DIRECT SELECTION RESPONSE FOR FEED EFFICIENCY OF EGG PRODUCTION

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ABSTRACT: *The present experiment was carried out in the Poultry Farm, Department of Poultry Production, Faculty of Agriculture, Minufya University at Shibin El-Kom, Egypt. The local strain used was Sinai Bedouin fowl. The experiments lasted for four years, starting from October 2004. The aim of the experiment was to study the effect of selection for high feed efficiency on laying Sinai hens.*

A base population consisted of 300 Sinai pullets aged 38 weeks were used to measure individually residual feed consumption (R) as will be mentioned later. Feed consumption (FC) was calculated as the difference between taken feed and residual feed.

To improve feed efficiency for egg production during 90 days (FE) mass selection was applied. Fifty hens were selected for high feed efficiency to be used as parents for next generation.

A total of 50 hens were chosen at random from the base population as a control line with no significant difference between control and the base line. In each generation 50 females and 17 males were chosen at random with aim to keep family size stable as possible in order to minimize the inbreeding, and mated randomly with expections full sib mating.

The following results were obtained :

1. *The means of the selected trait [feed efficiency (g F / 1 g egg)] for the selected line and control line were estimated among the base population and three selected generations 1, 2 and 3, respectively. In the selected line means of feed efficiency were 5.66, 5.63, 11.39 and 4.76 [(g) feed / 1 g egg) in base, 1, 2 and 3, generations, respectively. The corresponding values in control line were 6.66, 6.98, 11.91and 7.93 (g Feed / 1 g egg), respectively.*
2. *The differences between generations were highly significant. The difference between the selected line and control line was also highly significant. But the interaction between generations and lines was not significant.*
3. *The cumulative realized selection response in last generation was equal to – 3.17 g where the expected value was – 2.88 g and in the same generation the difference was equal to (- 0.25). These results illustrate the possibility of improving feed efficiency of Sinai Bedouin fowls during laying period by direct selection for more than 3 generations of individual selection method or by using selection indices, family selection and independent*

culling level for more rapid and high selection responses.

4. *It was noticed that the realized heritability was higher (0.75) than the calculated value (0.419) from dam component.*

Key words: Selection, Feed efficiency, Sinai fowl.

INTRODUCTION

Feed efficiency is an important trait to be improved to realize income over feed cost. Due to direct selection for increase egg production, improvement in feed conversion has been achieved in the commercial laying stocks. The improvement in feed efficiency is primarily due to increase in egg mass. Feed cost account for more than 70 % of poultry production cost and is a major input of poultry enterprise. Bentsen (1983) concluded that feed efficiency for egg production had a real genetic basis and information on food consumption should be incorporated in a selection programme, which should enhance genetic gain in egg production efficiency.

Feed conversion ratio may be improved by direct selection (Guill and Washburn, 1974; Pym and Nicholls, 1979) but measurement of this trait requires individual housing and food intake measurement. The most commonly used criteria for feed efficiency in laying hens are daily feed intake per hen, feed intake per egg, feed conversion (kg / feed / kg egg mass) and egg income minus feed cost (Flock, 1998). Also, the efficiency of feed conversion has been considerably improved by breeding programme of selection to increase egg production and to decrease hen's body weight through deliberate reduction of maintenance requirements.

In egg lines, feed efficiency depends mainly on body size and egg production of the hen. However, once individual differences of body weight, body weight changes, and egg production have been accounted for some variation in feed efficiency still remains between birds. This variation may be characterized by residual feed consumption (RFC) (e.g., Byerly *et al.*, 1980). Selection for higher egg production has also improved feed efficiency of laying birds, mainly because the amount of feed needed for maintenance remained almost constant while egg production increased.

Studies conducted by Soltan *et al.* (1985) indicated that means of egg number, egg weight, feed consumption (g / bird / day) and feed efficiency (g /g egg mass) were 20.7 eggs, 47.2 g, 67.47 g and 6.34 g, respectively.

