.

As regard to indirect response of RGR in Japanese quail divergently selected for 4-wk body weight, **Samuel (2003)** reported that the selection for high 4-wk body weight resulted in higher RGR for the first two weeks (early in life) compared to quail from the LL, while by the third week of age, quail from the LL had higher RGR compared to the quails from the HL.

Farahat *et al.* (2010) found that the fastest growth rate was shown during RGR_{2-6} whereas; the slowest rate was obtained during RGR_{4-6} for the combined sexes. Sex significantly influenced growth rate favoring males during all periods. These results agreed with those obtained by **Badawy (2008)**. While **Abd El-Fattah *et al.* (2006)** found lower growth rates during RGR_{2-4} and RGR_{4-6}. However, that growth rate in males and females of Japanese quail should be considered a distinct characteristic of the population. This matter should be taken into account in any breeding program aiming at improving growth characteristics in Japanese quail.

Furthermore, **Lepore and Marks (1971)** indicated that daily of gain (g/day) in Japanese quail weight ranged around 2.64, 3.21 and 1.36 g during WG_{0-2}, WG_{2-4} and WG_{4-6}, respectively. **Sefton and Siegel (1974)** reported the average daily gain during WG_{0-2}, WG_{2-4}, WG_{4-6} and WG_{0-6} to be 2.34, 3.12, 1.54 and 3.34 g, respectively. Similar values were also reported by **Aboul-Hassan (2000)** stated that the average daily gain for the previously mentioned periods to be 2.62, 5.82, 1.42 and 3.41, respectively. Average daily gain values reported by **Darden and Marks (1989)** were 2.43 and 3.57g at WG_{0-2} and WG_{2-4}, respectively. **Bahie El-Deen (1994)** reported high significant differences among lines and generations for daily gain during all the studied periods that he reported. Averages daily gain were 2.73, 3.66, 3.89 and 3.43 g during the periods WG_{0-2}, WG_{2-4}, WG_{4-6} and WG_{0-6}, respectively. Averages mentioned by **Shalan (1998)** were 3.18, 4.59, 3.95 and 3.94 g for WG_{0-2}, WG_{2-4}, WG_{4-6} and WG_{0-6}, respectively. **Shalan (2003)** reported that gain in weight is higher in females than males during all periods evaluated.

Mean gain in weight for females during the period 2-6 wk of age was 138.3 and 111.0 g in the selected and control lines, respectively while for males it was 122.9 and 106.2 g, in the same manner, respectively (**Debes, 2004**).

Badawy (2008) and Badawy *et al.* (2010) concluded that the pre-eminence of females over males may be due to that female quails got higher growth performance than males at the same age stages; which can be hormonally mediated and ascribed to the development of females' sex organs and accumulation of reservoirs for facing of the later sexual activities.

This work has been carried out to investigate the quails' bidirectional individual selection response either direct to 4 wk of age body weight on body weights, in addition to estimate the realistic effective selection differential.

MATERIALS AND METHODS

Experimental birds were produced and raised at the experimental farm, Department of Animal and Poultry Production, Faculty of Environmental Agricultural Sciences, Arish University, El-Arish, North Sinai, Egypt. A base population constituted of 500 Japanese quail individuals were used for subsequent divergent 4 wk of age body-weight-selection to produce the succeeding three generations (G1, G2 and G3). Eggs were collected daily and marked according to their families. Healthy hatched chicks were leg banded. All through the experimental period; feeds were allowed *ad libitum* in a mash form (diet with 23 % and 20% crude protein, 2800 kcal ME/kg and 2850 kcal ME/kg for growing and layer diet, respectively).

Selection and Mating Methods

Individual selection for divergent 4-wk body weight was carried out. Birds were measured weighted individually. In each type, the upmost 2/3 ranked birds were considered the high body weight line (HL), while the lowest 1/3 ranked ones were considered the low body weight line (LL). At 5 wk of age, the selected birds were transferred to cages (1 male and 2 female) which assigned at random from the same category avoiding sib mating. The same peculiar trend for body weight selection was applied to each line within each successive generation.

Studied Traits and Statistical Analysis

Individual body weights (g) were recorded at hatch, 2, 4, 6 and 8 wk of age. The relative growth rate (RGR) and the weight gain (WG) were estimated for every 2-wks interval during the period from hatch to 8 wk of age.

Data for each generation were analyzed separately using the general linear model procedure (PROC GLM) of SAS software package (**SAS, 2004**). Data were categorized into various growth traits (*i.e.* body weight, body weight gain, growth rate). Significant between line, sex and generation means were applied by Duncan's multiple range test (**Duncan, 1955**).

Data of growth parameters were analyzed within each generation using Least Squares ANOVA applying the following model:

$$Y_{ijk} = \mu + T_i + S_j + T*S_{(ij)} + e_{ijk}$$

Where:

Y_{ijk} = Individual observation on the bird.

μ = the overall mean for the trait under consideration;

T_i = the fixed effect of the i^{th} selection type (two levels; high and low body weight)

S_j = the fixed effect of the j^{th} sex (two levels; male and female).

$T*S_{(ij)}$ = the fixed effect of the interaction between the i^{th} selection type and the j^{th} sex.

e_{ijk} = random residual error assumed to be normally and independently distributed with zero mean and common variance equals unity.

RESULTS AND DISCUSSION

Relative Growth Rate (RGR)

Data in Table 1 represented the interactions between group by sex for the parent stock on RGR were insignificant at the two periods studied. Data in Table 1 revealed that the group difference was found to be significant ($P< 0.05$) from 6 to 8 wk of age. However, group impact was insignificant from 4 to 6 wk of age, where the High group showed high values (Table 2). Sex impact was not significant at all studied ages, as represented in Table 1.

