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GENETIC IMPROVEMENT OF BODY WEIGHT AT EIGHT WEEKES OF AGE, FEED EFFICIENCY AT (4-8 WEEKS) AND GROWTH CURVE IN QUAIL

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ABSTRACT: *This experiment was carried out at the Poultry Farm of the Faculty of Agriculture, Minufiya University, Shebin El-Kom, Egypt. The experiment continued for four generations, (G0,G1, G2 and G3), through the hatching seasons of 2010-2011 and 2011 - 2012.*

The aim of the experiment was to study the genetic improvement for some economic traits in quails, during the growth period in quail population, also to increase body weight in different growth periods for increasing meat production in quails and in the same time improving feed efficiency during growth period (28 – 56 days).

Birds were selected according to independent culling level and each selected bird must have body weight at 8 weeks higher than the population by average ½ standard deviation and feed efficiency was chosen less than the population by average -½ standard deviation.

The following results were obtained :

A. The selected traits :

1. Selection for high body weight at 8 weeks of age had a positive effect on body weight at 8 weeks of age, body weight means were 245.62, 270.94, 283.32 and 292.10 g in the selected line (S) for Go, G1, G2 and G3 of selection, respectively.
2. The feed efficiency means were 3.43, 3.16, 3.06 and 2.13 (g feed / g body weight gain) in the selected line (S) for Go, G1, G2 and G3, respectively.
3. The rate of selection response per generation for body weight at 8 wks were 17.5 g / G. Higher realized heritability estimate was noticed (0.59). It was calculated as the ratio of cumulative selection response to the cumulative selection differential.
4. The rate of selection response for feed efficiency per generation was - 0.12 g. The realized heritability for feed efficiency was 0.23.
5. Growth curve equation :

Y = -8.350573 + 129.514638* Age.

Age = at hatch, 1, 2, 4, 6 and 8 weeks of age.

Weight and age at the inflection point (POI) were 119.49 g and age 28 days.

Key words: *Selection, body weight, feed efficiency, quails.*

INTRODUCTION

For many species of livestock, feed costs represent a major part of total production costs. Accordingly, improvement of feed conversion ratio (FCR), feed intake (I), weight gain (WG) should be a major objective in most breeding programs. For long time, genetic improvement was achieved as a correlated response to selection for increased growth rate. Now, there is a considerable interest on direct selection for feed utilization efficiency within the poultry industry. Feed conversion ratio(FCR) is usually measured as the ratio of feed intake to weight gain. Thus selection for improved (FCR) can either increase growth or decrease feed intake or both (Varkoohi *et al.* (2010).

The role of feed efficiency in allowing for the expression of genetic variation in growth is not fully understood. Although early work by Siegel and Wisman (1966) demonstrated a definite relationship between feed efficiency and genetic differences in growth, the general consensus has been that the growth rate of selected lines is associated with only a small increase in the efficiency of feed utilization (McCarthy and Siegel,

1983). However, Since most comparisons of feed efficiency involve birds of older ages or cover the entire period from hatch to market age consensus may contain certain biases.

The main goal of this study was to estimate the effect of selection for two traits (feed efficiency during 4 – 8 weeks and body weight at 8 weeks of age) in the same time with the independent culling method on the performance of Quail meat line under Egyptian conditions.

MATERIALS AND METHODS

This experiment was carried out at the Poultry Farm of the Faculty of Agriculture, Minufiya University, Shebin El-Kom, Egypt. The experiment continued for four generations, (G0,G1, G2 and G3), through the hatching seasons of 2010 - 2011 and 2011 - 2012.

The aim of the experiment was to study the genetic improvement for some economic traits in Japanese quails, during the growth period in quail population, also to increase body weight in different growth periods for increasing meat production in quails and at the same time improving feed efficiency during growth period (28 – 56 days).

Chickens stock and experimental design:

The base population (600 males and females) were divided into two lines. One line was selected for high body weight at 8 weeks of age and better feed efficiency at (4-8) weeks of age (S) and the second line was chosen at random from the base population (100) as a control line (C) for the selected line.

