U.A.R. J. Anim. Prod., Vol. 10, No. 1, pp. 55-63 (1970).

THE EFFECT OF SELECTION FOR HIGH BODY WEIGHT AND HIGH NUMBER ON GENETIC AND PHENOTYPIC VARIATION IN TWO STRAINS OF FAYOUMI CHICKENS

By

M. A. EL-HOSSARI *

Two selection experiments were carried out on two strains of Fayoumi chicken, one to increase body weight at 8 weeks of age in seven generations, and the other to increase egg number to the first of January in five generations. The phenotypic and the genetic variation before and after selection were studied.

In the first strain, selection for high body weight decreased the phenotypic variation in body weight measurements; at 4 weeks, 8 weeks, and at 12 weeks of age, while the genetic variance of these traits had a tendency to be increased. Similarly in the second strain, selection for high egg number decreased the phenotypic variation in egg number measurements; to 21 weeks after the first egg, to 12 months of age, to January the first and to June the first, while the genetic variance were increased.

The increase in genetic variance might be attributed to the transformation of potential into free variability due to additive selction.

It is generally assumed that additive selection for s particular character leads to more uniformity in performance. This is due to the exhaustion of the genetic variability and hence, the phenotypic variability may be decreased. Lerner (1950) however, reported that selection might increase genetic variability. He suggested that selection does not create such new genetic variation, but may aid in the transformation of potential into free variation. "Selection may utilize the variability already present in the population by changing gene frequencies and by creating new genotypes from the genes already present through a re-sorting of whole chromosomes and through picking a more desirable cross-over types within a chromosome pair".

Mather and Harrison (1949), on Drosophila, reported that genetic variance was increased in the selected character due to the release of potential variability.

The phenotypic variability of a population may be changed according to the degree of heterozygostiy, less variance is in heterozygotes than in homozygotes (Wigan, 1944 and Prevesti, 1953). This is because the heterozygotes are less susceptible to uncontrolled environments than the homozygotes (the phenotypic extremes).

* Animal Production Dept. Ministry of Agric. Cairo, U.A.R.

Selection is towards the fixation of desirable genes. If a character in a random population is controlled by a desirable allele (A), the genotype frequency will be (AA : Aa : aa). Selection increases the frequency of (A) in the population. That is to say, it increases the genotypes (AA) and (Aa) and decreases the genotype (aa). In this case, if the increase is more in genotypes (Aa) "The heterozygous advantage" than in the genotypes (AA) "the homozygotes", the phenotypic variance is expected to be decreased. On the other hand, if the increase is more in genotypes (AA) "additive effect" than in genotypes (Aa) and the rate of increase is equal to the rate of decrease in genotypes (aa), the phenotypic variance may be unchanged. Since the chance of releasing potential variability is more in heterozygotes than in homozygotes (Mather and Harrison, 1949), the genetic variability may be increased, though the phenotypic variability has been decresed.

Therefore, the effect of selection on genetic and phenotypic variance depends on genotype frequency and on the type of genes which govern the selected characters in a particular population.

Some workers found that after many generations of selection for a certain trait, the degree of uniformity of this particular trait was not satisfactory and less than expected theoretically. On chickens, Maloney (1963) found that selection for high body weight at 12 weeks of age decreased the phenotypic variance but not as desired. This is also supported by Ideta and Siegel (1966).

The relationship between genetic and phenotypioc variation and the roles of their behaviours during selection procedure are still a matter of argument. More explanation in poultry are needed to clarify such phenomena. In this paper, the genetic and phenotypic variance before and after selection were discussed in two strains of Fayoumi chickens; one selected for high body weight and the other for high egg number.

Material and Method

Two strains were established by selection from a Fayoumi flock. Individual selectin was carried out in the "growth strain" to increase body weight at eight weeks of age, and full-sibs family selection was practiced in the "production strain" to increase egg number to the first of January. Records were collected over seven generations of selection in the former strain and five generations in the latter.

A randombred control (unselected population) was also established since the beginng of selection experiments and its performance was recorded for comparisn and to estimate the genetic gains more accurately.