While for the 1st generation; line by sex interactions on RGR (Table 3) were insignificant at the two studied periods. Data in Table 3 revealed that the line effect highly significant ($P\leq 0.0001$) during the two studied periods**.** The previous results revealed that the RGR decreased with the advancing in age. The same trend of results was reported by **Bahie El-Deen and El-Sayed (1999); Samuel (2003); Badawy (2008) and Farahat *et al.* (2010)**. Sex effect was not significant at the two studied periods, as represented in Table 3. Higher values were recorded for males, females and lines for RGR_{0-2} and reduced gradually by increasing age (Table 4). Same trend was obtained by **Jones and Hughes (1978), Marks (1993) and Badawy (2008)**. Also, for selected parents for the 2nd generation; line by sex interactions on RGR (Table 5) were insignificant at the two studied periods. Data in Table 5 revealed that the difference between the two lines was as expected highly significant ($P\leq 0.0001$) only on $RGR_{4-6.}$ Sex effect was not significant at the two studied periods, as represented in Table 5.

About the 2nd generation; effect of line by sex interaction on RGR (Table 7) was significant at the two studied periods. Data in Table 7 revealed that the line effect was highly significant ($P\leq 0.0001$) during the two studied periods (Figure 1). The RGR decreased with the advancing in age. Higher values were recorded for both sexes and lines for RGR_{0-2} while, reduced gradually by increasing age, also the high females was higher than males at the two studied periods (Table 8 and Figs. 1 and 2). As well as selected parents for the 3rd generation, line by sex interactions on RGR (Table 9) were insignificant at the two studied periods. Data in Table 9 revealed that the difference between the two lines was as expected highly significant ($P\leq 0.0001$) at RGR_{4-6}. Sex effect was not significant at the two studied periods, as represented in Table 9. Data in Table 10 showed that the males had higher RGR than females.

Furthermore, for the 3rd generation; line by sex interactions on RGR (Table 11) were insignificant at the two studied periods. Data in Table 11 revealed that the line effect highly significant during the two studied periods. Sex effect was significant at RGR_{2-4} only, as represented in Table 11. The high females were higher than males during two studied periods (Table 12).

And for the selected parents for the next generation; effect of line by sex interactions on RGR (Table 13) were significant at RGR_{4-6}. Data in Table 13 revealed that the

Table 1. Least squares analysis of variance of relative growth rate (%) for the parent stock

Source of variance	df.	RGR_{4-6}		RGR_{6-8}	
		SS	Prob.	SS	Prob.
Group (G)	1	11.52	0.54	183.70	0.03
Sex (S)	1	0.02	0.98	21.56	0.44
G x S interaction	1	31.49	0.32	26.71	0.40
Error	136	4204.47		4983.09	

Table 2. Least square means ±SE of relative growth rates (%) for the parent stock

Traits				N	RGR_{4-6}			RGR_{6-8}		
					Mean	±	SE	Mean	±	SE
Overall means	Group (G)	High		93	26.41	±	0.61	18.37	±	0.67^a
		Low		47	25.77	±	0.86	15.80	±	0.93^b
	Sex (S)	Female		93	26.11	±	0.61	16.65	±	0.67
		Male		47	26.08	±	0.86	17.52	±	0.93
Interaction Means	G x S interaction	High	Female	62	26.96	±	0.71	17.44	±	0.77
			Male	31	25.87	±	1.00	19.30	±	1.09
		Low	Female	31	25.25	±	1.00	15.85	±	1.09
			Male	16	26.29	±	1.39	15.75	±	1.51

RGR_{4-6} and RGR_{6-8} = Relative growth rate during the period from 4 to 6 wk and 6 to 8 wk of age.

For the main effects within column: any two means ± SE within group with different superscripts are significantly different ($P \leq 0.05$).

Table 3. Least squares analysis of variance of relative growth rates (%) for the first generation

Source of variance	df.	RGR_{0-2}		RGR_{2-4}	
		SS	Prob.	SS	Prob.
Line (L)	1	2043.47	<.0001	17628.65	<.0001
Sex (S)	1	4.09	0.615	88.29	0.213
L x S interaction	1	0.002	0.992	14.38	0.615
Error	924	14929.40		52429.37	

Table 4. Least square means ±SE of relative growth rates (%) for the first generation

Traits				N	RGR_{0-2}			N	RGR_{2-4}		
					Mean	±	SE		Mean	±	SE
Overall means	Line (L)	High		650	164.06	±	0.16[a]	635	75.07	±	0.30[a]
		Low		317	160.77	±	0.25[b]	293	65.39	±	0.46[b]
	Sex (S)	Female		516	162.34	±	0.18	516	70.57	±	0.34
		Male		412	162.49	±	0.23	412	69.88	±	0.43
Interaction Means	L x S interaction	High	Female	326	163.99	±	0.22	326	75.55	±	0.42
			Male	309	164.14	±	0.23	309	74.59	±	0.43
		Low	Female	190	160.69	±	0.29	190	65.59	±	0.55
			Male	103	160.84	±	0.40	103	65.18	±	0.74

RGR_{0-2} and **RGR_{2-4}** = Relative growth rate during the period from hatch to2 wk and 2 to 4 wk of age.
For the main effects within column: any two means ± SE within line with different superscripts are significantly different between (P≤ 0.05) and (P≤ 0.0001).

Table 5. Least squares analysis of variance of relative growth rates (%) for selected parents for the second generation

Source of variance	df.	RGR_{4-6}		df.	RGR_{6-8}	
		SS	Prob.		SS	Prob.
Line (L)	1	8556.11	<.0001	1	165.10	0.064
Sex (S)	1	3.866	0.761	1	58.839	0.268
L x S interaction	1	0.108	0.959	1	57.085	0.275
Error	264	11045.21		258	12308.75	

Table 6. Least square means ±SE of relative growth rates (%) for selected parents for the second generation

Traits				N	RGR_{4-6}			N	RGR_{6-8}		
					Mean	±	SE		Mean	±	SE
Overall means	Line (L)	High		180	20.90	±	0.51[b]	176	14.61	±	0.55
		Low		88	33.68	±	0.73[a]	86	12.82	±	0.79
	Sex (S)	Female		179	27.15	±	0.51	174	14.25	±	0.56
		Male		89	27.42	±	0.73	88	13.18	±	0.78
Interaction Means	L x S interaction	High	Female	120	20.78	±	0.59	117	15.67	±	0.64
			Male	60	21.01	±	0.84	59	13.55	±	0.90
		Low	Female	59	33.52	±	0.84	57	12.83	±	0.91
			Male	29	33.84	±	1.20	29	12.82	±	1.28

RGR_{4-6} and RGR_{6-8} = Relative growth rate during the period from 4 to 6 wk and 6 to 8 wk of age.
For the main effects within column: any two means ± SE within line with different superscripts are significantly different (P≤ 0.0001).

