

A genetic study of partial egg production records in a randombred *Fayoumi* flock

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Summary

A genetic study of the annual egg production and 23 different partial records was done on 950 *Fayoumi* pullets, daughters of 40 sires and 311 dams, belonging to the Faculty of Agriculture Cairo University. The partial records include the egg production till 40, 44, 48, 52 and 70 weeks of age using full trapnesting and partial trapnesting (3 days every week), together with the annual partial trapnesting record, beside the production during six fixed periods all in the first year of the bird's life (also using full and partial trapnesting).

Sire, dam and combined heritability estimates were computed for the 24 traits beside the genetic correlations between the annual full record and each of the 23 partial records.

Relative efficiencies of the genetic progress expected in the annual record using the different part records were studied. It was shown that the highest annual relative efficiency could be obtained by using for selection the production of the pullet during the 4 week period between 40 and 44 weeks of her age (trait D12). A selection index using the production from first egg to the age of 40 weeks (trait A1) beside trait D12 was shown to excel that of D12.

Introduction

Partial recording, during specific periods or till fixed ages early in the production life of the fowl, beside reducing the generation interval, may help increase the annual progress when breeding for egg production. The partial trapnest records may also be effected by trapnesting only a few days every week to decrease further the amount of labour needed to evaluate the experimental birds. The significance of using partial records depends of course on the size of correlated response gained in the annual egg production record.

A considerable amount of work has been done on partial recording and trapnesting (e.g. : OLIVER *et al.*, 1957; WHEAT and LUSH, 1961; WARING *et al.*, 1962; MORRIS, 1963; NORDSKOG *et al.*, 1967; KINNEY *et al.*, 1968; BOHREN *et al.*, 1970,

SENDHU and DEV, 1972; EMSLEY, 1973). Many of these studies showed that more genetic gain could be obtained in the full year egg production record when using partial records for the evaluation of animals. The objective of this work is to evaluate the necessary parameters of partial records in a randombred *Fayoumi* flock, in an attempt to seek the most economic method of recording that leads to the highest expected genetic gain in the annual egg production.

Material and methods

This work was carried out on the randombred *Fayoumi* flock belonging to the Faculty of Agriculture, Cairo University. The flock was not previously subjected to any kind of genetic selection. Forty males and 400 females were randomly chosen and divided into 40 groups each of one male and ten females. Nine weekly hatches were obtained during the period from mid January to mid March, 1974. The number of females actually contributing to the progeny used in this study was only 311. Individual daily egg production records were kept for each of 950 pullets of the progeny of these parents for a full year starting from sexual maturity. The following 24 traits were recorded for each individual (designations between brackets):

1. The total number of eggs laid till the ages of:

- 40 weeks (A1),
- 44 weeks (A2),
- 48 weeks (A3),
- 52 weeks (A4),
- 70 weeks (A5),

beside (A6); the complete annual egg production record (that is, the total number of eggs laid during a 365 day period from date of first egg).

2. The total number of eggs produced during the following periods of the first year of the bird's life:

- from 40 to 44 weeks of age (D12),
- from 44 to 48 weeks of age (D23),
- from 48 to 52 weeks of age (D34),
- from 40 to 48 weeks of age (D13),
- from 44 to 52 weeks of age (D24) and
- from 40 to 52 weeks of age (D14).

3. The number of eggs trapped in the first three consecutive days every week till the ages, or during the periods of the 12 traits described above. These traits will be given the same designations of the corresponding complete trapnesting traits using the lower case letters (thus, for instance, a1 stands for the 3-days-a-week record of the number of eggs laid by the pullet till 40 weeks of her age).

Data were all corrected for hatch effect (which proved to be highly significant in all traits except D12 and d12) before performing the hierarchical analyses of variances and covariances. Sire, dam and combined heritabilities were estimated for all the traits beside the combined genetic correlations between A6 and

the rest of the characters. The following table I shows the degrees of freedom and the k values of the analyses. The standard errors of the heritability estimates were calculated according to the method suggested by WOOLF (1961), and those of the genetic correlations were estimated by ROBERTSON'S (1959) formula.

TABLE I

Degrees of freedom and " k " values of the analyses
Degrés de liberté et valeurs « k » des analyses

Degrees of Freedom between			k values		
Sires	Dams / Sires	Progeny / dams / Sires	$k_1^{(1)}$	$k_2^{(2)}$	$k_3^{(3)}$
39	271	639	2.968	3.628	23.587

⁽¹⁾ k_1 = The coefficient of the dam component in the MS or MCP between dams within sires.

