SHORT-TERM SELECTION FOR BODY WEIGHT AND GROWTH RATE IN JAPANESE QUAIL
2. CORRELATED RESPONSES

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ABSTRACT:

Three quail lines were used in this work to evaluate the correlated responses of growth and some fitness traits in Japanese quail after mass selection for increased either weight or growth rate: HBW_{42} line was selected for high body weight at 42 days of age, HGR_{1-42} line was selected for high growth rate during the period from one-day to 42 days of age and randombred control line RBC was used as non-selected pedigreed population. **The results obtained can be summarized as follows:**

The highest correlated responses of body weights were attained in the 1st generation for BW_1 and BW_{35} associated with faster GR_{21-42}. The highest fertility and hatchability percentages either calculated from total egg set (HTE%) or fertile eggs (HFE%) were obtained after one generation of selection. Asymmetrical correlated responses between the two sexes were found and were not stable throughout the three generations. Selection for HBW_{42} resulted in increases in body weights at 14, 21, 28 and 35 days of age and faster growth rate during the period from 1-21 days than other lines. However, the HGR_{1-42} line had heavier body weights at 7 and 42 days of age than other lines. Significant line differences favoring HGR_{1-42} followed by HBW_{42} were attained for fertility%, HTE% and HFE%. Correlated responses in the line HGR_{1-42} were higher but insignificant than that for the HBW_{42} line for males and females. However, females had higher correlated response in BW_7 with significant sex differences in the HBW_{42} and HGR_{1-42} lines. Generally, the realized correlated responses of all studied growth traits in males were positive and higher than their expected correlated responses. The highest realized correlated responses were 4.97 in BW_{35} of the HBW_{42} line and 4.76 in BW_{42} of the HGR_{1-42} line. Realized correlated responses in all body weights from 7 up to 42 days of age for the HGR_{1-42} line, except BW_1 were significantly higher and positive than their expected estimates, whereas the realized correlated responses in growth rate traits of this line were insignificantly different than their expected estimates. The highest correlated responses for females were 7.21 and 5.86 for BW_{21} in the HBW_{42} and HGR_{1-42} lines, respectively. The realized correlated responses were insignificantly lower than expected estimates for all fitness traits in the line selected for HBW_{42}. Similar trend was observed for fitness traits except HTE%, which indicated highly significant differences favoring realized correlated responses as a result of selection for HGR_{1-42} . It can be concluded that selection for high growth rate is more effective than selection for body weight because both insignificantly differed from each other for all growth traits and the survivability during the periods from 1-21 and 1-42 days of age. Besides, there are significant differences favoring HGR_{1-42} line for fertility% and hatchability% which calculated as a percentage of total eggs or as a percentage of fertile eggs, which can be used as additional indirect goals from selection in that line.

Key words: Selection, correlated response, body weight, growth rate, Japanese quail.

INTRODUCTION

Selection experiments for improving a certain trait have frequently resulted in changing one or more of unselected traits. These associated changes are due to the genetic effects, environmental influences and a combination of both. Pleiotropy is probably the main cause of permanent genetic associations while these caused by linkage are transient **(Lerner, 1958 and Falconer, 1989)**. Either phenotypically or genetically, there are high associations between body weights obtained at various ages prior to sexual maturity. Positive correlations, which considered part whole relationships, during the juvenile growth period should be expected **(Siegel 1963).** Early growth rate was correlated with other body weight measurements as reviewed by **Marks (1979)**. Similar results were obtained by several investigators **(Anthony *et al.*, 1986, Bahie El Deen, 1991 and 1994, El Fiky, 1991, Kosba and Soliman, 1992, El Sayed *et al.*, 1995, Tawfuek, 1995, Anthony *et al.*, 1996** and **Badawy *et al.*, 1997, Emmerson, 1997** and **Buyse *et al.*, 2001)**. Yet it is clear that the main correlated response to selection for growth at, or near, the inflection point of the growth curve is early exponential growth rate, generally described as occurring during the first two post hatched weeks **(Barbato, 1991 and 1992)**.