A total of 300 quails (150 males + 150 females) were selected for high body weight at 8 weeks of age and high feed efficiency at (4-8) weeks of age according to the selection equation. A total of 100 quails (50 males + 50 females) were used as a control with random mating for the selected line (S). Outline of the experimental design is given in Fig. (1).

Mating system and reproduction:

Mating system was applied in a ratio of one male with one female. Pedigree fertile eggs were collected from each dam and stored in cold room at 16 - 18º C for 7 days or less, with 80-90 % relative humidity.

Management procedures:

At hatching day, quails were wing-banded according to their families for identification. All chicks were brooded in floor brooders with wheat chaff litter. The starting brooder temperature was 35°C during the first week, then the brooder temperature decreased gradually from 2-3°C every week to reach 20-22°C at almost 42 days of age, and exposed to 24 hours of constant light during the first 6 weeks of age, then pullets were moved to individual cages in laying house, where the laying hens were kept under 16 hours light a day. All quails were kept under the same managerial hygienic and environmental conditions.

The quails were weighed weekly at 1,2,4,6 and 8 weeks of age. Live body weight, and weight gain during these periods were recorded. Feed efficiency was calculated from 4 – 8 weeks of age.

Water was available all time and all the experimental quails were fed *ad libitum* on a starter diet contained 24.30 % crude protein and 2826 Kcal ME/Kg diet then at 6 weeks of age the diet was changed by a layer diet contained 21.07 % crude protein and 2844 Kcal ME/Kg diet. Compositions of diet used are shown in Table (1).

Selection method :

Birds were selected according to independent culling level and each selected bird must have body weight at 8 weeks higher than the population by average ½ standard deviation and feed efficiency was chosen less than the population by average-½ standard deviation.

Estimated growth curve :

Data of individual body weights of quails were analyzed using the compertz model described by Ricklefs (1967).