⁽²⁾ k_2 = The coefficient of the dam component in the MS or MCP between sires.

⁽³⁾ k_3 = The coefficient of the sire component in the MS or MCP between sires.

Results and discussion

I. — The means

The least squares means of the number of eggs laid by the fowl from first egg till the different ages used in this study are presented in table 2. The egg production of this *Fayoumi* base population is indeed low. As mentioned above, this flock has not been previously subjected to any kind of genetic selection. Starting from the age of 40 weeks it can be seen that the rate of egg production increased with the advancement of age till it reached its maximum during the period from 52 to 70 weeks of age (when the rate was 39 p. 100). It may be mentioned that the least squares mean of age at sexual maturity was 38 weeks (266.14 \pm 1.5 day), and thus the average age at which the bird completes its annual record may be taken as 90 weeks.

II. — The heritabilities

1. Egg production till different ages :

Sire, dam and combined heritability estimates (h^2_s , h^2_d and h^2_c resp.) of the number of eggs laid till the ages described above (the " A " and " a " traits) together with the amount of genetic and phenotypic variances are shown in table 3. The

TABLE 2

The least squares means (\pm S.E.) of the number of eggs laid till certain ages of the bird's life
Moyennes obtenues par les moindres carrés, pour le nombre d'œufs pondus jusqu'à certains âges

	The average number of eggs laid till the ages of:					
	40 weeks	44 weeks	48 weeks	52 weeks	70 weeks	A year from first egg
Complete trapnesting	6.12 \pm 0.31	12.77 \pm 0.42	21.92 \pm 0.50	32.69 \pm 0.58	82.01 \pm 0.91	119.77 \pm 1.02
3-days-a-week trapnesting	2.60 \pm 0.14	5.45 \pm 0.19	9.41 \pm 0.23	14.12 \pm 0.26	35.38 \pm 0.40	51.75 \pm 0.45

sire heritabilities of A1 and a1 (egg production till 40 weeks of age) are a little bit higher than the dam heritabilities. This was not the case in the other "A" or "a" traits in which the dam heritabilities were higher than the sire ones. The combined heritability estimates and the genetic variances increased in magnitude with the length of the recorded laying period till the age of 52 weeks. The combined heritability value of A5 (the number of eggs laid till 70 weeks of age) is a little bit lower than that of A4. Table 3 shows that the amount of genetic variance of A5 is almost double that of A4 (143.2 vs 74.5), and the lower heritability of A5 is due to the very high increase of the phenotypic variance. The same picture could be seen also with respect to a4 and a5. The combined heritability value of A6 (the complete annual record) is indeed low (0.09) and table 3 makes it clear that the amount of genetic variance of this character is almost the same as that of A4, and that the amount of phenotypic variance is about three times the corresponding amount of A4. Again an exact picture could be observed with respect to a6 and a4. The combined heritability of A6 is lower than most of the published comparable heritabilities (e.g., KING and HENDERSON, 1954; AMER, 1967; BOHREN *et al.*, 1970; ACHARYA *et al.*, 1971). But the value of combined heritability of A1 (egg production till 40 weeks of age) obtained in this study (0.176) is very much the same as those obtained by WARING *et al.* (1962) (0.19) and KINNEY and LOWE (1968) (0.18). Also, the h^2_c estimate obtained in this work for A4 (egg production till 52 weeks of age) (0.267) is very close to the estimate of 0.29 for egg production till 55 weeks of age obtained by WARING *et al.* (1962). The value of 0.28 for combined heritability was reported by KINNEY and LOWE (1968) for the number of eggs laid till 72 weeks of age, and is not much different from the estimate of A5 (number of eggs laid till 70 weeks of age) obtained in this work (0.21).

It might be of interest to note that the combined heritability values of the 3-days-a-week trapnesting records are all lower than the comparable values of the complete trapnesting records. All the "a" traits have less genetic variance (except a1) and more phenotypic variance compared to the corresponding "A" traits (that is; after multiplying the σ^2_g and σ^2_p of the "a" traits by 49/9).