It has long been known that selection for two traits having a negative genetic correlation will result in a subsequent reduction in fitness **(Decuypere *et al.*, 2003)** with a reduction in immunocomptence and disease resistance **(Li *et al.*, 2000)**. Moreover, their reproductive potential is adversely affected **(Havenstein *et al.*, 1994, Nicholson, 1998** and **Decuypere *et al.*, 2003)**. Thus, further breeding should consider not only how to increase production but also how to alleviate correlated side effects by extending or changing selection goals for obvious economic reasons. Selection for high four-week body weight resulted in decreases in fertility and hatchability percentages, but the declines in hatchability were less during selection for high body weight in Japanese quail **(Marks, 1979)**. Divergent selection for four-week body weight under two nutritional treatments resulted in hatchability decrease as found by **Darden and Marks (1988)**. However, **Nestor and Bacon (1982)** reported that fertility and hatchability insignificantly differed among strains divergently selected for four-week body weight and yolk precursor in the fifth generation of selection. Fertility and hatchability in the divergently selected lines for body weight at six-weeks of age over 65 generations were significantly lower than those in the control line **(Suda and Okamoto, 2003)**.

It is important to measure the actual changes occurred in one trait as a result of selection program for another trait. This study was done to evaluate the correlated responses over three generations of selection for either high body weight or growth rate on some growth and fitness traits in Japanese quail.

MATERIALS AND METHODS

The experimental work of the present study was carried out at the Poultry Research Center, Faculty of Agriculture, Fayoum University. It lasted for three generations after establishing the base population. Three quail lines were used in this study. Line HBW_{42} was established for high body weight at 42 days of age, line HGR_{1-42} was established for high growth rate during the

period from one-day to 42 days of age and a randombred control line (RBC) was maintained as non-selected pedigreed population. Details of the origin, maintenance, rearing and breeding design of the HBW_{42}, HGR_{1-42}, and RBC lines were previously outlined by **Abdel Fattah (2006)**.

The following criteria were measured or calculated

1. Body weight at hatch, 7, 14, 21, 28, 35, and 42 days of age (BW_1, BW_7, BW_{14}, BW_{21}, BW_{28}, BW_{35}, and BW_{42}, respectively) were individually recorded to the nearest 0.01g.
2. Growth rates during the periods from 1-21, 21-42, and 1-42 days of age (GR_{1-21}, GR_{21-42}, and GR_{1-42}, respectively) were calculated according to **Brody (1945)** using the following formula:

$$\mathbf{GR = [W_2 - W_1 / {}^1/_2 (W_2 + W_1)] \times 100}$$

where: $\mathbf{W_1}$ is the weight at the beginning and $\mathbf{W_2}$ is the weight at the end of the period**.**

3. Fertility% and hatchability% which calculated as a percentage of total eggs (HTE%) or as a percentage of fertile eggs (HFE%).
4. Mortality data were collected and defined as the time from hatch to the date the bird died to calculate the survivability during the periods from 1-21 (S_3%) and 1-42 days of age (S_6%).

Statistical analyses

Means and standard errors of all studied correlated traits were subjected to analysis using three ways ANOVA with generation, sex and line as main effects, according to the following model:

$$\mathbf{Y_{ijk} = \mu + G_i + L_j + S_k + e_{ijk},}$$

where: μ is the common mean, G is the effect of i^{th} generation, L_j is the effect of j^{th} line, S_k is the effect of k^{th} sex and e_{ijk}**:** random error term, using the GLM procedure of SPSS program **(SPSS, 1999).** Means were compared for main effects by Duncan's multiple range test **(Duncan, 1955**), when significant F values were obtained ($P<0.05$).

Expected correlated responses were calculated according to **Falconer (1989)** as follows:

$$\mathbf{CR_y = i\, h_x\, h_y\, r_g\, \delta_{p(Y)}}$$

where: h_X, h_Y is the square root of heritabilites of X and Y traits, **rg** is the genetic correlation between X and Y traits, $\delta p_{(y)}$ is the phenotypic standard deviation of Y trait and **i** is the selection intensity for trait X. The expected, realized and cumulative values for correlated responses in the present study were calculated according to **Falconer (1989).** Also, pairing t-test was used to compare all the realized and expected values for the all correlated responses to selection.