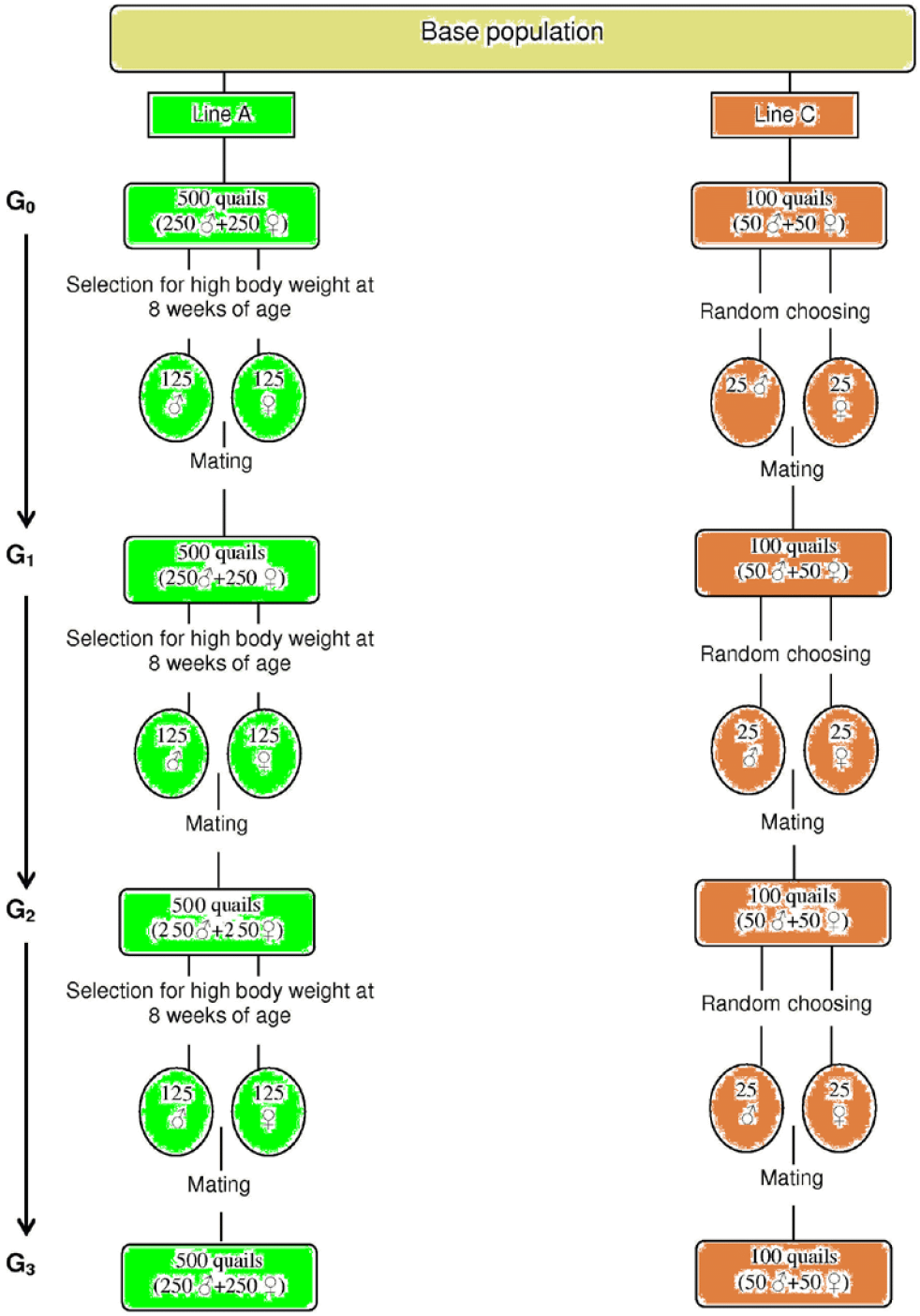

Figure (1) : Outline of the experimental design

Table (1): Composition of the experimental diets.

Ingredients	Starter diet	Layer diet
Ground yellow corn,8.8%	53.05	60.8
Soybean meal, 44%	44	35.7
Dicalcium phosphate	2.0	2.55
Salt (Na cl)	0.5	0.5
Vit. & min. Mix*	0.3	0.3
Methionine	0.1	0.1
Dl-Lysine	0.05	0.05
Total	100	100
Calculated values:		
Crude protein, %	24.03	21.06
ME, Kcal/Kg	2826	2844

* Each 2.5kg of vitamins and minerals mixture contain :
12000.000 IU Vitamin A acetate; 2000.000 IU Vitamin D_3; 10.000 mg Vitamin E acetate; 2000 mg Vitamin K_3; 100 mg Vitamin B_1; 4000 mg Vitamin B_2; 1500 mg Vitamin B_6; 10 mg Vitamin B_{12}; 10.000 mg Pantothenic acid; 20.000 mg Nicotinic acid; 1000 mg Folic acid; 50 mg Biotin; 500.000mg Choline; 10.000 mg Copper; 1000 mg Iodine, 300.00 mg Iron; 55.000 mg Manganese; 55.000 mg Zinc, and 100 mg Selenium.

The fertility and hatchability percentages were evaluated every generation and that for each generation .

$Y_t = A \exp(-B\exp(-Kt))$

Where **Y_t** is the body weight (g) of birds at t weeks of age (t = 0, 1, ……, 8); A, B and K are model parameters :

A is asymptotic weight when time goes to infinity; **B** is a scaling parameter (constant of integration), which is related with initial values of **Y**, and **K** is relative growth rate.

Weight and age at the inflection point (POI) were calculated as the following Ricklefs (1967).

$Y_1 = A / e$ and $t_1 = \ln(B) / K$; respectively.

The growth curve functions were fitted individually to the observed data by using a non-linear regression procedure with Marquardt algorithm (SAS, 1999).

The following traits were studied :

1. Body weight (BW): at hatch , 2 , 4, 6 and 8 weeks of age (g).
2. Feed efficiency from 4 - 8 weeks of age (g feed/g gain).
3. Growth curve.

Statistical Analysis :

Analysis of variance:

Recorded data were subjected to statistical analysis using SAS (The least squares and maximum likelihood general purpose program – mixed model LSMLMW (Harvey, 1990).

The following model was used :

$$Y_{ijk} = \mu + G_i + L_j + (G \times L)_{ij} + e_{ijk}$$

Where :

Y_{ijk} = The observation on l^{th} bird.

μ = The overall mean.

G_i = The fixed effect of i^{th} generation.

