

Genetic and phenotypic parameters of egg production and some constituents of blood serum in *Fayoumi* layers

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Summary

Out of 9 hatches, a total of 439 *Fayoumi* layers, ranging in age between 12 and 19 months, was used to study (1) egg production beside the following blood serum constituents: (2) inorganic phosphorus, (3) calcium, (4) glucose, (5) urea, (6) uric acid, (7) total proteins, (8) albumen, (9) cholesterol, (10) bilirubin, (11) alkaline phosphatase, (12) lactic dehydrogenase and (13) transaminase. These layers were the daughters of 40 sires and 241 dams. Blood serum analyses were done using the Sequential Multiple Auto-Analyser, SMA-12/60. The least squares mean of the number of eggs produced per layer till 70 weeks of age was 78. The least squares means of the forementioned blood serum traits were in respective order: (2) 5.55 mg p. 100, (3) 21.62 mg p. 100, (4) 196 mg p. 100, (5) 3.96 mg p. 100, (6) 5.66 mg p. 100, (7) 5.93 mg p. 100, (8) 0.71 mg p. 100, (9) 167.4 mg p. 100, (10) 0.36 mg p. 100, (11) 1.023 mu/ml, (12) 667 mu/ml, (13) 169.7 mu/ml.

Hatch showed statistically significant effects on all the characters studied except inorganic phosphorus, uric acid, total proteins and cholesterol. Age of the layer significantly affected all the blood serum traits except inorganic phosphorus, uric acid and total proteins.

Data were corrected for hatch effects, and, in case of the plasma traits, for age effect, before performing the hierarchical analyses of variances and covariances to evaluate heritabilities, genetic and phenotypic correlations. The combined heritability estimates of the characters studied were in respective order: (1) 0.224 ± 0.136 , (2) -0.057 ± 0.124 , (3) 0.656 ± 0.226 , (4) 0.639 ± 0.224 , (5) 0.401 ± 0.195 , (6) 0.752 ± 0.236 , (7) 0.114 ± 0.154 , (8) 0.561 ± 0.215 , (9) 0.197 ± 0.168 , (10) 0.187 ± 0.166 , (11) 0.732 ± 0.234 , (12) 0.625 ± 0.223 , (13) 0.622 ± 0.222 .

Significant genetic correlations (of at least ± 0.7) were found between egg production and all the blood serum traits except inorganic phosphorus and total proteins.

Introduction

Information on the genetics of the blood serum constituents in chicken may be valuable in breeding for high productivity. Some of the results reported indicate positive relationship between egg production and serum alkaline phosphatase

(GUTOWSKA, PARKHURST, PARROT and VERBERG, 1943; and WILCOX, VANVLECK and SHAFFNER, 1962). WILCOX (1966) selected for high level of alkaline phosphatase and found the egg production of the high line to be higher than the control in four generations out of five. Genetic relationship between serum alkaline phosphatase and body weight in chicken was studied by MATSUMOTO, TONOUE and OKADA (1960), OKADA and TSUTSUMI (1963) and WILCOX, VANVLECK and HARVEY (1963).

This experiment was undertaken to obtain information on blood serum constituents of the *Fayoumi* layers: their means, heritabilities and the genetic and phenotypic correlations between them, together with their relationships with egg production.

Material and methods

This work was carried out in the *Poultry Breeding Farm, Faculty of Agriculture, Cairo University*. A total of 439 *Fayoumi* layers produced in nine biweekly hatches starting 1st February and ending 31st May 1974, was used for this study. These layers represent 40 sire families and 241 dam families. Samples of blood were collected from the birds for chemical analysis during June, July and August 1975. The age of layers when blood samples were taken averaged about 70 weeks (488 days). About 7 cm³ of blood from each bird were taken from the wing vein in the morning (between 8 and 10 o'clock) before feeding. Blood was kept at 37 °C for 30 minutes and the serum was separated by centrifuging at 3,000 rpm for 20 minutes. Sera were analysed within two weeks of blood collection using the Sequential Auto-Analyser, SMA-12/60, of the Sahil Hospital, Cairo. Traits determined in the blood serum shall be treated in three groups:

- Group 1 : includes the following chemical and non-protein-nitrogen traits: inorganic phosphorus, calcium, glucose, urea and uric acid.
- Group 2 : includes the plasma proteins (total proteins and albumen), cholesterol and bilirubin.
- Group 3 : includes three of the blood serum enzymes, namely, alkaline phosphatase, lactic dehydrogenase and transaminase.

Egg production of the layers was taken as the number of eggs produced till the age of 70 weeks.

For statistical analysis, the model for each of the blood serum traits was taken as:

$$x_{ij} = \mu + a_i + b(y_{ij} - \bar{Y}) + e_{ij}, \text{ where;}$$

x_{ij} = the observation on the j^{th} individual of the i^{th} hatch group,
 μ = overall mean of x_{ij} when equal subclass numbers exist,
 a_i = the effect of the i^{th} hatch group,
 b = partial regression coefficient of x on age of layer,
 y_{ij} = age of the j^{th} layer of the i^{th} hatch group,
 \bar{Y} = the mean of the y_{ij} and
 e_{ij} = random error.