RESULTS AND DISCUSSION

Means for body weight at different ages, growth rates during different periods of growth and fitness traits are presented in Table 1.

Generation effect

Significant differences due to generation effect were found for BW_1, BW_7, BW_{14}, BW_{35} and growth rates during different periods studied. The highest body weights were attained in the first generations for BW_1 and BW_{35} accompanied with faster growth rate during the period from 21 to 42 days of age (8.14, 168.71g and 65.7%). However, the second generation had heavier body weights at all ages, except at hatch and 35 days of age, associated with

faster growth rate during 1- 21 and 1- 42 days of age than other generations ($P \leq 0.05$, Table 1).

The highest fertility, HTE% and HFE% were obtained in the first generation of selection (82.88, 71.53 and 87.27%, respectively). Similar trends were reported by **Marks (1979), Darden and Marks (1988) and Suda and Okamoto (2003)**. However, no generation effects through selection generations had shown on percentages of S_3% and S_6% as shown in Table 1.

Line effect

Significant line differences ($P \leq 0.05$) were found for growth traits at all ages, except hatch weight, and growth rate during the period from 1-21 days of age. The selected lines had significantly heavier body weights at these ages than their controls, whereas they insignificantly differed from each other for all body weight traits. Similarly, the RBC line had significant slower growth rates during 1-21 and 1-42 days of age periods than the selected lines (Table 1). Selection for high 42-day body weight resulted in significantl increases in body weights at 14, 21, 28 and 35 days of age and faster growth rate during the period from 1-21 days of age in HBW_{42} line (55.66, 97.45, 136.49, 169.22g and 169.9%) than the RBC and HGR_{1-42}lines as shown in Table 1. However, the HGR_{1-42} had heavier body weights at seven and 42 days of age (25.29 and 188.91 g) than the RBC and HBW_{42} lines. These results are in accordance with those reported by **Anthony *et al.* (1986)** who illustrated that selection for rapid growth at any age was effective in increasing body weight when compared to the control line.

Significant line differences favoring HGR_{1-42} line followed by HBW_{42} line were attained for fertility%, HTE% and HFE% (83.34, 65.85 and 79.72% vs 80.97, 62.23 and 76.62%, respectively) as shown in Table 1. Whereas, the lowest estimates in these respects were indicated by the control line ($P \leq 0.05$). Opposite trend was reported by **Suda and Okamoto (2003)** that fertility and hatchability in the divergently selected lines for body weight at six-weeks of age over 65 generations were significantly lower than those in the control line. This different results is mainly due to the longer period of selection in the work of **Suda and Okamoto (2003).** However, line insignificantly affected S_3% and S_6% as illustrated in Table 1.

Sex effect

Sex significantly influenced body weights at 21, 28, 35 and 42 days of age favoring females (97.28, 137.22, 171.14 and 192.87g vs 95.50, 133.54, 165.31 and 183.18g, respectively) as shown in Table 1. Similarly, females had higher ($P \leq 0.01$) growth rates during the periods 21-42 and 1-42 days than males (66.2 and 184.2% vs 63.2 and 183.4%, respectively). Similar results were reported by **Marks (1996), Nestor *et al.* (1996), Shalan (1998) and Bahie El Deen (2003).** This divergence in body weight may be attributed to an acceleration of weight gain by females just prior to laying their first egg **(Sefton and Siegel, 1974)**.