L_j = The fixed effect of j^{th} line within the i^{th} generation.

$(G \times L)_{ij}$ = The interaction between i^{th} generation and j^{th} line.

e_{ijk} = The random error assumed to be normally distributed with zero mean and variances σ_e^2.

Genetic Gain:

1. Actual genetic gain was calculated as deviation from the control line performance by equation given by Hill (1972) as follows :

$$\Delta G = (S_t - C_t)$$

Where : S and C are the means of selected and control lines in generation number (t).

2. Realized heritabilites were estimated according to Hill (1972) as follow :

$$realizedh \quad h_r^2 = \frac{R_t}{S_t}$$

Where:

R_1 = Cumulative response in generation (t).

S_1 = Cumulative selection differential in generation (t).

RESULTS AND DISCUSSION

Direct response to selection of body weight at 8 weeks of age and feed efficiency among (4-8) weeks of age:

According to model 1 analysis of variance was estimated (Table 2) for the selected traits; body weight at 8 weeks of age and feed efficiency among 4 – 8 weeks of age. The effect of generations were highly significant for both traits (P ≤ 0.01), also the effect of lines were significant for body weights (at 8 wks) and feed efficiency (4 – 8 wks) (≤ 0.05). Interaction effect (GxL) was not significant for body weights at 8 wks of age and highly significant for feed efficiency 4 – 8 wks of age) (P ≤ 0.01). Similar trend was noticed by Marks (1996), Farrag (2005) and Varkoohi *et al.* (2010).

Means of body weight at 8 weeks of age (BW8) are shown in Table (3). Selection for high body weight at 8 weeks of age had a positive effect on body weight at 8 weeks of age, body weight means were 245.62, 270.94, 283.32 and 292.10 g in the selected line (S) for Go, G1, G2 and G3 of selection, respectively. On the other hand, body weight at 8 weeks of age in the control line (C) were 231.01, 235.08, 239.57 and 239.36 g for Go, G1, G2 and G3, respectively. These values were higher than those obtained by Farrag (2005). This finding may be due to strain differences where Farrag study was applied on hohenheime strain which imported from west Germany by Soltan *et al.* (1987) and the present study was applied on Alexandria strain of Japanese quail college of Agriculture, Alex. University. Body weight means obtained in Table (3) were in agreement with those obtained by Shalan (2003).

In respect of means of feed efficiency among 4 – 8 weeks of age, Table (3) showed that feed efficiency means were 3.43, 3.16, 3.06 and 2.13 (g feed / g gain) in the selected line (S) for Go, G1, G2 and G3, respectively. In the control line (C), feed efficiency means were 3.90, 3.36, 3.49and 2.50 (g feed / g gain) for G0, G1, G2 and G3, respectively.

Table (4) illustrate cumulative selection differential and selection responses for both selected traits (BW at 8 weeks of age and feed efficiency during 4 – 8 weeks of age). The cumulative selection differentials for body weight at 8 weeks of age were 51.6, 73.0 and 90.2 g in G0, G1 and G2, respectively. Corresponding cumulative selection responses were 35.86, 43.75 and 52.74 g in G1, G2 and G3, respectively.

Table (2) : Analysis of variance for selected traits (body weight at eight weeks of age and feed efficiency among (4–8 weeks) according to generation, line and interaction effect.

Source of variations	d.f.	M.S. body weight at 8 weeks	d.f.	M.S. feed efficiency among (4 – 8 weeks
Geneations (g)	3	12139.826**	3	32.962***
Lines (L)	1	41726.284**	1	6.611*
Interaction (G*L)	3	7573150	3	1.413**
Error	1202	1892.875	487	0.185

Df = degree of freedom.

M.S. = Mean of squares for selected trait from ANOVA table.

* Significant (P ≤ 0.05)

** Highly significant (P ≤ 0.01)

Table (3) : Means of selected traits (body weight at eight weeks of age and feed efficiency at (4 – 8) weeks of age) among the generations (Mean ± S.E.)