The present work was conducted to study the effect of selection for high feed efficiency in Sinai fowl to improve feed efficiency during laying period as a direct response.

MATERIALS AND METHODS

The present experiment was carried out in the Poultry Farm, Department of Poultry Production, Faculty of Agriculture, Minufiya University at Shibin El-Kom, Egypt. The local strain used was Sinai Bedouin fowl. The experiments lasted for four years, starting from October 2004. The aim of the experiment was to study the response of selection for high feed efficiency of laying Sinai hens.

Flock history :

Sinai chickens were characterized by laying fewer eggs which were smaller in weight. The first study was conducted by Arad *et al.* (1975) during the occupation of Sinai by Israil.

This breed was compare to F1 cross bred from leghorn males X Sinai females. Additional information has been gathered concerning egg shell characteristic of the Sinai breed in comparison with White Leghorn as reported by Arad and Marder (1982 b). They concluded that Sinai egg shell is thicker and stronger than that of the Leghorn. The result of Arad and Marder (1982 a) reported that Sinai breed was more resistant to the extreme conditions of desert environment later on, Soltan *et al.* (1985) gave an economical study for this breed. He and his research team improved egg productions of this breed from 1985 till 2004 by using selection programs and egg number of this strain reached about 200 – 220 eggs per year. They indicated that means of egg number till 90 days of laying , egg weight, feed consumption (g / bird / day) and feed efficiency (g / g egg mass) were 20.7 eggs, 47.2 g, 47 g and 6.34 g, respectively. Soltan and El-Nady (1986) found that average body weight were 357.6, 486.6 and 711.6.9 for Sinai selected at 12, 16 and 20 weeks. Corresponding values for control line were 347.7, 510 and 717.7 g in the same respective order, they added that viability of Sinai selected chickens were 94.2, 92.9, 92.5, 89.3, 83.6 and 83.3 % at 8-12, 12-16, 16-20, hatch -12, hatch-16 and hatch-20 weeks of age, respectively.

Soltan and Ahmed (1990) showed that means of egg number, age at sexual maturity and egg weight of Sinai selected were 34.5 eggs, 186.6 days and 41.1 g. respectively. Corresponding values were 31.6 eggs, 211.9 days and 42.0 g for the control line. Soltan (1991 b) stated that, in general, selection is very important tool for breeders to select Sinai strains on the basis of partial records. Soltan (1992 a, b) investigated some phenotypic and genetic parameters of body reactions in Sinai fowl in order to utilize experimental data in breeding programs. He reported that Sinai fowl laid heavier eggs (43.3 g) compared to both Fayoumi (37.3 g) and Baladi (39.2 g).

Recently, Mahgoub (2002) reported that Sinai breed is adapted to high environmental temperature.

Experimental design and management :

Fig. 1 showed the experimental plan during 4 years. A base population consisted of 300 Sinai pullets aged 20 weeks were used to measure individually remain feed consumption. Precautions were taken to collect residual feed (*i.e.* the remainder feed; R). Feed consumption (FC) was calculated as the difference between taken feed and residual feed.