TABLE 3

Sire, dam and combined heritability estimates (\pm S.E.) and the genetic (σ^2_g) (¹) and phenotypic (σ^2_p) variances of the number of eggs laid till certain ages

Estimations paternelles, maternelles et combinées de l'héritabilité (\pm écart-type) et variances génétiques (σ^2_g) et phénotypiques (σ^2_p) du nombre d'œufs pondus jusqu'à certains âges

I. — Full Trapnesting

Trait						
	A1	A2	A3	A4	A5	A6
h^2_s	0.179 \pm 0.082	0.163 \pm 0.081	0.152 \pm 0.082	0.098 \pm 0.073	0.071 \pm 0.065	— 0.035 \pm 0.042
h^2_d	0.174 \pm 0.143	0.251 \pm 0.148	0.356 \pm 0.155	0.436 \pm 0.161	0.346 \pm 0.157	0.213 \pm 0.153
h^2_c	0.176 \pm 0.077	0.207 \pm 0.078	0.254 \pm 0.080	0.267 \pm 0.080	0.208 \pm 0.077	0.089 \pm 0.070
σ^2_g	14.05	30.81	52.95	74.53	143.16	76.39
σ^2_p	79.69	148.77	208.64	278.91	687.50	855.97

II. — 3-days-a-week Trapnesting

Trait						
	a1	a2	a3	a4	a5	a6
h^2_s	0.177 \pm 0.082	0.163 \pm 0.080	0.183 \pm 0.085	0.143 \pm 0.079	0.113 \pm 0.072	0.005 \pm 0.047
h^2_d	0.159 \pm 0.142	0.203 \pm 0.145	0.234 \pm 0.147	0.320 \pm 0.152	0.272 \pm 0.151	0.150 \pm 0.148
h^2_c	0.168 \pm 0.076	0.183 \pm 0.077	0.209 \pm 0.078	0.231 \pm 0.079	0.193 \pm 0.076	0.077 \pm 0.069
σ^2_g	2.63	5.35	8.88	13.15	25.84	12.84
σ^2_p	15.61	29.27	42.59	56.88	134.19	166.31

(*) σ^2_g is taken as double the sum of the sire plus the dam components of variance.

2. — Egg production of different periods of pullet's production life:

Table 4 shows the sire, dam and combined heritability values together with the amount of genetic and phenotypic variances of the number of eggs laid during the different periods of the first year of the pullet's life (the "D" and "d" traits). It could be seen in all these traits that the dam heritabilities are higher than the

TABLE 4

Sire, dam and combined heritability estimates (\pm S.E.) and the genetic (σ_g^2) and phenotypic (σ_p^2) variances of the number of eggs laid during certain periods of the laying year

Estimations paternelles, maternelles et combinées (\pm écart-type) de l'héritabilité, et variances génétiques (σ_g^2) et phénotypiques (σ_p^2) du nombre d'œufs pondus durant certaines périodes de l'année de ponte

I. — Full Trapnesting

Trait						
	D12	D23	D34	D13	D24	D14
h^2_s	0.102 \pm 0.070	0.022 \pm 0.052	— 0.075 \pm 0.033	0.099 \pm 0.072	— 0.024 \pm 0.044	0.044 \pm 0.061
h^2_d	0.299 \pm 0.153	0.202 \pm 0.150	0.148 \pm 0.151	0.380 \pm 0.158	0.222 \pm 0.153	0.374 \pm 0.160
h^2_c	0.200 \pm 0.077	0.112 \pm 0.071	0.036 \pm 0.067	0.240 \pm 0.078	0.100 \pm 0.070	0.209 \pm 0.076
σ_g^2	4.23	2.36	0.80	14.37	6.36	24.05
σ_p^2	21.16	21.03	21.92	59.97	63.93	115.28

II. — 3 days-a-week Trapnesting

Trait						
	d12	d23	d34	d13	d24	d14
h^2_s	0.097 \pm 0.067	0.056 \pm 0.057	— 0.055 \pm 0.036	0.129 \pm 0.075	0.016 \pm 0.049	0.088 \pm 0.067
h^2_d	0.199 \pm 0.148	0.146 \pm 0.146	0.140 \pm 0.149	0.252 \pm 0.150	0.132 \pm 0.146	0.280 \pm 0.153
h^2_c	0.148 \pm 0.074	0.101 \pm 0.071	0.042 \pm 0.067	0.190 \pm 0.077	0.074 \pm 0.069	0.184 \pm 0.076
σ_g^2	0.70	0.49	0.23	2.45	1.04	4.55
σ_p^2	4.72	4.89	5.35	13.14	13.97	24.73

(*) σ_g^2 is taken as double the sum of the sire plus the dam components of variance.

sire estimates, and that the heritability estimates of the "D" traits are higher than the corresponding estimates of the "d" characters. The amounts of phenotypic variance of the number of eggs laid during the 4 week periods of D12, D23 and D34 are almost the same, but the genetic variance of the first period is markedly higher than the other two periods (4.2, 2.4 and 0.8 resp.). In the 8 week periods (D13 and D24) it could be seen that the amount of genetic variance of the number of

eggs laid in the first period (D13) is more than double that of the number laid in the second period (D24). The same holds true with respect to d13 and d24. It could also be observed that the records which include the egg production during the period from 40 to 44 weeks of age (D12, D13 and D14) showed all the highest sire, dam and combined heritability estimates, compared to the other three part records D23, D34 and D24. The same holds true also with respect to the "d" traits. The period of production that showed the lowest heritability values is that between 48 and 52 weeks of age.