Generation	Line	Body weight at 8 week of age	Feed efficiency at (4 – 8) weeks of age
0	S	245.62 ± 2.31[a]	3.43 ± 0.01[b]
	C	231.01 ± 2.52[b]	3.90 ± 0.03[a]
1	S	270.94 ± 1.35[a]	3.16 ±0.02[b]
	C	235.08 ± 1.27[b]	3.36 ±0.03[a]
2	S	283.32 ± 1.14[a]	3.06 ±0.03[b]
	C	239.57 ± 1.25[b]	3.49 ± 0.04[a]
3	S	292.10 ± 1.02[a]	2.13 ± 0.03[b]
	C	239.36 ± 1.22[b]	2.50 ± 0.03[a]

0 = Base population.
1,2,3 = First, second and third selected generation.
S = Selected line for high body weight at 8 weeks of age and feed Efficiency at (4-8) weeks of age.
C = Control line.
a, b = Values having the same superscript in each column within each generation are not significant at P ≤ 0.05.

Table (4) : Cumulative selection differential (ΔS) and selection responses (ΔG) for the selected traits, realized heritability (h^2) and rate of response per generation, (ΔG/G).

Generation	Selected traits							
	Body weight at 8 wks of age				Feed efficiency 4 – 8 wks			
	ΔS (g)	ΔG (g)	h^2r	AG/generation (g)/G	ΔS (g)	ΔG (g)	h^2r	ΔG/G (g)/G
0	51.6	--	--	--	-0.74	--	--	--
1	73.0	35.86	--	--	-1.02	-0.20	--	--
2	90.2	43.75	--	--	-1.59	-0.43	--	--
3	--	52.74	0.59	17.5	--	-0.37	0.23	-0.12

The rate of selection response per generation for body weight at 8 wks were 17.5 g / G. Similar values were found by Soltan (1984) and Farrag (2005). Higher realized heritability estimate was noticed (0.59) it was calculated as the ratio of cumulative selection response to the cumulative selection differential (Falconer and Mackay, 1996).

Soltan (1984) came to similar high realized heritability estimates and recently Farrag *et al.* (2008) and Farrag (2011).

In respect of feed efficiency, cumulative selection differentials were -0.74, -1.02 and -1.59 in G0, G1 and G2, respectively. Corresponding cumulative selection responses where -0.20, -0.43 and -0.37 g in G1, G2 and G3, respectively. Noticed that selection responses were -0.06, -0.05 and 0.08 in the individual as deviation between cumulative selection responses per generation, G2, G3 and G4, respectively when they selected only for feed efficiency from 1 to 28 days. The rate of selection response for feed efficiency per generation was -0.12 g .Varkoohi *et al.* (2010) found that the rate of response per generation was -0.03 g.

The realized heritability for feed efficiency was 0.23 (Table 4). This value was in agreement with those found by Soltan

(1984) and Soltan *et al.* (2009). But Varkoohi *et al.* (2010) calculated high realized heritability for feed efficiency from 1 day to 4 weeks of age. This may be due to time of estimation where feed efficiency in this work was estimated from 4 wk, to 8 weeks. Marks (1991) found similar trend in different estimation periods.

Calculated heritabilities for body weight at 8 weeks were ranged from 0.192 to 0.352 (Table 5) in different lines among generations. These values were in agreement with those obtained by Soltan (1984 and 1991), Farrag (2005) and Devi and Gupta (2012).

Calculated heritabilities of feed efficiency were ranged from 0.114 to 0.323 in different lines among different generations. Many authors were in agreement with those values such as Soltan, 1984, Soltan *et al.* (2009) and recently, Varkoohi *et al.* (2010).

These results obtained that using independent culling level as selection method for improving body weight at 8 weeks and feed efficiency during 4 – 8 weeks of age at the same time caused a positive and useful response for both selected traits body weight at 8 weeks of age and feed efficiency during 4 – 8 wks of age. Rate of realized responses per selected generation for both traits were +17.5 g for body weight at 8 weeks and -0.12 g feed /g gain (Table 4). These values were very important from the economic view according the feed costs and the net gain of body weight.