Realized correlated responses for growth traits

Realized correlated responses to selection for BW_{42} and GR_{1-42} are presented in Table 2 for males and females and in the Figures from 1 to 3 for the combined sex. The response is presented as an absolute deviation (g) and as a percent deviation from the RBC line. Differences between the correlated responses of males and females were not constant throughout the three generations. The overall correlated response (as a percent deviation from RBC line) to selection for HBW_{42} by the 3rd generation indicated that males had a

Table 1

Table 2

Fig. 1

Fig. 2

Fig. 3

higher percent increase in all growth traits except BW_1, BW_{14} and GR_{21-42} whereas females exceeded the RBC line by 1.483%, 3.756% and 0.743%, respectively. Males exceeded the RBC line by 3.407%, 7.166%, 6.498%, 5.621%, 1.311% and 0.415% for BW_7, BW_{21}, BW_{28}, BW_{35}, GR_{1-21} and GR_{1-42}, respectively (Table 2). This may be due to the fact that selection pressure was much higher on the sire side than the dam side. Similar asymmetry in response to selection for increased broiler body weight between the two sexes was found by **Khan *et al*. (1975), Benoff and Renden (1983)** and **El Gindy (1984).** The direct response to selection for HBW_{42} was greater than the correlated responses which accompanied selection. This result confirms those of **El Hossari (1977)** who indicated that the direct response to selection for any trait was greater than the correlated responses. Similarly, asymmetry in response to selection between the two sexes was found. The overall correlated response (as a percent deviation from RBC line) to selection for HGR_{1-42} by the 3rd generation indicated that males had a higher percent increase in body weight than females at 7, 14, 21, 28, 35 and 42 days of age (4.409, 3.170, 5.825, 5.386, 4.739 and 5.228 vs 2.151, 2.964, 3.574, 4.126, 4.365 and 4.758 %, respectively) and growth rate during the period from 1 to 21 days of age (0.955 vs 0.290). Whereas, females exceeded the RBC line by 0.106 g (1.508%) in BW_1 and GR_{21-42} 0.010 (1.586%) as shown in Table 2.

Except, a significant regression coefficient of -2.067% for females BW_7 response on generation number in the selected line for HBW_{42} the regression coefficients were insignificant (Table 2).

There were significant regression coefficients of 1.526% for males BW_{42} and 48.064% for males GR_{1-21} response to selection for HGR_{1-42} line on generation number as shown in Table 2.

Realized cumulative correlated responses for growth traits

Realized cumulative correlated responses for growth traits of the selected lines as percent of their RBC are presented in Table 3. There were inconsistent sex differences for various growth traits across generations. Males had positive and higher correlated responses in BW_1 than females to selection for HBW_{42} or HGR_{1-42} (1.8 and 3.1% vs -0.50 and 1.20%, respectively). The correlated responses in the line selected for HGR_{1-42} were higher but insignificant than that for the line selected for HBW_{42} for males, females and combined sexes. However, females had higher correlated responses in BW_7 of 7.80g (10.30%) vs 3.40g (3.80%) and BW_{21} of 14.60g (12.50%) vs 7.20g (5.60%) with significant sex differences in the HBW_{42} and HGR_{1-42} lines. For the combined sexes, the correlated responses in HBW_{42} line were insignificantly differed than those of the HGR_{1-42} line across the three generations of selection. However, significant sex differences for both HBW_{42} and HGR_{1-42} lines were found for BW_7, BW_{21}. Similar trends of significant sex differences were observed for BW_{28} and BW_{42} in the HGR_{1-42} line as shown in Table 3. The highest resultant response in BW_{21} of the combined sexes was 11.3 % in the line selected for HBW_{42}, whereas the highest correlated responses of the combined sexes were 9.7 % in BW_{28} and BW_{42} in the HGR_{1-42} line (Table 3).

Comparison among expected and realized correlated responses

Expected and realized correlated responses for growth traits

The realized correlated responses for the generations average of all studied growth traits in males were positive and higher than their expected correlated responses (Table 4). The realized correlated responses in BW_7 and

Table 3. Realized cumulative correlated responses for growth traits by generation for HBW_{42} and HGR_{1-42} lines as a percent deviation from their RBC line in Japanese quail.