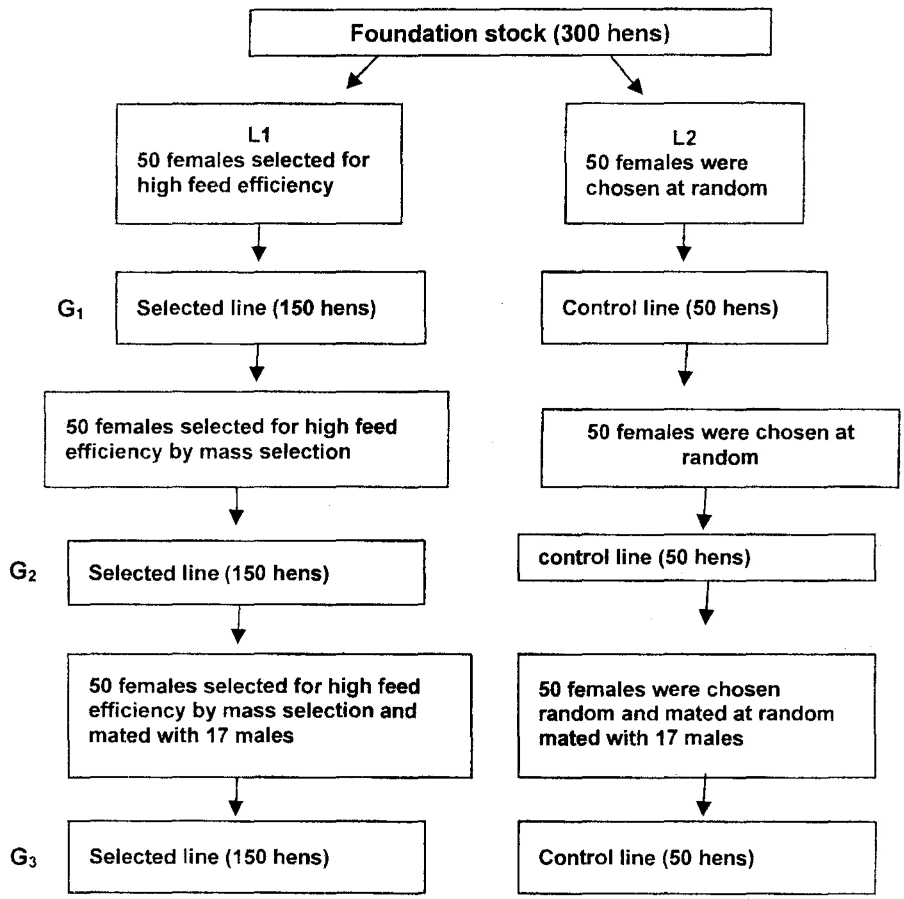

Fig 1 : Experimental plan

To improve feed efficiency for egg production during 90 days (FE) mass selection was applied. Fifty hens were selected for high feed efficiency to be used as parents for the next the generation.

A total of 50 hens were chosen at random from the base population as a control line with no significant difference between control and the base lines. In each generation 50 females and 17 males were chosen at random with aim to keep family size stable as possible in order to minimize the inbreeding effect according to Soltan (1984), and mated randomly with expections of the full sib mating.

Mating system was applied by collect semen from one sire to three dams. Insemination was done twice a week and two weeks before collecting hatching eggs. The semen used for the insemination was fresh and undiluted.

Chicks were brooded in floor brooder watered continuously and fed ad libitum during brooding period a diet (1) containing 21.1 % crude protein and 2734.6 ME/kg. kcal, then at 16 weeks the ration was changed by a layer ration containing 17.4 % crude protein and 2779.6 ME / kg. Kcal, the compositions of the two rations are given in Table (1).

Table (1) : Compositions of the experimental rations:

Ingredients	Starter ration	Layer ration
Ground yellow corn	57	65
Soybean meal	37	27
Limestone	1.8	2.5
Salt	0.5	0.5
Di-calcium phosphate	2	2.35
Bone meal	1.35	2.3
Methionine	0.1	0.1
Vitamin and mineral premix %*	0.25	0.25
Total kg	100	100
Crude protein	21.1	17.4
ME/kg. Kcal	2734.6	2779.6

* Pfizer premix provided per kilo gram of diets :-
10000 IU. Vit. A, 2000 1U. vit D_3, 2 mg vit-E, 3mg vit. B_3, 3mg vit.B_2, 10mg pantothenic, 250 mg cgholine, 25mg Fe, 10mg Mg, 2mg Cu, 1.2mg I and Co, 0.2mg.

At sexual maturity (*i.e.* 22 wk.), body weights were recorded at the beginning of the experiment. Precautions were taken to estimate the actual feed intake per hen using separate individual cages and more over enough distances between hens were provided to avoid mixed ration. Every week individual records were taken for egg production. Eggs were weighed 3 days every week (Saturday, Tuesday and Thursday). Feed intake weights were weighed 3 days weekly (700 g / hen / weekly). In base population, first, second and third generations. Feed residual were weighed every two weeks till the experiment period (90 days). Feed consumption was calculated for each individual hen as the difference between feed intake and feed residual. Body weights were weighed again at the finishing of the experiment.