Before selection, a random sample of 650 day- old chicks was taken from a Fayoumi flock in Fayoum Poultry Experimental station. The chickes were weighed every four weeks to twelve weeks of age. The performance of 1258 selected chicks were recorded in the second generation. The data for analysis was taken from 486 pedigree pullets mated rondomly.

At the end of selection 1402 day - old chicks taken from the growth starain, were weighed every four weeks to twelve weeks of age. The flocks' size from which the rusults were obtained after selecton were about, 600 pullets for the growth strain, 800 pullets for theuction strain and 500 pullets for the randombred control.

The average selection differential per generation for body weight at eight weeks of age during the selection periods was 100.8 grams, and for egg number to the first of January was 17.33 egggs.

The traits studied :

Simbol	*Trait*
4. WK.	Body weight at 4 weeks of age.
8. WK.	Body weight at 8 weeks of age.
12. WK.	Body weight at 12 weeks of age.
S.M.	Age at sexual maturity (age at first egg)
M.B.W.	Body weight at sexual maturity
M.E.W.	Egg weight at sexual maturity
12 E.W.	Egg weight at 12 months of age.
Pause 5.	Number of unproductive days during five months (December to Aprel).
P_1	Egg number to 21 weeks after the first egg.
P_2	Egg umber to 12 months of age.
P_3	Egg number to the first of January.
P_4	Egg number to the first of June·

Method of Analysis

(*a*) The phenotypic variance was expressed in two ways, before and after the selection experiments :-

1. The standard deviation of the population (S.D.)

2. The coefficient of variance percentage. (C.V.)

(*b*) The genetic variance was measured as, the heritability × Phenotypic variance, of the trait before and after selection. ($\sigma^1 G = h^2 \times \sigma^2_P$).

The heritabilities were estimated by these ways :-

I. Analysis of variance (full-sib correlation). Before analysis, the data were adjusted to their hatch mean (El-Hossari 1966).

2. The realised h^2 (Facloner 1960) :

(*a*) The realised h^2 for the selected trait $(h^2_x) = \frac{\Delta \bar{G}}{i}$

where $\Delta \bar{G}$ is the gentic gain per generatin for the selected trait, and is the selection differential per generation.

(b) The realised h^2 for correlated trait. (h^2_y) for individual selection in the growth strain

$$h^2_y = \left(\frac{\Delta \bar{G}\ y}{\Delta \bar{G}x}\right)^2 \cdot \frac{\sigma^2_x}{\sigma^2_y} \cdot \frac{h^2_x}{r_G}$$

for faimiy selection in the production strain

$$h^2_y = \left(\frac{\Delta \bar{G}\ y}{\Delta \bar{G}x}\right)^2 , \frac{\sigma^2_x}{\sigma^2_y} \cdot \frac{h^2_x}{r_G} \cdot \frac{n+1}{2+(n-1)\,h^2_x}$$

Where $\Delta\ \bar{G}_x$ represents the genetic gain in the selected trait (X)

$\Delta\ \bar{G}_y$ is the genetic change in the correlated trait not directly selected (y),

h^2_x and h^2_y are the hertiabilities of traits (X) and (y,)

σ^2_x and σ^2_y are the phenotypic variance,

r_G is the genetic correlation between trait X and Y and is the average size of dam family.

The genetic correlation was estimated by using analysis of covariance (El-Hossari 1961). The standard errors of the heritabilities and of the genetic correlations were derived according to the method shown by Falconer (1960).

The genetic gain for the direct responses ($\Delta \bar{G}_x$) and for the correlated responses ($\Delta \bar{G}_y$) were obtained from the difference between the performance of the randombred control (R) and the performance of the strain after the period of selection.

Results and Discussion

Table I. represents the phenotypic variance measured as standard deviation and as coefficient of variance percentage for the different trait studied in the original flock (F_o) before selection, in the randombred control (R), in the growth strain (strain G) and in the production strain (strain P) at the end of the selection experiments.