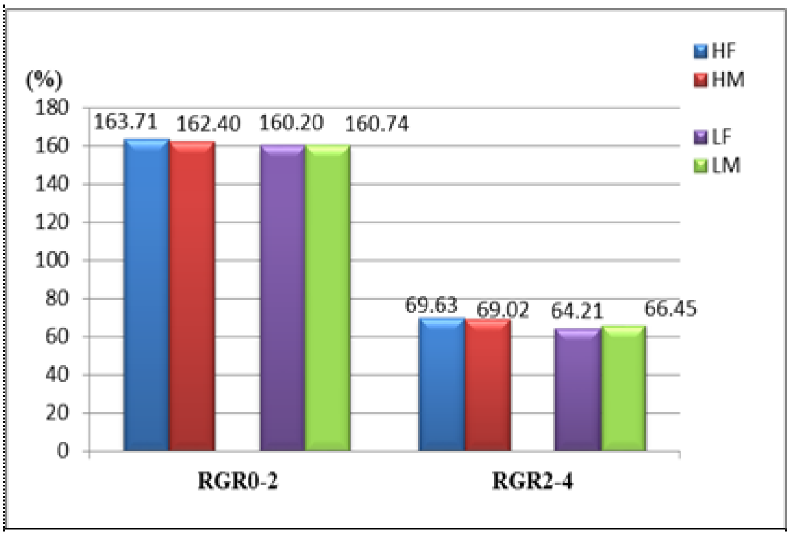

Fig. 1. Differences between sexes in relative growth rates within line in 2nd gene

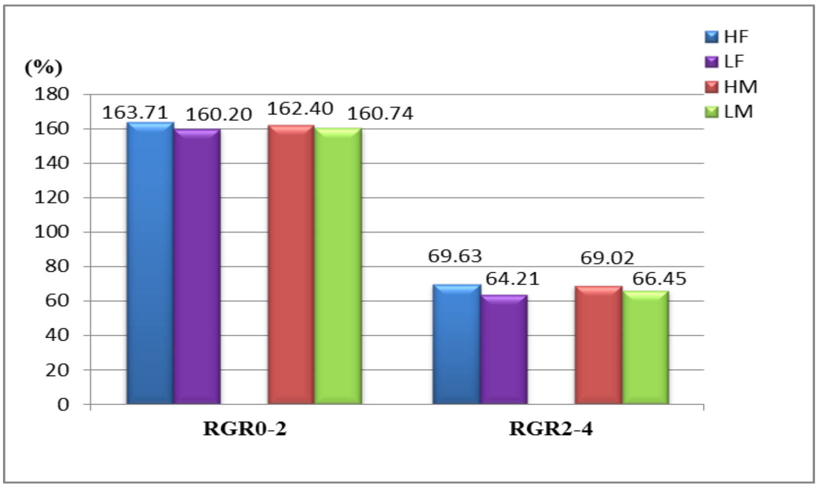

Fig. 2. Differences between lines in relative growth rates within sex in 2nd gene

Table 7. Least squares analysis of variance of relative growth rates (%) for the 2nd gene

Source of variance	df.	RGR_{0-2}		RGR_{2-4}	
		SS	Prob.	SS	Prob.
Line (L)	1	772.69	<.0001	1839.30	<.0001
Sex (S)	1	17.13	0.3805	76.64	0.241
L x S interaction	1	99.08	0.035	235.06	0.040
Error	537	11943.78		29841.50	

Table 8. Least square means ±SE of relative growth rates (%) for the second generation

Traits				N	RGR_{0-2}			N	RGR_{2-4}		
					Mean	±	SE		Mean	±	SE
Overall means	Line (L)	High		390	163.06	±	0.25	370	69.33	±	0.40
		Low		195	160.47	±	0.36	186	65.33	±	0.57
	Sex (S)	Female		311	161.95	±	0.28	311	66.92	±	0.44
		Male		230	161.57	±	0.34	230	67.74	±	0.54
Interaction Means	L X S interaction	High	Female	197	163.71	±	0.34^{a}	197	69.63	±	0.53
			Male	162	162.40	±	0.37^{b}	162	69.02	±	0.59
		Low	Female	114	160.20	±	0.44	114	64.21	±	0.70^{b}
			Male	68	160.74	±	0.57	68	66.45	±	0.90^{a}

RGR_{0-2} and RGR_{2-4} = Relative growth rate during the period from hatch to2 wk and 2 to 4 wk of age.
For the interaction means within column: any two means ± SE (female and male) within line are significantly different ($P \leq 0.05$).

Table 9. Least squares analysis of variance of relative growth rates (%) for selected parents for the third generation.

Source of variance	df.	RGR_{4-6}		df.	RGR_{6-8}	
		SS	Prob.		SS	Prob.
Line (L)	1	10082.936	<.0001	1	71.55	0.302
Sex (S)	1	0.302	0.957	1	76.09	0.287
L x S interaction	1	1.476	0.905	1	14.65	0.640
Error	264	27238.12		260	17358.87	

Table 10. Least square means ±SE of relative growth rates (%) for selected parents for the third generation

Traits				N	RGR_{4-6}			N	RGR_{6-8}		
					Mean	±	SE		Mean	±	SE
Overall means	Line (L)	High		176	20.44	±	0.80^{b}	174	14.96	±	0.65
		Low		92	34.07	±	1.12^{a}	90	16.12	±	0.91
	Sex (S)	Female		176	27.22	±	0.80	174	14.94	±	0.65
		Male		92	27.29	±	1.12	90	16.14	±	0.91
Interaction Means	L x S interaction	High	Female	115	20.48	±	0.95	114	14.09	±	0.77
			Male	61	20.39	±	1.30	60	15.82	±	1.05
		Low	Female	61	33.95	±	1.30	60	15.78	±	1.05
			Male	31	34.19	±	1.82	30	16.45	±	1.49

RGR_{4-6} and RGR_{6-8} = Relative growth rate during the period from 4 to 6 wk and 6 to 8 wk of age.
For the main effects within column: any two means ± SE within line with different superscripts are significantly different ($P \leq 0.0001$).