Feed efficiency for egg production during the first 90 days of production was calculated according to :

$$\text{Feed efficiency (g feed / 1 g egg) (Selected trait)} = \frac{\text{Feed consumption}}{\text{Egg mass}}$$

Model (1) statistical analysis :

The least squares and maximum likelihood general purpose program – mixed model LSMLMW (Harvey, 1990) was used to estimate the values of heritability and phenotypic, genetic and environmental correlation for selected and control lines of Sinai fowl during 1st, 2nd and 3rd generations. The general random model utilized by (LSMLMW) was as follow :

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

Where

Y_{ijk} = the value of trait for K^{th} progeny from j^{th} dam.

1. μ = overall mean of the trait.
2. G_i = Fixed effect of the j^{th} generation.
3. L_j = the fixed effect of the j^{th} line within the i^{th} generation.
4. $(G\times L)_{ij}$ = the interaction between i^{th} generation and j^{th} line.
5. e_{ij} = Random error component, assumed to be normally distributed with zero mean and variances σ^2_e .

Heritability was estimated according to the method of Becker (1980).

σ^2_s = Sires component of variance

σ^2_D = Dams component of variance

σ^2_e = progeny within mating components of variance.

$$h^2_D = 4\,\sigma^2_D / (\sigma^2_D + \sigma^2_s + \sigma^2_e)$$

$$h^2_s = 4\,\sigma^2_s / (\sigma^2_D + \sigma^2_s + \sigma^2_e)$$

Expected genetic gain (ΔG_E) was calculated according to the formula given by Pirchner (1979). $\Delta G_E = S \times h^2$

Where :

S = selection differential (means of selected individuals – means of stock)

h^2 = heritability of the trait.

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).

Realized heritability were estimated according to Hill (1972) as follow :

$$\text{realized } h^2 = 2 \; \frac{R_t}{S_t}$$

Where :

R_t = cumulative response in generation (t)

S_t = cumulative selection differential in generation (t)

Rate of increasing of inbreeding per generation was calculated according to Falconer (1960) by the following formula :

$$\Delta F = \frac{1}{2Ne} \quad \text{where} \quad Ne = \frac{4N - 2}{2 + \sigma^2_K}$$

ΔF = Rate of increasing of inbreeding per generation.
Ne = Effective number of population.
N = Real population size.
σ^2_K = Variation of family size.

RESULTS AND DISCUSSION

Data in Table (2) showed the means of the selected trait [feed efficiency (g F / 1 g egg)] for the selected line and control line were estimated among the base population and three selected generations 1, 2 and 3, respectively In the selected line feed efficiency were 5.66, 5.63, 11.39 and 4.76 [(g) feed / 1 g egg) in base, 1, 2 and 3, generations respectively. The corresponding values in control line were 6.66, 6.98, 11.91and 7.93 (g Feed / 1 g egg), respectively. These values were in agreement with that obtained by Soltan (1984) and El-Neney (1996). It is clear that the means in selected line was reduced till generation 3 except in generation 2. In control line the means were approximately not more changed except in generation 2. The higher feed efficiency values in generation 2 may be due higher feed consumption and lower egg production in both lines . And this could be explained by environmental conditions or random error. Figure (2) showed this discrepancy. Falconer (1960) explanted this variation between the generations by sampling variation, depending on the number of individuals measured; and environmental change, which is usually the more important of the two.