III. — Genetic correlations and index efficiencies

I. — Genetic correlations with the annual record:

Table 5 shows the genetic correlations and genetic covariances between A6 and all the part records used in this study. The genetic correlation between A6 and a6 is complete. Among the other 22 part records, D23 showed the highest

TABLE 5

Combined genetic correlations (r_g) (\pm S.E.) and the genetic covariances (cog) (*) between the complete annual egg production record (A6) and the different part records

Corrélations génétiques combinées r_g (\pm écart-type) et covariances génétiques (cog) entre la ponte annuelle totale (A6) et les différentes mesures partielles

Trait . . .	A1	A2	A3	A4	A5	A6
r_g	0.727	0.810	0.815	0.746	0.828	1.00
cog	\pm 0.195 23.81	\pm 0.132 39.28	\pm 0.118 51.83	\pm 0.152 56.27	\pm 0.119 86.62	76.39
Trait . . .	a1	a2	a3	a4	a5	a6
r_g	0.578	0.720	0.666	0.700	0.780	1.001
cog	\pm 0.280 8.19	\pm 0.195 14.56	\pm 0.213 17.36	\pm 0.229 19.34	\pm 0.154 34.66	31.35
Trait . . .	D12	D23	D34	D13	D24	D14
r_g	0.861	0.935	0.568	0.846	0.771	0.757
cog	\pm 0.100 15.47	\pm 0.063 12.55	\pm 0.573 4.437	\pm 0.102 28.02	\pm 0.213 16.99	\pm 0.161 32.46
Trait . . .	d12	d23	d34	d13	d24	d14
r_g	0.872	0.456	0.477	0.663	0.536	0.598
cog	\pm 0.106 6.37	\pm 0.415 2.80	\pm 0.609 1.98	\pm 0.222 9.16	\pm 0.429 4.77	\pm 0.258 11.14

(*) Cog is taken as double the sum of the sire plus the dam components of covariance.

correlation with A6 ($r_g = 0.935$), and the following characters showed genetic correlations of more than 0.8 (in descending order): d_{12} , D_{12} , D_{13} , A_5 , A_3 and A_2 . The lowest r_g values were those between A6 and d_{23} , d_{34} and d_{24} ; the partial trapnesting records collected during the first year of the bird's life, during the periods that do not include the production of the period from 40 to 44 weeks of age.

2. — *Relative efficiency of selection on part records in improving the annual egg production:*

The significance of using part records depends upon the expected correlated response gained in the annual record (A6) by selection on the part records (FALCONER, 1961). The amount of correlated response in the annual record is equal to ($i \sigma_g r_g h_x$); where i is the selection intensity, σ_g is the genetic standard deviation of A6, r_g is the genetic correlation between the A6 and the record x and h_x is the square root of the heritability of trait x . The response to direct selection on A6 will then be $i \sigma_g h_{A6}$. The ratio of the response obtained by indirect selection on trait x to that gained by direct selection (that is; $r_g h_x / h_{A6}$) would show the relative efficiency (R. E.) per generation of the use of any part record in selection for A6. The part records, usually completed early in the production life of the pullet, is supposed to decrease the generation interval, and the relative efficiency per year would then be the best yardstick for comparison. To compute the value of the relative efficiency per year, 8 weeks will be allowed after the age at which the part

TABLE 6

Relative efficiency (R.E.) of selection on part records
Efficacité relative de la sélection sur enregistrements partiels

Trait (x)	Efficiency (1)	R.E. per generation (2) %	R.E. per year % (3)	Trait (x)	Efficiency (1)	R.E. per generation (2) %	R.E. per year % (3)
A1 . . .	0.305	102	209	a1 . . .	0.237	79	162
A2 . . .	0.368	123	232	a2 . . .	0.308	103	194
A3 . . .	0.411	138	241	a3 . . .	0.304	102	178
A4 . . .	0.386	129	210	a4 . . .	0.293	98	160
A5 . . .	0.378	127	158	a5 . . .	0.342	115	144
A6 . . .	0.299	100	100	a6 . . .	0.278	93	93
D12 . . .	0.385	129	243	d12 . . .	0.335	112	211
D23 . . .	0.313	105	183	d23 . . .	0.145	49	85
D34 . . .	0.104	35	57	d34 . . .	0.098	33	54
D13 . . .	0.414	139	243	d13 . . .	0.289	97	169
D24 . . .	0.243	81	133	d24 . . .	0.146	49	80
D14 . . .	0.346	116	189	d14 . . .	0.256	86	140

(1) Efficiency = $r_g h_x$; where r_g is the genetic correlation between trait x and A6.