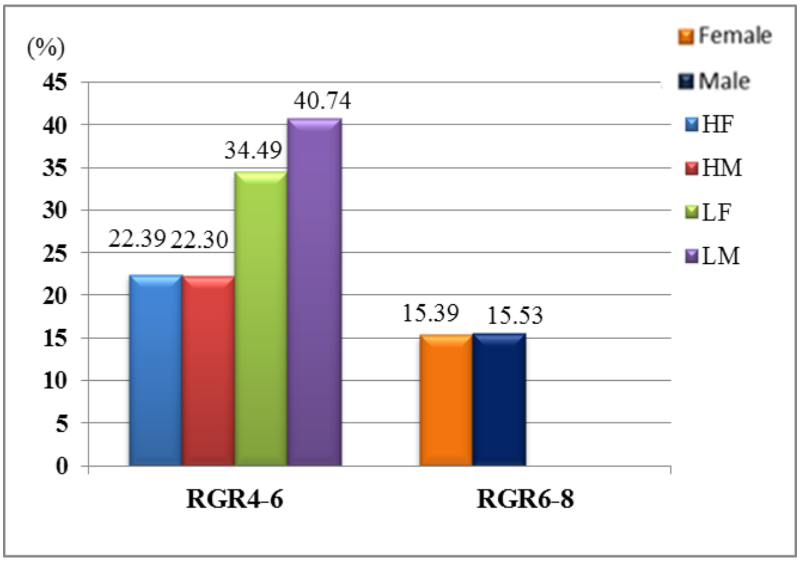

Fig. 3. Sex effect on relative growth rates of selected parents

Table 11. Least squares analysis of variance of relative growth rates (%) for the third generation

Source of variance	df.	RGR_{0-2}		RGR_{2-4}	
		SS	Prob.	SS	Prob.
Line (L)	1	324.84	0.003	6458.79	<.0001
Sex (S)	1	76.45	0.146	482.55	0.0003
L x S interaction	1	66.51	0.176	6.674	0.669
Error	836	30240.79		30474.43	

RGR_{0-2} and RGR_{2-4} = Relative growth rate during the period from hatch to2 wk and 2 to 4 wk of age.

Table 12. Least squares analysis of variance of relative growth rates (%) for selected parents for next generation

Source of variance	df.	RGR_{4-6}		df.	RGR_{6-8}	
		SS	Prob.		SS	Prob.
Line (L)	1	12613.55	<.0001	1	113.97	0.0006
Sex (S)	1	512.94	0.0008	1	0.98	0.7480
L x S interaction	1	545.47	0.0005	1	8.83	0.3346
Error	273	12079.42		266	2514.19	

Table 13. Least square means ±SE of relative growth rates (%) for the third generation

Traits				N	RGR_{0-2} Mean	±	SE	N	RGR_{2-4} Mean	±	SE
Overall means	Line	High		607	162.15	±	0.25[a]	595	68.94	±	0.25[a]
		Low		252	160.78	±	0.38[b]	245	62.84	±	0.39[b]
	Sex	Female		429	161.80	±	0.32	429	66.72	±	0.32[a]
		Male		411	161.13	±	0.33	411	65.05	±	0.33[b]
Interaction Means	Line X Sex interaction	High	Female	301	162.79	±	0.35	301	69.68	±	0.35
			Male	294	161.51	±	0.35	294	68.20	±	0.35
		Low	Female	128	160.80	±	0.53	128	63.77	±	0.53
			Male	117	160.76	±	0.56	117	61.90	±	0.56

RGR_{0-2} and RGR_{2-4} = Relative growth rate during the period from hatch to2 wk and 2 to 4 wk of age.

For the main effects within column: any two means ± SE within line with different superscripts are significantly different ($P \leq 0.0001$).

line effect was highly significant during the two studied periods. The previous results revealed that the RGR decreased with the advancing in age as shown in Table 14. Sex effect was significant at RGR_{4-6}, as represented in Table 13 and Fig. 3. Data in Table 14 showed that the males had higher RGR than females, this is agreed with **Samuel (2003), Abd El-Fattah *et al.* (2006) and Farahat *et al.* (2010)**.

Weight gain (WG)

For the parent stock; effect of group by sex interactions on WG were insignificant at the two studied periods (Table 15). Highly significant differences between the two groups in WG were observed, where the H group showed higher values (Tables 15 and 16). The highest values were recorded for the H group is expected since it was selected for heavier body weight. Insignificant differences were found between the two sexes.

About the 1st generation; L x S interactions on WG were insignificant at the two studied periods (Table 17). Highly significant differences between the two lines in WG were observed, where the HL showed higher values (Table 18). The highest values were recorded for the HL is expected since it was selected for heavier body weight. Insignificant difference was found between the two sexes in WG_{0-2}, but a significant difference was found in WG_{2-4}. Data in Table 18 showed that higher values were obtained for females in both selected lines where the HL showed higher values than the LL. As for the selected parents for the 2nd generation; L x S interactions on WG were insignificant at the two studied periods (Table 19). Significant differences between the two lines in WG were observed at WG_{6-8} only, where the HL showed higher values (Tables 19 and 20). The highest values were recorded for the HL is expected since it was selected for heavier body weight. Insignificant difference was found between the two sexes. However, Data in Table 20 showed that higher values were obtained for females than males in both selected lines and that the HL showed higher values than the LL.