Growth curve :

The essential traits used in breeding program to increase poultry meat production are for live weight and feed consuming. In evaluation regarding growth, live weight measured in fixed ages, growth curves reveal line dependent non linear changes of the body or organ weight in birds. Growth curves usually express the growth achieved generally with 3 or 4 parameters and with the biologically interpretable values calculated from these parameters. There additive and non additive genetic variations between breeds, lines, individuals in terms of growth curve parameters (Akbas and Oguz (1998). Growth curve parameters and some values calculated from a model can be used as the selection criteria in index, independent culling and BLUP application in poultry breeding (Dogan Narnic *et al.* 2010).

Table (5) : Heritability estimates (calculated) (h^2 ± S.E.) for selected traits (Body weights at eight weeks of age (BW8) and Feed efficiency at (4-8) weeks of age) among the generations.

G	Line	Heritability estimates of selected traits	
		Feed efficiency at (4-8) weeks of age calculated	Body weight at eight weeks of age calculated
0	S	0.134 ± 0.156	0.220 ± 0.209
	C	0.195 ± 0.251	0.299 ± 0.216
1	S	0.223 ± 0.071	0.192 ± 0.134
	C	0.323 ± 0.192	0.259 ± 0.216
2	S	0.158 ± 0.122	0.352 ± 0.217
	C	0.271 ± 0.032	0.246 ± 0.260
3	S	0.114 ± 0.110	0.234 ± 0.113
	C	0.144 ± 0.160	0.288 ± 0.144

S = Selected line for high body weight at 8-weeks of age and feed efficiency at (4-8) weeks of age.
C = Control line.
G = Generation.

Table (6) and Figure (2) illustrate the growth curve and it was plotted in Fig. (2). Value of coefficient of determination was 0.82940, adjusted coefficient of determination 0.82938 with standard error of 33.39218. Constant value was -8.350573, and Beta value was 0.910716. The growth equation was :

Y = -8.350573, + 129.54638* Age

where : growth equation, Age = age at hatch 1, 2, 4, 6 and 8 weeks of age. These results were in agreement with those obtained by Balcioglu *et al.* (2005) and Dogan Narnic *et al.* (2010). Most of authors suggested that the growth rate parameter may be useful in selecting birds that have rapidly growth at early ages.

Table (6) : Curve fit for growth rates

Analysis of variance					
	DF	Sum of squares	Mean square		
Regression	1	40620320.8	40620320.8		
Residuals	7493	8354978.5	1115.0		
F = 36429.54468		Signif F = .0000			
Variables in the Equation					
Variable	B	SE B	Beta	T	Sig T
BW	129.514538	.678566	.910716	190.865	.0000
(Constant)	-8.350573	.755589		-11.052	.0000

Multiple R	.91072
R. Square	.82940
Adjusted R Square	.82938
Standard Error	33.39218

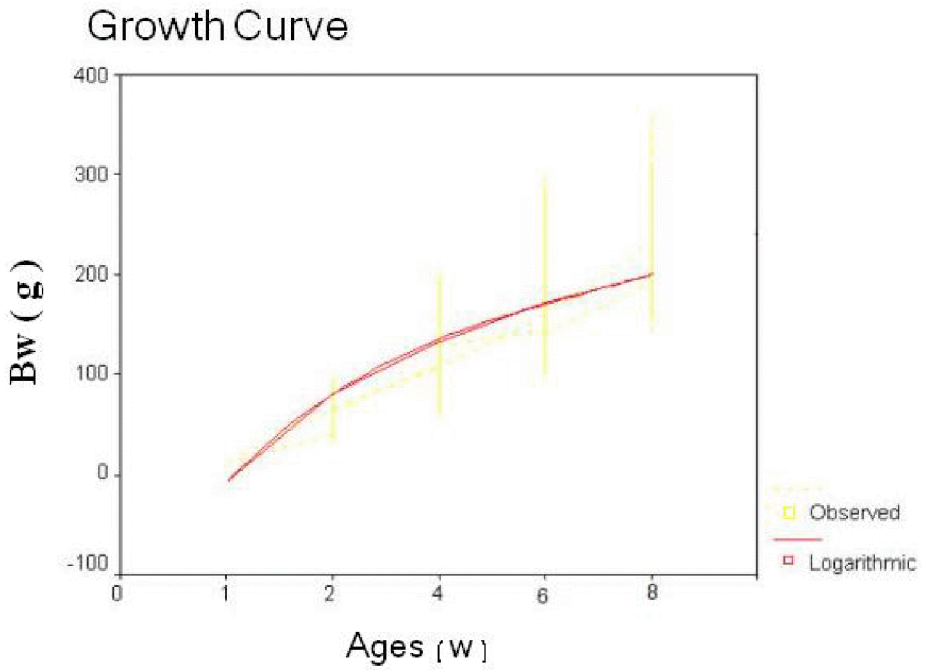

Figure (2) : Growth curve for selected birds for high body weights (S) at different ages compared to the control line (C).