It is obvious that selection for 8 - week body weight in the growth strain has decreased the phenotypic variance in early body weights. There is consistent difference between the coefficients of variation of the growth strain and the tandombred control, as well as the original flock. However, the difference does not appear to be important in the egg production traits except in pause duration and in egg weight at sexual maturity which show considerable increase in variability. Maloney *et al* (1963) also found that selection for high body weight at 12 weeks of age for ten generations caused the coefficient of variance in body weight to become smaller.

The penotypic variance in growth were decreased in the later years and at the same time gain,due to direct or correlated responses to selection were increase and some of the observed responses exceeded the expected values

TABLE 1.—PHENOTYPIC VARIANCE IN THE DIFFERENT POPULATIONS

Traits	Origin Flock Before selection		Random Control Last generation		Strain G After selection		Strain P After selection	
	S. D.	C. V. %	S. D.	C. V. %	S. D.	C. V. %	S. D.	C. V. %
4 Wk. M (Grams)	30.63	21.72	38.46	23.55	36.55	16.75	—	—
F (,,)	28.21	20.82	32.59	24.80	34.49	17.86	—	—
8 Wk. M (,,)	83.23	21.95	105.10	24.64	101.24	18.00	—	—
F (,,)	85.04	25.69	89.52	26.05	83.17	17.32	—	—
12 Wk. M (,,)	127.67	18.56	165.49	23.08	162.06	16.47	—	—
F (,,)	126.43	21.21	112.21	18.78	132.57	16.46	—	—
SM. (Days)	39.42	17.69	34.54	17.30	44.20	18.02	35.78	17.75
M.B.W. (Grams)	205.00	13.61	206.21	14.87	246.34	13.82	194.46	13.91
M.E.W. (,,)	3.70	8.85	3.01	7.82	4.32	10.03	4.35	11.08
12 E.W. (,,)	3.12	6.58	2.37	5.26	2.43	4.90	2.09	4.11
Pause 5 (days)	38.25	78.20	35.84	72.64	42.36	88.07	24.82	103.72
P_1 (eggs)	—	—	16.86	52.41	21.20	49.65	16.95	31.55
P_2 (,,)	22.53	42.21	20.56	57.66	18.46	55.70	21.26	37.09
P_3 (,,)	24.99	64.24	18.96	61.22	14.42	62.24	19.69	47.25
P_4 (,,)	31.22	34.92	28.99	52.86	33.37	51.43	30.87	34.44

S.D. : Standard deviation.
C.V.% : Coefficient of variance percentage.
G : Growth strain.
P : Production strain.

(Ragab and Hossrai 1969). The decrease in variance was more marked in female than in male progeny for body weight at 8 weeks of age, the selection criterion used, while the observed gain was markedly larger than expected particularly in the last two generations for female progeny. This observation support the work of Hammond and Birds (1942) and Backer and Berge (1959) who found that better growing condition were the smaller in phenotypic varaince.

With respect to selection for egg number in the production strain, consistent significant decrease in phenotypic variablitiy was observed after five generations of selection, while considerable increase was shown in pause duration and in egg weight at maturity. However, variability in age at sexual maturity and body weight at maturity was little effected.

Table 2 shows the, estimates of the heritabilities of the different traits studied before and after slection.

TABLE 2. —HERITABILITY ESTIMATES BEFORE AND AFTER SELECTION

Traits	h^2 of the flock before selection (F_o)	h^2 after selection (analysis of variance)		Realized h^2	
		Strain G	Strain P	Str. G	Str. P
4W k. (Gm)	.390±.061	.519±.083	—	.446	—
8 Wk. (,,)	.388±.061	.405±.083	—	.438	—
12 Wk. (,,)	.434±.062	.417±.083	—	.428	—
M. B. W.	.403±.086	.552±.077	.356±.062	.379	.222
M.E.W. (,,)	.484±.088	.340±0.71	.286±.051	.374	.252
12.E.W. (,,)	.458±.088	—	—	—	.280
S.M. (Days)	.309±.084	.332±.085	.320±.062	.211	.255
Pauses (,,)	.254±.082	—	.303±.061	—	.543
P_1 (Eggs)	.151±.078	.444±.089	.343±.062	.323	.419
P_2 (,,)	.245±.081	.446±.089	.289±.059	.706	.276
P_3 (,,)	.233±.091	—	—	—	.402
P_4 (,,)	.200±.080	.210±.061	.283±.059	.233	.329

Table 3 shows the genetic gain in both strains due to selection. It also indicates the significant differences of the genetic and phenotypic variance abefore and after selection.