Data in Table 21 revealed that the interaction between line and sex in 2nd generation was found to be significant only at WG_{2-4} ($P \leq 0.0008$). Highly significant differences ($P \leq 0.0001$) between the two lines in WG were observed, where the HL

Table 14. Least square means ±SE of relative growth rates (%) for selected parents

Traits				N	RGR_{4-6}			N	RGR_{6-8}		
					Mean	±	SE		Mean	±	SE
Overall means	Line	High		184	22.35	±	0.52	183	16.20	±	0.24[a]
		Low		93	37.62	±	0.74	87	14.73	±	0.35[b]
	Sex	Female		187	28.44	±	0.51	180	15.39	±	0.25
		Male		90	31.52	±	0.74	90	15.53	±	0.34
Interaction Means	Line X Sex interaction	High	Female	124	22.39	±	0.60	123	15.92	±	0.28
			Male	60	22.30	±	0.86	60	16.47	±	0.40
		Low	Female	63	34.49	±	0.84[b]	57	14.86	±	0.41
			Male	30	40.74	±	1.21[a]	30	14.59	±	0.56

RGR_{4-6} and RGR_{6-8} = Relative growth rate during the period from 4 to 6 wk and 6 to 8 wk of age.
For the main effects within column: any two means ± SE within line with different superscripts are significantly different between ($P\leq 0.001$) and ($P\leq 0.0001$).
For the interaction means within column: any two means ± SE (female and male) within line or within sex (HL and LL) are significantly different ($P\leq 0.0005$).

Table 15. Least squares analysis of variance of weight gain (g) for the parent stock

Source of variance	df.	WG_{4-6}		WG_{6-8}	
		SS	Prob.	SS	Prob.
Group (G)	1	9220.82	<.0001	11074.04	<.0001
Sex (S)	1	58.56	0.500	521.15	0.131
G x S interaction	1	0.49	0.951	503.78	0.138
Error	136	17440.48		30756.37	

Table 16. Least square means ±SE of weight gain (g) for the parent stock at 4, 6 and 8 wk of age

Traits				N	WG_{4-6}			WG_{6-8}		
					Mean	±	SE	Mean	±	SE
Overall means	Group (G)	High		93	60.76	±	1.25[a]	52.62	±	1.65[a]
		Low		47	42.59	±	1.74[b]	32.71	±	2.31[b]
	Sex (S)	Female		93	50.95	±	1.25	40.51	±	1.65
		Male		47	52.40	±	1.74	44.83	±	2.31
Interaction Means	G x S interaction	High	Female	62	59.97	±	1.44	48.34	±	1.91
			Male	31	61.55	±	2.03	56.90	±	2.70
		Low	Female	31	41.94	±	2.03	32.68	±	2.70
			Male	16	43.25	±	2.83	32.75	±	3.76

WG_{4-6} and WG_{6-8} = Body weight gain from 4 to 6 wk and 6 to 8 wk of age.
For the main effects within column: any two means ± SE within group with different superscripts are significantly different ($P\leq 0.0001$).

Table 17. Least squares analysis of variance of weight gain (g) for the first generation

Source of variance	df.	WG_{0-2}		WG_{2-4}	
		SS	Prob.	SS	Prob.
Line (L)	1	50562.68	<.0001	254741.17	<.0001
Sex (S)	1	265.40	0.204	1389.53	0.0005
L x S interaction	1	1.33	0.928	135.07	0.273
Error	924	151951.79		103876.27	

Table 18. Least square means ±SE of weight gain (g) for the first generation

Traits				N	WG_{0-2} Mean	±	SE	N	WG_{2-4} Mean	±	SE
Overall means	**Line (L)**	**High**		650	81.55	±	0.51^{a}	635	107.44	±	0.42^{a}
		Low		317	65.15	±	0.78^{b}	293	70.63	±	0.65^{b}
	Sex (S)	**Female**		516	73.94	±	0.59	516	90.40	±	0.48^{a}
		Male		412	72.75	±	0.73	412	87.68	±	0.60^{b}
Interaction Means	**L x S interaction**	**High**	**Female**	326	82.10	±	0.71	326	109.23	±	0.59
			Male	309	81.00	±	0.73	309	105.66	±	0.60
		Low	**Female**	190	65.79	±	0.93	190	71.57	±	0.77
			Male	103	64.51	±	1.26	103	69.70	±	1.04

WG_{0-2} and WG_{2-4}= Body weight gain from hatch to 2 wk and 2 to 4 wk of age.

For the main effects within column: any two means ± SE within line or within sex with different superscripts are significantly different (P≤ 0.0001).

Table 19. Least squares analysis of variance of weight gain (g)for selected parents for the 2nd gen

Source of variance	df.	WG_{4-6}		df.	WG_{6-8}	
		SS	Prob.		SS	Prob.
Line (L)	1	126.04	0.522	1	18874.59	<.0001
Sex (S)	1	39.644	0.720	1	938.892	0.152
L x S interaction	1	4.625	0.902	1	567.132	0.265
Error	264	80983.19		258	117210.03	

Table 20. Least square means ±SE of weight gain (g) for selected parents for the 2nd generation

Traits				N	WG_{4-6} Mean ± SE	N	WG_{6-8} Mean ± SE
Overall means	Line (L)	High		180	52.95 ± 1.38	176	43.77 ± 1.70[a]
		Low		88	51.39 ± 1.99	86	24.65 ± 2.43[b]
	Sex (S)	Female		179	52.61 ± 1.39	174	36.34 ± 1.72
		Male		89	51.73 ± 1.98	88	32.08 ± 2.42
Interaction Means	L x S interaction	High	Female	120	53.23 ± 1.60	117	47.56 ± 1.97
			Male	60	52.66 ± 2.26	59	39.98 ± 2.77
		Low	Female	59	51.98 ± 2.28	57	25.12 ± 2.82
			Male	29	50.81 ± 3.25	29	24.17 ± 3.96

WG_{4-6} and WG_{6-8} = Body weight gain from 4 to 6 wk and 6 to 8 wk of age.
For the main effects within column: any two means ± SE within line with different superscripts are significantly different ($P \leq 0.0001$).