Trait	G	Male		Female		Combined sexes	
		HBW_{42}	HGR_{1-42}	HBW_{42}	HGR_{1-42}	HBW_{42}	HGR_{1-42}
BW_1	**1**	0.36	0.73	-0.85	-1.22	-0.24	-1.46
	2	0.52	1.44	-1.57	1.05	-0.26	0.13
	3	4.51	7.11	0.92	3.68	3.08	3.75
	X	**1.80**	**3.10**	**-0.50**	**1.20**	**0.90**	**0.80**
BW_7	**1**	0.16	1.35	5.15	6.09	2.96	4.23
	2	4.45	3.64	8.62	12.07	6.84	8.37
	3	5.67	6.54	9.75	12.59	7.87	9.84
	X	**3.40**	**3.80**	**7.80**	**10.30**	**5.90**	**7.50**
BW_{14}	**1**	1.31	2.69	4.84	4.75	3.35	3.94
	2	10.57	6.20	7.80	8.71	9.46	7.79
	3	11.33	8.96	9.66	9.40	10.70	9.32
	X	**7.70**	**6.00**	**7.40**	**7.60**	**7.80**	**7.00**
BW_{21}	**1**	1.29	2.36	8.28	7.97	5.20	5.49
	2	8.31	3.53	13.94	12.09	11.58	8.18
	3	11.98	10.77	21.6	17.52	17.1	14.3
	X	**7.20**	**5.60**	**14.60**	**12.50**	**11.30**	**9.30**
BW_{28}	**1**	3.46	4.38	7.68	6.41	5.71	5.40
	2	11.25	7.39	12.97	11.26	12.32	9.41
	3	13.59	12.35	19.54	16.21	16..86	14.32
	X	**9.40**	**8.00**	**13.40**	**11.30**	**6.00**	**9.70**
BW_{35}	**1**	4.29	4.07	6.72	6.02	5.54	4.98
	2	10.06	6.63	9.98	9.88	10.20	8.33
	3	15.11	13.25	16.98	14.32	16.12	13.61
	X	**9.80**	**8.00**	**11.20**	**10.10**	**10.60**	**9.00**
BW_{42}	**1**		3.28		5.12		4.01
	2		8.04		10.60		9.66
	3		14.32		17.07		15.44
	X		**8.50**		**10.9**		**9.70**
GR_{1-21}	**1**	0.30	0.84	1.93	1.93	1.14	1.44
	2	4.12	3.52	2.95	2.06	3.54	2.83
	3	4.34	3.76	4.03	3.14	4.08	3.37
	X	**2.90**	**2.70**	**3.00**	**2.40**	**2.90**	**2.50**
GR_{21-42}	**1**	3.94	1.31	1.28	1.28	2.73	1.77
	2	5.55	6.20	1.36	3.93	3.62	3.78
	3	16.24	16.56	4.06	10.08	4.51	5.29
	X	**8.60**	**8.00**	**2.20**	**5.10**	**3.60**	**3.61**
GR_{1-42}	**1**	0.43		0.60		0.49	
	2	0.82		0.98		0.87	
	3	0.92		1.31		1.09	
	X	**0.70**		**1.00**		**0.80**	

HBW_{42}: selected line for higher 42-day body weight, HGR_{1-42}: selected line for higher 1- 42-day growth rate.
BW: body weight, GR: Growth rate.
X: unweighted mean, G: generation.

Table 4. Expected and realized correlated responses for growth traits for males in HBW_{42} and HGR_{1-42} lines by generation in Japanese quail.