It can be seen that, in the growth strain, the genetic variance for body weight measurements (4 weeks, 8 weeks, 12 weeks and M.B.W.) were not decreased after selection for high body weight at 8 weeks of age (the difference between the h^2 estimates of Fo and strain G are insignificant). Actually they showed tendency to be increased. Similarly in the production strain the variance estimates of the egg production measurements were not decreased due to selection for high egg number but they were significantly incresed in P_1, P_3 and P_4. The h^2 estimates were also increased in pause 5.

Robertson and Reeve (1952) found also that the genetic variation was increased when they selected for wing and thorax length on Drosophila melanogaster. They suggested that the selected genes which could be fixed might have their effect on the character magnified the selection of modifying genes. This provides one possible explanation for rise in variance of a character after many generations of selection.

It can be also seen that the genetic variation in age at suxual maturity was not effected by selection in both selection experiments (strain G and P).

There was adecrease in h^2 estimates of body weight and egg weight measurements the production strain, while h^2 estimates were increaed in egg number measurements (P_1 and P_2) in the growth strain. Random drift could be a possible explanation for these observations.

Therefore, selection for 8-weeks body weight in the growth strain decreased the phenotypic variance in body weight measurements (4 WK, 8 WK and 12 WK.), while the genetic variance of these traits had a tendency to be increased. Similarly in the production strain, selection for egg number decreased the phenotypic variance in egg number measurements, while the genetic variances were increased.

TABLE 3.—GENETIC GAINS AND SELECTION EFFECT ON PHENOTYPIC AND GENETIC VARIANCE

Traits	Genetic Gains		*Gentic variance (σ^2G)			σ^2G		σ^2P	
	St. G	St. P	F_o.	St. G.	St. P.	St. G	St. P	St. G	St. P
4Wk. (Gm)	58.30	...	337.10	654.07	...	+	...	—	...
8Wk. (,,)	136.90	...	2746.86	3442.84	...	=	...	—	...
12Wk. (,,)	235.01	...	7005.50	9050.23	...	+	...	—	...
M.B.W. (,,)	396.40	11.50	16936.08	34386.36	13462.03	+	—	=	=
M.E.W (,,)	4.58	0.78	6.63	5.34	5.41	—	—	+	+
12E.W. (,,)	4.54	1.13	4.60	...	4.73	...	=	=	—
S.M. (Days)	45.79	1.93	480.17	448.61	409.67	=	=	=	=
Pauses (,,)	−1.23	−25.41	371.62	...	186.66	...	—	+	+
P_1 (,,)	10.53	21.65	76.58	199.55	93.44	+	+	=	—
P_2 (,,)	−2.52	21.66	124.36	160.33	130.63	+	=	=	—
P_3 (,,)	−7.80	10.70	145.51	...	189.12	...	+	=	—
P_4 (,,)	10.05	34.80	194.94	233.85	269.69	=	+	=	—

* : Genetic variance (σG) = Heritability (h^2) × Phenotypic variance (σ^2P).

\+ : The vairance is larger after selection than before selection.

— : The variance is smaller after selection than before selection.

= No significant difference between the variance.

The decrease of the phenotypic variation in both selection experiments might be due to more uniformity in performance as a result of selection as discussed above. The increase of the genetic variation is generally attributed to two reasons: 1. the presence of non - additive effect, 2. the transformation of potential to free variation.

The first reason, however, could be rejected in our case because there was no significant difference between the observed and the expeced responses to selection in both strains (Ragab and Hossari 1969).

It would be thenconcluded that, although the phenotypic variability was significantly decreased due to selection for high body weight and for high egg number, the genetic variation was not affected and shows tendency to be increased particularly in egg number characters.

These evidences indicate that sleection has released genetic variation, and further generations of additive selection on these two Fayoumi strains are suggested for more uniformity and for more imporvement in performance.