Table 21. Least squares analysis of variance of weight gain (g) for the 2nd generation

Source of variance	df.	WG_{0-2} SS	WG_{0-2} Prob.	WG_{2-4} SS	WG_{2-4} Prob.
Line (L)	1	89044.71	<.0001	169532.28	<.0001
Sex (S)	1	2550.14	0.0004	1776.83	0.0024
L x S interaction	1	141.95	0.402	2185.97	0.0008
Error	537	108531.93		102921.64	

showed higher values (Table 22). The high values were recorded for the HL is expected since, it was selected for heavier body weight. Significant effect was found between the two sexes in WG (Table 21). As represented in Table 22 and Fig. 4 the higher values were obtained for females in both selected lines, where the HL females showed highest.

Effect of interaction between line by sex on WG for the selected parents for the third generation were insignificant at the two studied periods (Table 23). Significant differences between the two lines in WG was observed at WG_{6-8} only, where the HL showed higher values (Table 23 and 24). The high values were recorded for the HL is expected since, it was selected for heavier body weight. Sex differences were not significant at the two studied periods, as represented in Table 23.

In 3rd generation, data in Table 25 revered the effect of interaction between line and sex was found to be significant only at WG_{2-4} ($P \leq 0.019$). Highly significant differences ($P \leq 0.0001$) between the two lines in WG were observed, where the HL showed higher values (Tables 25 and 26). The high values were recorded for the HL is expected since, it was selected for heavier body weight. Significant effect was found between the two sexes in WG (Table 25). As represented in Table 26 and Fig. 5 the higher values were obtained for females than males in both selected lines and that the HL showed higher values than the LL.

Finally; the effect of line by sex interactions on WG for the selected parents for the next generation were insignificant at the two studied periods (Table 27). Highly significant differences between the two lines in WG were observed, where the HL showed higher values (Table 27 and 28). Insignificant difference was found between the two sexes. However, Data in Table (27) showed that higher values were obtained for males than females in both selected lines.

Table 22. Least square means ±SE of weight gain (g) for the 2nd gen

Traits				N	WG_{0-2}			N	WG_{2-4}		
					Mean	±	SE		Mean	±	SE
Overall means	Line (L)	High		390	89.29	±	0.75[a]	370	104.70	±	0.73
		Low		195	61.49	±	1.09[b]	186	66.34	±	1.06
	Sex (S)	Female		311	77.74	±	0.84[a]	311	87.48	±	0.81
		Male		230	73.04	±	1.03[b]	230	83.56	±	1.00
Interaction Means	L X S interaction	High	Female	197	92.20	±	1.01	197	108.84	±	0.99[a]
			Male	162	86.38	±	1.12	162	100.56	±	1.09[b]
		Low	Female	114	63.28	±	1.33	114	66.12	±	1.30
			Male	68	59.69	±	1.72	68	66.55	±	1.68

WG_{0-2} and WG_{2-4}= Body weight gain from hatch to 2 wk and 2 to 4 wk of age.
For the main effects within column: any two means ± SE within line or within sex with different superscripts are significantly different between (P≤ 0.005) and (P≤ 0.0001).
For the interaction means within column: any two means ± SE (female and male) within line are significantly different (P≤ 0.001)

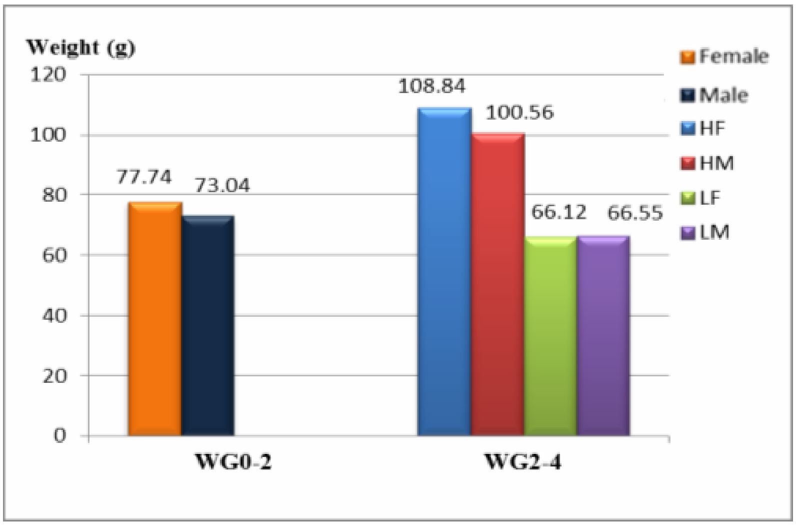

Fig. 4. Sex effect on weight gain of 2nd generation

Table 23. Least squares analysis of variance of weight gain (g) for selected parents for the 3rd gen

Source of variance	df.	WG_{4-6}		df.	WG_{6-8}	
		SS	Prob.		SS	Prob.
Line (L)	1	837.81	0.207	1	13030.23	<.0001
Sex (S)	1	0.18	0.985	1	265.75	0.423
L x S interaction	1	28.43	0.816	1	48.40	0.732
Error	537	138435.23		260	107232.93	

Table 24. Least square means ±SE of weight gain (g) for selected parents for the 3rd gen

Traits				N	WG_{4-6}			N	WG_{6-8}		
					Mean	±	SE		Mean	±	SE
Overall means	Line	High		176	53.70	±	1.81	174	45.31	±	1.62[a]
		Low		92	49.77	±	2.53	90	29.64	±	2.27[b]
	Sex	Female		176	51.76	±	1.81	174	36.36	±	1.62
		Male		92	51.70	±	2.53	90	38.60	±	2.27
Interaction Means	Line X Sex interaction	High	Female	115	53.36	±	2.14	114	43.72	±	1.90
			Male	61	54.03	±	2.93	60	46.91	±	2.62
		Low	Female	61	50.15	±	2.93	60	29.00	±	2.62
			Male	31	49.38	±	4.11	30	30.28	±	3.71

WG_{4-6} and WG_{6-8} = Body weight gain from 4 to 6 wk and 6 to 8 wk of age.
For the main effects within column: any two means ± SE within line with different superscripts are significantly different ($P \leq 0.0001$).