Table (2) : Means of selected trait during test period in three selected generations (Mean ± SE)

Line	Generations			
	0	1	2	3
Selected line	6.6609 ± 0.348	5.63 ± 0.3630 b	11.39 ± 0.5100 a	4.76 ± 0.0782 b
Control line	6.6609 ± 0.8348	6.88 ± 0.8009 b	11.91 ± 0.8365 a	7.93 ± 0.3335 ab

0 = Base population
1, 2, 3 = First, second and third selected generations
a, b = Values having the same superscript in each row are not differed significantly at $P \leq 0.05$

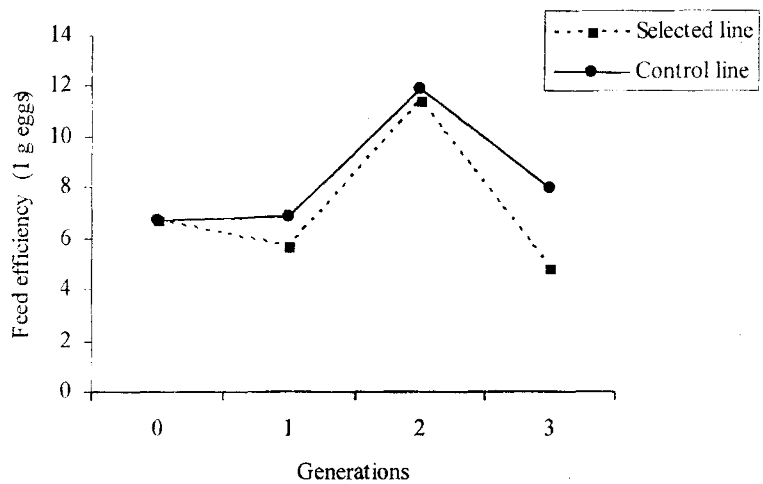

Fig. (2) : Means of Feed efficiency (g feed / 1 g eggs) among three generations in selected and control lines

Table (3) illustrated that the differences between generations were highly significant. The difference between the selected line and control line was also highly significant. But the interaction between generations and lines was not significant. Similar finding was noticed by Soltan (1984), El-Neney (1996), Bordas and Minvielle (1999), Flock and Tiller (1999), Hazary *et al.* (2002) and Reddy *et al.* (2004)

Table (3) : Analysis of variance of feed efficiency in three generations

Source of variations	df	M.S.
generations (G)	2	1461.733**
Lines (L)	1	296.672**
Interaction (G * L)	2	62.903
error	573	21.120

df = degree of freedom
M.S. = Mean of squares for selected trait from ANOVA table
* Significant ($P \leq 0.05$)
** Highly significant ($P \leq 0.01$)

Selection response :

Expected and realized selection differentials, selection intensity and selection response were presented in Table (4). It was indicated that the realized selection response for the selected trait feed efficiency was higher than the expected response except that obtained in generation 2. This may be due to lower egg production in this generation, which affected the performance of the selected trait. The cumulative realized selection response in last generation was equal to – 3.17 g where the expected value was – 2.88 g in the same generation the difference was equal to (- 0.25). These results illustrate the possibility of improving feed efficiency of Sinai Bedouin fowls during laying period by direct selection for more than 3 generations of individual selection method or by using selection indices, family selection and independent culling level for more rapid and high selection responses.

Table (4) : Expected and realized selection differential, selection intensity generation selection response of feed efficiency in three generations and rate of increasing of inbreeding

Generation	Expected			Realized			ΔF_1	ΔF_2
	ΔS	i	ΔG_1	ΔS	i	ΔG_2		
1	- 2.294	0.5	- 0.96	-1.79	0.39	-1.25	0.13 %	0.50 %
2	- 2.294	0.5	- 1.92	-3.97	0.87	-0.52	014 %	0.50 %
3	- 2.294	0.5	- 2.88	-2.66	0.58	-3.17	0.25 %	0.50 %

Δ.S. = Selection differential for selected trait
i = Selection intensity for selected trait
ΔG_1 = Expected selection response for selected trait
ΔG_2 =Realized selection response for selected trait
ΔF_1 = Rate of increasing of inbreeding in each generation in selected line
ΔF_2 = Rate of increasing of inbreeding in each generation in control line

Figure (3) illustrates the expected and realized selection response for feed efficiency among three generations and also selection differential which differed from one generation to another according to the realized selection intensity in each generation which was affected by population size, the fertility and hatchability of the selected hens to produce the next generation. Similar finding was obtained by Soltan (1984) and Soltan (1991 b). The magnitude of the selection differential depended on two factors; the proportion of the population included among the selected group and the phenotypic standard deviation of the selected trait. The standardized selection differential (S/σ_p) was called the intensity of selection. Table (3) illustrates values of selection differentials and selection intensities among generations.