		HBW_{42}					HGR_{1-42}				
Trait	**Correlated response**	**G_1**	**G_2**	**G_3**	**X**	**b**	**G_1**	**G_2**	**G_3**	**X**	**b**
	Expected	0.53	0.11	0.02	0.22	-0.255 ^{NS}	-0.08	-0.31	-0.27	-0.22	-0.131 ^{NS}
BW_1	**Realized**	0.36	0.13	0.397	0.29		0.73	0.66	5.61	2.33	
	t-pairing			**NS**					**NS**		
	Expected	1.54	0.27	-1.39	0.14	-1.465*	-0.15	0.08	-0.42	-0.16	-0.135 ^{NS}
BW_7	**Realized**	0.16	4.28	1.15	1.86		1.35	2.30	2.84	2.16	
	t-pairing			*****							
	Expected	2.32	1.04	-2.48	0.29	-2.400 ^{NS}	0.17	1.74	-1.71	0.07	-0.940 ^{NS}
BW_{14}	**Realized**	1.31	9.21	0.72	3.75		2.69	3.41	2.74	2.95	
	t-pairing			**NS**					**NS**		
	Expected	3.62	2.74	-2.85	1.17	-3.240 ^{NS}	0.57	3.05	-0.31	1.10	-0.440 ^{NS}
BW_{21}	**Realized**	1.29	7.01	3.55	3.95		2.36	1.15	7.20	3.57	
	t-pairing			**NS**					**NS**		
	Expected	2.57	2.69	-6.79	-0.51	-4.680 ^{NS}	0.56	1.95	-0.12	0.79	-0.340 ^{NS}
BW_{28}	**Realized**	3.46	7.83	2.36	4.55		4.38	3.03	4.96	4.12	
	t-pairing			*****					**NS**		
	Expected	0.85	1.67	-9.76	-2.41	-5.305 ^{NS}	0.38	3.60	-0.28	1.23	0.050 ^{NS}
BW_{35}	**Realized**	4.298	5.65	4.97	4.97		4.07	2.44	6.57	4.36	
	t-pairing			**NS**					**NS**		
	Expected						0.21	1.43	-1.74	-0.03	-0.945 ^{NS}
BW_{42}	**Realized**						3.28	4.67	6.33	4.76	
	t-pairing								**NS**		
	Expected	0.003	0.04	-.004	0.01	-0.004 ^{NS}	0.003	0.019	0.011	0.01	-0.785 ^{NS}
GR_{1-21}	**Realized**	0.30	3.82	0.35	1.29		0.84	2.67	0.35	1.29	
	t-pairing			**NS**							
	Expected	-0.025	-0.01	-0.023	-0.003	-0.001 ^{NS}	-0.005	-0.012	0.009	-0.003	-2.181^{NS}
GR_{21-42}	**Realized**	3.94	1.63	1.59	2.06		1.31	1.68	3.18	2.06	
	t-pairing			**NS**					**NS**		
	Expected	-0.010	-0.001	-0.027	-0.013	-0.009 ^{NS}					
GR_{1-42}	**Realized**	0.43	0.38	0.11	0.31						
	t-pairing			**NS**							

BW: body weight, GR: Growth rate, NS: not significant.

*: $P \leq 0.05$ and b: regression coefficient realized correlated responses on generation number, X: unweighted mean and G: generation.

BW_{28} were statistically differed than their expected estimates. The highest realized correlated responses were 4.97 in BW_{35} of the HBW_{42} line and 4.76 in BW_{42} of the HGR_{1-42} line as shown in Table 4. Similar trend of higher realized correlated responses than their expected estimates in males was also obtained for females (Table 5). The realized correlated responses in GR_{1-21} and GR_{1-42} were statistically differed than their expected estimates in the line selected for HBW_{42}. Similarly, the realized correlated responses in all body weights from seven up to 42 days of age for the HGR_{1-42} line except BW_1 which significantly positive and higher than the expected estimates, whereas the realized correlated responses in growth rate traits of this line were insignificantly differed than their expected estimates. The highest correlated responses for females were 7.21 and 5.86 for BW_{21} in the HBW_{42} and HGR_{1-42} lines, respectively as shown in Table 5.

Expected and realized correlated responses for fitness traits

The realized correlated responses were insignificantly lower than expected estimates for all fitness traits in the line selected for HBW_{42}. Similar trends were observed for fitness traits, except (HTE%), which indicated highly significant differences favoring realized correlated responses as a result of selection for HGR_{1-42} ($P \leq 0.01$) as shown in Table 6 and Figure 4.