Table 25. Least squares analysis of variance of weight gain (g) for the 3rd gen

Source of variance	df.	WG_{0-2}		WG_{2-4}	
		SS	Prob.	SS	Prob.
Line (L)	1	103305.47	<.0001	244680.02	<.0001
Sex (S)	1	2053.50	0.005	6238.83	<.0001
BW x S interaction	1	908.77	0.064	1159.22	0.019
Error	836	221015.95		176052.93	

Table 26. Least square means ±SE of weight gain (g) for the third generationn

Traits				N	WG_{0-2}			N	WG_{2-4}		
					Mean	±	SE		Mean	±	SE
Overall means	Line	High		607	87.03	±	0.67[a]	595	101.42	±	0.59
		Low		252	62.62	±	1.04[b]	245	63.84	±	0.93
	Sex	Female		429	76.55	±	0.86[a]	429	85.63	±	0.77
		Male		411	73.11	±	0.89[b]	411	79.63	±	0.79
Interaction Means	Line X Sex interaction	High	Female	301	89.90	±	0.94	301	105.71	±	0.84[a]
			Male	294	84.17	±	0.95	294	97.13	±	0.85[b]
		Low	Female	128	63.19	±	1.44	128	65.55	±	1.28
			Male	117	62.04	±	1.50	117	62.14	±	1.34

WG_{0-2} and WG_{2-4}= Body weight gain from hatch to 2 wk and 2 to 4 wk of age.
For the main effects within column: any two means ± SE within line or within sex with different superscripts are significantly different between ($P \leq 0.005$) and ($P \leq 0.0001$).
For the interaction means within column: any two means ± SE (female and male) within line or within sex (HL and LL) are significantly different ($P \leq 0.01$).

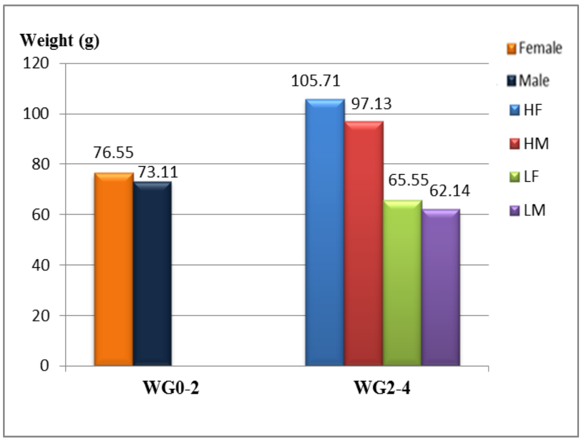

Fig. 5. Sex effect on weight gain of 3rd generation

Table 27. Least squares analysis of variance of weight gain (g) for selected parents

Source of variance	df.	WG_{4-6}		df.	WG_{6-8}	
		SS	Prob.		SS	Prob.
Line (L)	1	2394.07	0.003	1	35510.98	<.0001
Sex (S)	1	320.62	0.266	1	0.095	0.980
BW x S interaction	1	882.98	0.066	1	71.613	0.481
Error	273	70461.61		266	38243.28	

Table 28. Least square means ±SE of weight gain (g) for selected parents

Traits				N	WG_{4-6}			N	WG_{6-8}		
					Mean	±	SE			±	SE
Overall means	Line	High		184	59.34	±	1.26[a]	183	52.22	±	0.94[a]
		Low		93	52.69	±	1.78[b]	87	26.30	±	1.35[b]
	Sex	Female		187	54.80	±	1.24	180	39.24	±	0.96
		Male		90	57.23	±	1.80	90	39.29	±	1.34
Interaction Means	Line X Sex interaction	High	Female	124	60.15	±	1.44	123	51.62	±	1.08
			Male	60	58.54	±	2.07	60	52.83	±	1.55
		Low	Female	63	49.45	±	2.02	57	26.86	±	1.59
			Male	30	55.93	±	2.93	30	25.74	±	2.19

WG_{4-6} and WG_{6-8} = Body weight gain from 4 to 6 wk and 6 to 8 wk of age.

For the main effects within column: any two means ± SE within line with different superscripts are significantly different between (P≤ 0.005) and (P≤ 0.0001).

REFERENCES

Abd El-Fattah, M.H.; El-Full, E.A.; Farahat, G.S.; Hatba, N.A. and Khalifa, M.A. (2006). Inheritance of body weight, growth rate and fitness traits in Japanese quail. Egypt. Poult. Sci., 26:1195-1215.

Aboul-Hassan, M.A. (2000). Comparative study of growth traits in two strain of Japanese quail. Fayoum J. Agric. Res., 14: 189-197.

Badawy, A.Y. (2008). Divergent selection in Japanese quail for Body weight under Subtropical conditions. M.Sc. Thesis, Fac. Agric., Suze Canal Univ., Egypt.

Badawy, A.Y.; Abdel-Ghany, A.M.; Sabri, H.M. and Khattab, M.S. (2010). Genetic evaluation and trends of japanese quail data selected for 4-wk body weight. Agri. Res. J. Suez Canal Univ., e 10 (2): 11-16

Bahie El-Deen, M. (1994). Selection indices and crossing as a tool for improvement meat and egg production in Japanese quail. Ph.D. Thesis, Fac. Agric., Alex. Univ., Alex., Egypt.

Bahie El-Deen, M. and El-Sayed, T. M. (1999). Genotype environment interactions for growth and some egg production traits in Japanese quail. Egypt. Poult. Sci., 19:17-37.

Darden, J.R. and Marks, H.L. (1989). Divergent selection for growth in Japanese quail under split and complete nutritional environments. 3. Influences of selection for growth on heterotic effects for body weight, feed and water intake patterns, abdominal fat and carcass lipid characteristics. Poult. Sci., 68:37-45.

Debes, A.B. (2004). Selection indices for improving economic traits in Japanese quail. Ph.D. Thesis, Fac. Agric., Alex. Univ., Alex., Egypt.

Duncan, D.B. (1955). Multiple range and multiple F-tests. Biomet., 11: 1-42.