Data presented in Table (5) showed the calculated heritabilities according to dam and sire components. It was noticed that the realized heritability was higher (0.75) than the calculated value (0.419) from dam component. Similar high values were noticed by Khosravinia *et al.* (1999), Sabri and Abdel-Warith (2000 a, b), Reddy *et al.* (2004) and Dymkov *et al.* (2006). The selected trait had a higher heritability estimates and this may be due to the effect of the higher additive variance of this trait (Table 5) and high correlation with body weight and egg number. Joshi *et al.* (1949) showed that only 27 % of feed consumed was used for egg production, while 41 % was used for body maintenance. Similar finding was obtained by Wing and Nordskog (1982 a and 1982 b), Prichner (1985). Rate of increasing the inbreeding coefficient was obtained in Table (5) and Fig. (4) according to Falconer (1960). In control line one female and one male were chosen at random in each generation so, family size (σ^2K) was equal zero [Gowe *et al.* (1959) and Soltan (1984)]. Therefore, inbreeding coefficient was at minimum rate, and this will lead to more accuracy of determining the realized selection response. In selected line, the rate of increasing the inbreeding coefficient lower than 1 % in each generation. They were 0.12, 0.14 and 0.25 in the first, second and third generations, respectively. So, the performance of the selected line was not affected by inbreeding. Similar trend was marked by [Soltan (1984) and (1992a)].

Table (5) : Calculated and realized heritability and additive variance (σ^2A) of feed efficiency and additive genetic standard deviation for selected trait

$h^2 \pm$ SE			Additive variance
Calculated		Realized	
h^2D	0.419 ± 0.383	0.75	11.967
h^2S	1.787 ± 0.295		

σ^2A = Additive variance for selected trait.
h^2D = Heritability was estimated from dam observational components.
h^2S = Heritability was estimated from sire observational components.

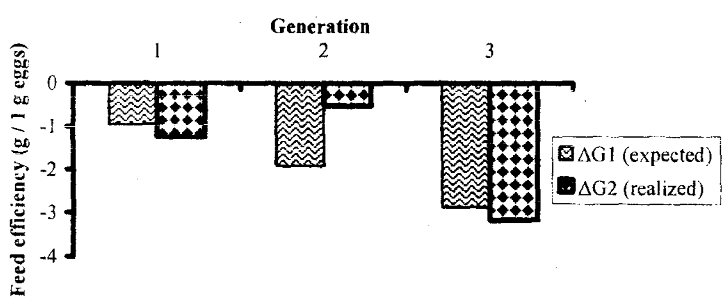

Fig. (3) : Expect (ΔG1) and realized (ΔG2) selection responses of feed efficiency (g feed / 1 g eggs) among three generations.

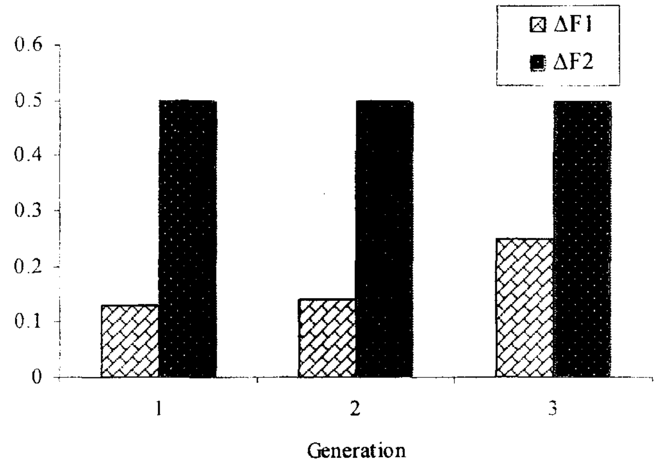

Fig. (4) : Increasing of inbreeding among three generations in selected and control lines.