It can be concluded that selection for high growth rate is more effective than selection for body weight because both insignificantly differed from each other for all growth traits and the survivability during the periods from 1-21 and 1-42 days of age. Besides, there are significant differences favoring HGR_{1-42} line for fertility% and hatchability% which calculated as a percentage of total eggs or as a percentage of fertile eggs, which can be used as additional indirect goals from selection in that line.

Table 5

Table 6. Expected and realized correlated response for fitness traits in HBW_{42} and HGR_{1-42} lines by generation in Japanese quail.

Line	Correlated trait		Generation G1	G2	G3	Overall mean	b	t-test sig.
		ECR	-0.02	-0.13	-0.40	-0.183	***-0.190*** ^{NS}	***NS***
	Fertility%	**RCR**	0.08	0.07	0.11	0.087		
		ECR- RCR	**-0.10**	**-0.20**	**-0.51**	**-0.270**		
		ECR	0.11	0.56	0.01	0.227	***-0.050*** ^{NS}	***NS***
	HTE%	**RCR**	0.07	0.02	0.08	0.057		
		ECR- RCR	**0.04**	**0.54**	**-0.07**	**0.170**		
		ECR	0.20	0.82	0.53	0.517	***0.165*** ^{NS}	***NS***
	HFE %	**RCR**	-0.003	0.02	0.001	0.006		
		ECR- RCR	**0.203**	**0.80**	**0.529**	**0.511**		
HBW_{42}								
		ECR	-0.08	-0.05	-0.03	-0.053	***0.025*** ^{NS}	***NS***
		RCR	0.02		0.01	0.011		
	S_3 %			0.004				
		ECR- RCR	**-0.10**	**-**	**-0.04**	**-0.064**		
				0.054				
		ECR	-0.40	-0.06	-0.09	-0.183	***0.155*** ^{NS}	***NS***
		RCR	-0.002	-	-0.002	-0.002		
	S_6 %			0.003				
		ECR- RCR	**-0.392**	**-**	**-0.088**	**-0.181**		
				0.057				
		ECR	0.13	0.15	0.35	0.210	***0.110*** ^{NS}	***NS***
	Fertility%	**RCR**	0.10	0.03	0.13	0.090		
		ECR- RCR	**0.03**	**0.12**	**0.22**	**0.123**		
		ECR	-0.07	-0.06	-0.02	-0.050	***0.025*** ^{NS}	********
	HTE%	**RCR**	0.09	0.06	0.12	0.090		
		ECR- RCR	**-0. 16**	**-0.12**	**-0.14**	**-0.140**		
		ECR	0.11	0.24	0.09	0.147	***-0.001*** ^{NS}	***NS***
HGR_{1-42}	**HFE %**	**RCR**	0.02	0.05	0.03	0.033		
		ECR- RCR	**0.09**	**0.19**	**0.06**	**0.110**		
		ECR	0.01	0.22	0.01	0.080	***0.000*** ^{NS}	***NS***
	S_3 %	**RCR**	0.01	0.01	0.02	0.013		
		ECR- RCR	**0.00**	**0.21**	**-0.01**	**0.067**		
		ECR	0.03	0.07	0.08	0.060	***0.250*** ^{NS}	***NS***
	S_6 %	**RCR**	0.01	0.02	0.001	0.010		
		ECR- RCR	**0.02**	**0.05**	**0.079**	**0.050**		

HBW_{42}: selected line for high body weight at 42 days of age, HGR_{1-42}: selected line for high growth rate from1 to 42 days of age.

NS: not significance, HTE %: calculated as a percentage of total eggs, HFE %: calculated as a percentage of fertile eggs, S_3 % and S_6 %: calculated during the first three and six weeks of age, respectively.

ECR: Expected correlated response, RCR: Realized correlated response.

b: regression coefficient for expected correlated responses on generation number and **: $P \leq 0.01$.