El-Sayed, T.M.; Isshak, N.S. and Tawefuek, F.A. (1995). Growth rate inheritance in Japanese quail. 1st Egypt. Hungarian Poult. Conf., II: 17-19.

Falconer, D.S. and Mackay, T.F.C. (1996). Introduction to quantitative genetics. (4th Ed.) Addison Wesley Longman, Harlow, Essex, UK.

Farahat, G.S.; El-Bahy, N.M. and Mahfoz, O.Y. (2010). Genetic parameter estimates for glutathione peroxidase and some blood constituents and their association with some growth traits in Japanese quail. Egypt. Poult. Sci., 30 (3): (847-873).

Jones, J.E. and Hughes, B.L. (1978). Comparison of growth rate body weight and feed conversion between Coturnix D1 quail and Bobwhite quail. Poult. Sci., 57:1471-1472.

Lepore, P.D. and Marks, H.L. (1971). Growth rate inheritance in Japanese quail. 4-Body weight composition following four generations of selection under different nutritional environments. Poult. Sci., 50:1191-1194.

Marks, H.L. (1993). Growth under different nutritional environments following selection in Japanese quail under specific environments. Poult. Sci., 72:1841-1846.

Moran, E.T.Jr. (1977). Growth and meat yield in poultry. In Boorman, K. N., and B.J. Wilson, editors. Growth and poultry meat production. Br. Poult. Sci. Ltd., Edinburgh.

Reese, E.P. and Reese, T.W. (1962). The Quail (*Coturnix coturnix)* as Laboratory Animal. J. Exptl. Anal. Behavior, 5: 265-270.

Samuel, E.A. (2003). Dynamics of relative growth rate in Japanese quail lines divergently selected for growth and their control. Growth, Develop. and Aging, 67: 47-54.

SAS (2004). SAS/STAT User's Guide for Personal Computers. Release 7.0 SAS Institute Inc., Cary, NC, USA.

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

Shalan, H.M. (1998). Independent culling levels selection and crossing for improving meat and egg production in Japanese quail. Ph.D. Thesis, Fac. Agric., Alex. Univ., Egypt.

Shalan, H.M. (2003). Long-term selection for body weight in Japanese quail under Egyptian conditions. 2-Correlated responses for growth traits. Egypt. Poult. Sci., 23 : 669-686.

Wilson, W.O.; Abbott, U.K. and Abplanalp, H. (1961). Evaluation of Coturnix (Japanese quail) as a pilot animal for poultry. Poult. Sci., 40: 651.

الملخص العربي

تأثير الانتخاب المتباين قصير المدى لوزن الجسم عند عمر 4 أسابيع في السمان الياباني تحت ظروف شمال سيناء ب. التأثير على صفات النمو

بسمة عبدالناصر يوشع[1]، محمود أحمد عبد الغفار[1]، أحمد محمد علي[1]، هاني محمد صبري[2]

1. قسم الإنتاج الحيواني والداجني، كلية العلوم الزراعية البيئية، جامعة العريش، مصر.
2. قسم الإنتاج الحيواني والداجني، كلية الزراعة، جامعة قناة السويس، مصر.

تم الحصول على جيل الآباء للسمان الياباني من قطيع عشوائي التزاوج حيث تم استخدام هذا القطيع للانتخاب في اتجاهين لوزن الجسم عند عمر 4 أسابيع لإنتاج الأجيال الثلاثة التالية (G1 و G2 و G3)، تم إنتاج وتربية الطيور الناتجة خلال الفترة من نوفمبر 2016 إلى نوفمبر 2017 في المزرعة التجريبية، قسم الإنتاج الحيواني والداجني، كلية العلوم الزراعية البيئية، جامعة العريش، العريش، شمال سيناء، مصر، تم إجراء الانتخاب عن طريق قياس الطيور بشكل فردي لوزن الجسم عند عمر 4 أسابيع و تقسيم الطيور حيث أن 3/2 الطيور تمثل خط وزن الجسم المرتفع (High line HL) ، بينما كانت 3/1 الطيور تمثل خط وزن الجسم المنخفض (Low line LL)،وفي عمر 5 أسابيع، تم نقل الطيور المنتخبة إلى أقفاص (بنسبة 1 ذكر و 2 أنثى تم تعيينهما عشوائياً من نفس فئة الاختيار مع تجنب تزاوج الأشقاء)، وتم تطبيق نفس الاتجاه من الانتخاب على كل جيل في كل خط. غُذِيت جميع الطيور النامية على عليقة موحدة بشكل حر بها نسبة بروتين خام 23% و2800 كيلو كالوري/كجم وكانت عليقة البياض تحتوي على 20% من البروتين الخام و2850 كالوري/ كجم، أشارت النتائج إلى أن التداخل بين الانتخاب لوزن الجسم والجنس أظهر تأثيرًا معنويًا على معظم صفات النمو المقدرة، علاوة على ذلك، تأثير خط الانتخاب كان معنويًا جدًا ($P \leq 0.0001$) على معظم صفات النمو المقدرة. أيضًا، انخفض معدل الزيادة في وزن الجسم النسبي مع التقدم في العمر، وسجلت القيم العليا لكلا الجنسين والخطوط ل $RGR_{0\text{-}2}$ وانخفضت تدريجيًا من زيادة العمر، كما كانت الإناث للخط العالي أعلى من الذكور في معظم الفترات التي شملتها الدراسة، ومع ذلك، فإن الزيادة في وزن الجسم فقد كانت القيم العليا للإناث في كلا الخطين (العالي والمنخفض) حيث أظهر HL قيمًا أعلى من LL.

الكلمات الإسترشادية: السمان الياباني، الانتخاب، المتباين، الانتخاب الفعال، الاستجابة، الفارق الانتخابي.

المحكمـــــون:

1- **أ.د. عـــادل إبـراهيـــم عطيـــــــة** أستاذ تغذية الدواجن، قسم الدواجن، كلية الزراعة، جامعة الزقازيق، مصر.

2- **أ.د. إسماعيل السيد إسماعيل عطية** أستاذ فسيولوجي الدواجن، قسم الدواجن، كلية الزراعة، جامعة الزقازيق، مصر.