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الاستجابة المباشرة للانتخاب للكفاءة الغذائية لإنتاج البيض

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الملخص العربي

أجريت هذه الدراسة بمزرعة الدواجن – قسم إنتاج الدواجن – كلية الزراعة جامعة المنوفية – شبين الكوم – مصر .

استخدم لهذه الدراسة السلالة المحلية دجاجة سيناء (دجاج البدو) ، واستمرت التجربة لمدة أربعة سنوات من بداية أكتوبر ٤٠٠٢ ، وتهدف هذه التجربة إلي دراسة تأثير الانتخاب للكفاءة الغذائية العالية (جم غذاء / ١ جم بيض) في إناث دجاج سيناء البياض .

تكونت العشيرة الأساسية من ٣٠٠ دجاجة في عمر ٢٠ أسبوع وتم تقدير كمية الغذاء المستهلك عن طريق حساب كمية الغذاء المقدمة وكمية الغذاء المتبقية .

استخدمت طريقة الانتخاب الإجمالي لتحسين الكفاءة الغذائية لإنتاج البيض خلال الـ ٩٠ يوم الأولي ، وكل جيل انتخابي يتم انتخاب ٥٠ أنثي من حيث الكفاءة الغذائية العالية لإنتاج أفراد الجيل التالي .

وتم اختيار ٥٠ أنثي من العشيرة الأساسية عشوائيا لتكوين خط المقارنة ، وفي كل جيل يتم الاحتفاظ بـ ٥٠ أنثي و ١٧ ذكر عشوائيا بهدف المحافظة علي حجم العائلة ثابتا بهدف تقليل تأثير التربية الداخلية لأقل حد ممكن وتزاوجت عشوائيا مع استبعاد تزاوج الأخوة الأشقة وأنصاف الأشقاء .

النتائج المتحصل عليها كانت كالتالي :

١ – قدرت متوسطات الصفة الانتخابية (الكفاءة الغذائية جم غذاء / لكل واحد جرام بيض) لكل من الخط المنتخب وخط المقارنة عبر العشيرة الأساسية وثلاثة أجيال انتخابية علي التوالي . كانت الكفاءة الغذائية في الخط المنتخب ٥,٦٦ ، ٢,٦٣ ، ١١,٣٩ ، ٤,٧٦ في كل من العشيرة الأساسية والجيل الأول والثاني والثالث علي التوالي .

٢ – الفروق بين الأجيال الانتخابية في الصفة الانتخابية كانت عالية المعنوية . وأيضا الفروق

بين الخط المنتخب والخط المقارن كانت عالية المعنوية ، بينما كان التداخل بين الأجيال والخطوط غير معنوي .

٣ - بلغ العائد الانتخابي المتجمع في الجيل الأخير -٣,١٧ جرام بينما كانت القيمة المتوقعة له -٢,٨٨ جرام في نفس الجيل وبلغ الفرق بينهم -٠,٢٥ جرام وهذه النتائج توضح إمكانية تحسين الكفاءة الغذائية لدجاج سيناء البياض خلال فترة إنتاج البيض بواسطة الانتخاب المباشر لأكثر من ثلاثة أجيال انتخابية بالانتخاب الفردي أو يمكن استخدام الأدلة الانتخابية أو الانتخاب العائلي أو مستويات الاستبعاد المستقلة لتحقيق عائد انتخابي سريع وعالي .

٤ - لوحظ أن الكفاءة الوراثية المحققة للصفة الانتخابية كانت عالي (٠,٧٥) عن القيمة الوراثية المحسوبة من المكونات الأسية (٠,٤١٩) .