Acknowledgement

The auther wishes to express his thanks to Prof. M. T. Ragab, and to Dr. A. A. El-Itriby for their help in this study.

REFERENCES

BACKER, W. A., AND BERG, L. R. (1959).—"Effect of growth rate homozygostiy and heterozygosity of chickens on the sensitivety of experiments". *Poul. Sci.* **38** : 1234.

FALCONER, D. S. (1960).—"*Introduction to Quantitative Genetics*". Oliver and Boys Ltd. Great Britain.

HAMMOND J. C., AND BIRDS, H. R. (1942).—"Effect of nutrition on variability in the growth of chickens". *Poul. Sci.* **21** : 230.

HOSSARI, M. A. F. (1961).—"*The genetic analysis of a selection experiment of Fayoumi domestic fowl.*, M. Sc. Thesis, Univ. of London (June 1961).

——— (1966).—"The Fayoumi Domestic Fowl : (C) the heritability of some of the economic traits. *Agric. Res. Rev. Cairo*, Vol. **44** : 141.

IDTA, G. AND SIEGEL, P. B. (1966).—"Selection for body wieght at 8 weeks of age. I. Realized. heritabilities of unselcted traits. *Poul. Sci.* **45** : 923.

LERNER, I. M. (1950).—"*Population genetics and animal improvement*". Cambridge Univ. Press

MALONEY, M. A., GILBREATH, J. C., AND MORRISON, R. D. (1963).—"Two ways selection for body weight in chickens. I. The effectiveness of selection for twelve-week body weight". *Poul. Sci.* **42** : 326.

MATHER, K., AND HARRISON, B. J. (1949).—"The maniford effect of selection". *Heredity*, **3** : I, 131.

PREVOSTI, A. (1952).—"Variabilidad genica en una popblacion natural de Drosophila subobscura." *Genetica Iberica*, **4** : 95.

RAGAB, M. T., AND HOSSARI, M. A. (1969).—"*Selection for high egg yield and for rapid growth in a closed flock of Fayoumi fowl*". (Under press).

ROBERTSON, F. W., AND REEVE, E. (1952).—"Studies in quantitative inheritance. I. The Effect of selection of wing and thorax length in Drosophila melanogaster." *J. Genet.* **50** : 414.

WIGAN, L. G. (9144).—"Balance and potence in natural populations". *Ibid* : **46** : 150.

تأثير الانتخاب لزيادة وزن الجسم ولزيادة عدد البيض على التباين الوراثى والتباين المظهرى فى سلالتين من الدجاج الفيومى

للدكتور محمد على فتح الباب الحصرى *

الملخص

اجريت تجربتان للانتخاب الكمى فى سلالتين من الدجاج الفيومى ، كان الانتخاب فى الأولى لزيادة وزن الجسم فى عمر ثمانية أسابيع لمدة سبعة اجيال ، وفى الثانية كان الانتخاب لزيادة عدد البيض حتى أول يناير من موسم الانتاج لمدة خمسة أجيال ...

وقد حللت التجارب لدراسة التباين المظهرى والتباين الوراثى قبل وبعد عمليات الانتخاب .

ادى الانتخاب لزيادة وزن الجسم فى السلالة الأولى الى نقص التباين المظهرى فى المقاييس المختلفة فى عمر ٤ ، ٨ ، ١٢ اسبوع ، ولكن لم ينقص تبعا لذلك التباين الوراثى بل ظهرت بعض الأدلة على ميله نحو الزيادة .. وبالمثل ادى الانتخاب لزيادة عدد البيض فى السلالة الثانية الى نقص التباين المظهرى فى المقاييس لانتاج البيض الى ٢١ اسبوعا بعد النضج الجنسى ، الى ١٢ شهرا من عمر الدجاجة ، الى شهر يناير وكذلك الى شهر مايو من موسم الانتاج وأما التباين الوراثى لهذه المقاييس فقد زاد زيادة معنوية.

وتعزى الزيادة فى التباين الوراثى الى فك قيد التباين الوراثى الناتج من الجينات الموجودة فعلا بالسلالتين نتيجة للانتخاب الكلى .

* الادارة العامة للانتاج الحيوانى ـ وزارة الزراعة