Growth curve equation :

Y = -8.350573 + 129.514638 * Age.

Age = at hatch, 1, 2, 4, 6 and 8 weeks of age.

Weight and age at the inflection point (POI) were 119.49 g and age 28 days. Akbas and Yaylak (2000) found that age and weight at point of inflection were 22.7 days and 100 g. Similar finding was noticed by Akbas and Oguz (1998). But Hyankova *et al.* (2001) found that ages at inflection point of 15.8 to 17.9 days in male and female of control lines.

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التحسين الوراثي لوزن الجسم عند عمر 8 أسابيع والكفاءة الغذائية من 4 – 8 أسابيع ومنحنى النمو في السمان

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الملخص العربى

أجريت التجربة بمزرعة الدواجن – كلية الزراعة – جامعة المنوفية – شبين الكوم – مصر ، واستمرت التجربة لمدة 4 أجيال (الجيل الأساسي – الجيل الأول والثاني والثالث) خلال مواسم التفريخ 2011/2010 ، 2012/2011 .

الهدف من التجربة هو دراسة التحسين الوراثي لبعض الصفات الاقتصادية في السمان خلال فترة النمو في عشائر السمان وأيضا زيادة وزن الجسم في فترات مختلفة من النمو بهدف زيادة إنتاج اللحم في السمان وفي نفس الوقت تحسين الكفاءة الغذائية خلال فترة 28 – 56 يوم .

استخدمت طريقة الانتخاب تبعا للمستويات الاستبعادية المستقلة بحيث أن كل طائر منتخب له وزن جسم عند 8 أسابيع أعلي من متوسط العشيرة ½ وحدة انحراف قياسي وكفاءة غذائية أقل من متوسط العشيرة بـ – ½ وحدة انحراف قياسي .

وتمت دراسة الصفات التالية :

1 – وزن الجسم في أعمار الفقس ، 2 ، 4 ، 6 ، 8 أسابيع من العمر .

2 – الكفاءة الغذائية عند 4 – 8 أسابيع من العمر (جم غذاء / جم زيادة في وزن الجسم).

وكانت النتائج كالتالي :

أ – الصفات المنتخبة

1 – أدي الانتخاب لوزن الجسم عند عمر 8 أسابيع لزيادة (موجبة) في وزن الجسم عند عمر 8 أسابيع وكانت متوسطات الوزن 245,62 ، 270,94 ،283,32 ، 292,10 جم في الخط المنتخب لكل من الجيل صفر ، 1 ، 2 ، 3 علي التوالي .

2 – بلغت متوسطات الكفاءة الغذائية في الخط المنتخب 3,43 ، 3,166 ، 3,06 ، 2,13 جم غذاء / جم زيادة في وزن الجسم) في الأجيال صفر ، 1 ، 2 ، 3 علي التوالي.

3 – بلغ معدل الاستجابة للانتخاب لكل جيل لصفة وزن الجسم عند 8 أسابيع 17,5 جم / جيل . ولوحظ تقدير عالي للكفاءة الوراثية المحققة (h^2) 0,59 حيث حسبت كنسبة العائد الانتخابي المتجمع للفارق الانتخابي المتجمع .

4 – بلغ معدل الاستجابة للانتخاب لكل جيل لصفة الكفاءة الغذائية –0,12 جم / جيل . وكانت القيمة الوراثية المحققة 0.23

5 – معادلة منحني النمو :

$$Y = -8.350573 + 129.514638* Age.$$

وكان الوزن والعمر عند نقطة الانقلاب (POI) 119,49 جم ، 28 يوم علي التوالي .