Fig. 4

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الانتخاب على المدى القصير لزيادة وزن الجسم ومعدل النمو فى السمان اليابانى
٢- الاستجابة المرتبطة

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استخدمت فى هذه الدراسة ثلاثة خطوط من السمان وذلك لتقدير الاستجابة المرتبطة للانتخاب لزيادة كل من وزن الجسم ومعدل النمو على صفات النمو والحيوية فى السمان اليابانى وهى خط HBW_{42} المشتق بالانتخاب لوزن الجسم العالى عند عمر ٤٢ يوم و خط HGR_{1-42} المشتق بالانتخاب لمعدل النمو الأعلى خلال الفترة من ١ إلى ٤٢ يوم من العمر وخط RBC وهو خط المقارنة المنسب المحتفظ به دون إجراء اى نوع من الانتخاب عليه.

وتتلخص النتائج المتحصل عليها فيما يلى:

كانت أعلى استجابات مرتبطة لأوزان الجسم فى الجيل الأول لصفتى BW_1 و BW_{35} ارتباطا بمعدل النمو الأسرع خلال الفترة من ٢١ إلى ٤٢ يوم من العمر. كانت أعلا نسب مئوية لصفات الخصوبة أو الفقس سواء كانت كنسبة مئوية من البيض الكلى أو البيض المخصب فى الجيل الأول من الانتخاب. كانت الاستجابات المرتبطة للانتخاب مطردة فيما بين الجنسين حيث أن الفروق للاستجابات المرتبطة بين الجنسين لم تكن ثابتة عبر ثلاثة أجيال من الانتخاب. حقق خط HBW_{42} أعلا قيم لكلا من صفات BW_{14} و BW_{21} و BW_{28} و BW_{35} و GR_{1-12} مقارنة بالخطوط الأخرى فى حين أن خط المنتخب HGR_{1-42} كان له أعلا وزن جسم عند أعمار ٧ ، ٤٢ يوم من العمر مقارنة بالخطوط الأخرى. وجدت فروق معنوية عند مستوى ٠.٠٥ لصالح خط HGR_{1-42} يتبعه خط HBW_{42} لكلا من صفات النسبة المئوية للخصوبة والفقس سواء كنسبة مئوية من البيض الكلى أو منسوبة إلى البيض المخصب. ولقد أشار المتوسط العام للاستجابات المرتبطة لثلاثة أجيال من الانتخاب لزيادة معدل النمو بين ١ إلى ٤٢ يوم من العمر إلى ارتفاع النسبة المئوية للزيادة فى أوزان جسم الذكور مقارنة بالإناث. ولقد تفوقت إناث هذا الخط عن مثيلتها فى الكنترول لوزن الفقس. بصفة عامة كانت الاستجابات المرتبطة المحققة لكل صفات النمو المدروسة فى الذكور موجبة وأعلا من الحسابات المتوقعة كما اختلفت الاستجابات المرتبطة المحققة لـBW_7، BW_{28} إحصائيا عن حساباتها المتوقعة. وكانت أعلا استجابة مرتبطة محققة لصفات وزن الجسم للإناث لصفة BW_{21} فكانت (٧.٢١ جم) لخط HBW_{42} و (٥.٨٦ جم) فى خط HGR_{1-42}. كانت الاستجابات المرتبطة المحققة اقل بصورة غير معنوية عن الحسابات المتوقعة لكل صفات الموائمة فيما عدا صفة الفقس كنسبة مئوية من البيض الكلى والتى أشارت إلى وجود فروق معنوية جدا عند مستوى ٠.٠١ لصالح الاستجابات المرتبطة المحققة كنتيجة للانتخاب لزيادة معدل النمو خلال الفترة من يوم حتى ٤٢ يوم من العمر.

يمكن التوصية بالانتخاب لمعدل النمو حيث انه أفضل من الانتخاب لوزن الجسم نظرا لعدم وجود اختلافات معنوية فى العائد الانتخابي لكلا منهما سواء لصفات النمو أو التناسل فيما عدا صفات نسبة الخصوبة ونسبة الفقس سواء منسوبة للبيض المخصب أو منسوبة للبيض الكلى والتى أشارت لاختلافهما معنويا بين الخطين ولصالح HGR_{1-42} وهو ما قد يعد ميزة نسبية إضافية وغير مباشرة من الانتخاب بهذا الخط.