(2) R. E. per generation = (Efficiency of trait x) / (Efficiency of trait A6).

(3) R. E. per year = R. E. per generation multiplied by $98/w_x$; where w_x is equal to 8 plus the age (in weeks) when the partial record x is completed.

record is completed (for the collection and hatching of eggs to produce the new generation), bearing in mind that A6 is completed at an average age of 90 weeks. Table 6 shows the relative efficiency per generation and per year for the part records used in this study. D12, D13, A3 and A2 give the highest expected yearly genetic gain in A6, followed by $dI2$, A4 and A1. The first six of these seven part records involve the production of the 4 week period between 40 and 44 weeks of age. The egg production of this period, with complete or partial trapnesting (D12 and $dI2$) would be very convenient part records for the breeder since he can produce one generation every year (52 weeks). These two traits, D12 and $dI2$, were also the only ones, among all the traits studied, which showed no significant hatch effect.

Selection indexes involving two or more of the discussed part records could be used to attain higher efficiency. The following index is the one adopted now for selection in the *Fayoumi* flock of the Faculty of Agriculture, Cairo University. It involves the A1 and D12 traits; that is, the A2 record divided in two pieces. The index equation to be solved was as follows:

$$\begin{array}{l} A1 : (79.69 \quad 23.96) \\ D12 : (23.96 \quad 21.16) \end{array} \quad \begin{pmatrix} b_1 \\ b_2 \end{pmatrix} = \begin{pmatrix} 23.81 \\ 15.47 \end{pmatrix}$$

(23.96 = the phenotypic covariance between A1 and D12, other figures are shown in tables 3, 4 and 5). The two regression coefficients are then

$$b_1 = 0.1196 \quad \text{and} \quad b_2 = 0.5957.$$

The accuracy (R) of the index (or the squared efficiency) is

$$R = \frac{(0.1196 \times 23.81) + (0.5957 \times 15.47)}{76.39} = \frac{12.065}{76.39} = 0.1579$$

where 76.39 is the genetic variance of A6. Thus the efficiency will be equal to 0.397 and the genetic standard deviation of the index will be 3.474 (the square root of 12.065). The relative selection efficiency of this index per generation is 134 p. 100 and per year is 252 p. 100. If we select 20 p. 100 of the pullets ($i = 1.4$) yearly using this index, the expected genetic superiority in A6 of the selected individuals will be:

$$\Delta_g = 1.4 \times 3.474 = 4.86 \text{ eggs,}$$

or about 4.1 p. 100 of the mean of A6. Half of this superiority is expected to be recovered in the progeny every year.

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Résumé

Étude génétique d'enregistrements partiels de la production d'œufs dans un troupeau de Fayoumi en panmixie

Une étude génétique de la production annuelle d'œufs et de 23 enregistrements partiels a été faite sur 950 poulettes *Fayoumi*, filles de 40 pères et de 311 mères, appartenant à la Faculté d'Agriculture, Université du Caire. Les enregistrements partiels comprennent la production d'œufs jusqu'à 40, 44, 48, 52 et 70 semaines d'âge avec trapnestage complet ou partiel (3 jours par semaine), la production annuelle estimée avec trapnestage partiel, enfin la production pen-

dant six périodes fixées dans la première année de vie de la poule (également avec trapnestage complet ou partiel).

Des estimations d'héritabilité basées sur le père, la mère et combinées, ont été calculées pour les 24 caractères, ainsi que les corrélations génétiques entre la ponte totale annuelle et chacune des 23 mesures partielles.

Les efficacités relatives, exprimées d'après le gain génétique prévu dans la ponte annuelle en utilisant les différents enregistrements partiels, ont été examinées. Il est montré que l'efficacité relative la plus élevée serait obtenue en sélectionnant sur la production de la poulette pendant la période de 4 semaines comprise entre les âges de 40 et 44 semaines (caractère D₁₂). Un index de sélection, utilisant la production depuis le premier œuf jusqu'à l'âge de 40 semaines (caractère A₁) et le caractère D₁₂, s'est révélé supérieur à D₁₂ seul.

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