The same model, after dropping the regression term, was used for egg production. The overall means and the hatch means beside the partial regression coefficients were fitted by the least-squares analysis (HARVEY, 1960).

It may be of interest to note that the cycle of egg formation was thought first to be one of the factors affecting the blood serum traits. This cycle was measured by the time the hen lays its egg within the 24 hours following blood sampling. However, this factor proved to be statistically insignificant and explained almost nothing of the variance in all the serum traits without exception, and thus was dropped from the model.

Data were corrected for hatch effects and, in case of the plasma traits, for age effect. The hierarchical analyses of variances and covariances were then done on the corrected data to compute the heritabilities of the characters and the genetic and phenotypic correlations between them. The coefficient of the dam component of variance was 1.760 in the M.S. between dams within sires and 2.128 in the M.S. between sires. The coefficient of the sire component of variance in the M.S. between sires was 10.943. Heritabilities and genetic correlations were estimated using combined sire plus dam components.

Results and discussion

I. — *The means*

The overall means (\pm S.E.) and the means of the nine hatches (\pm S.E.) for egg production and the three groups of blood serum characters studied, beside the partial regression coefficients (\pm S.E.) on age at blood sampling are given in Tables 1, 3 and 5. The analyses of variances of these characters are shown in Tables 2, 4 and 6.

Estimates of the means of the blood serum traits studied have been reported by SHIMER (1937), STURKIE and NEWMAN (1951), TAPPER and KARE (1960), McDANIEL and CHUTE (1961), WILCOX (1966), WEISS, JOHNSON and NABER (1967), ESTEP, FANGUY and FERGUSON (1969), BELL and FREEMAN (1971), STURKIE (1976) and others. Whenever estimates are comparable, it can be seen that the *Fayoumi* means are not much different from those reported in different breeds.

Highly significant effects of hatch are clear in all characters except inorganic phosphorus, uric acid, total proteins and Cholesterol. Late hatches showed in general lower means than earlier hatches. This was clear in all the characters significantly affected by hatch except calcium and lactic dehydrogenase, in which the means increased in the late hatches.

The regression on age at blood sampling showed significant effects on nine of the blood serum traits and had no effect only on inorganic phosphorus, uric acid and total proteins (hatch had no effect also on these three traits). Examining the sign of the regression coefficients, it can be seen that the level of calcium and lactic dehydrogenase in the blood serum increased by the advancement of age, while the levels of the other seven serum traits affected significantly by age, decreased. The amount of variance explained by regression in each of the nine traits affected by age is tremendous indeed. This would suggest that, for genetic studies of these blood serum characters, age must be corrected for, even within the range of layer ages of this study (ca 12-19 months).

TABLE I
Least-squares means (± S.E.) of egg production, blood serum chemical traits and plasma non-protein-nitrogen traits
Moyennes estimées par les moindres carrés, pour la production d'œufs, les paramètres chimiques du sérum sanguin et l'azote non protéique du plasma

Classification	N	Egg production	Inorganic phosphorus (mg %)	Calcium (mg %)	Glucose (mg %)	Urea (mg %)	Uric acid (mg %)
Overall mean . . .	439	77.88 ± 2.047	5.55 ± 0.087	21.62 ± 0.276	196.03 ± 2.287	3.96 ± 0.229	5.66 ± 0.133
Hatches:							
1.	86	100.72 ± 33.781	5.71 ± 0.226	12.94 ± 0.771	250.53 ± 5.892	8.42 ± 0.590	5.89 ± 0.344
2.	58	86.22 ± 4.605	5.46 ± 0.199	16.71 ± 0.628	232.05 ± 5.202	5.78 ± 0.521	5.25 ± 0.303
3.	62	92.66 ± 4.453	5.60 ± 0.179	17.81 ± 0.564	215.93 ± 4.675	5.58 ± 0.468	5.61 ± 0.272
4.	38	89.21 ± 5.698	5.50 ± 0.229	19.20 ± 0.724	203.80 ± 5.997	4.40 ± 0.601	5.15 ± 0.349
5.	58	75.59 ± 4.605	5.59 ± 0.194	20.46 ± 0.611	188.55 ± 5.068	3.12 ± 0.508	5.69 ± 0.296
6.	67	86.31 ± 4.284	5.88 ± 0.197	23.71 ± 0.621	179.53 ± 5.143	1.96 ± 0.515	5.49 ± 0.299
7.	41	71.71 ± 5.477	5.80 ± 0.249	25.42 ± 0.785	170.36 ± 6.519	1.25 ± 0.652	5.49 ± 0.379
8.	12	47.33 ± 10.123	5.45 ± 0.418	29.32 ± 1.319	160.16 ± 10.929	2.84 ± 1.095	5.53 ± 0.437
9.	17	57.24 ± 8.505	4.92 ± 0.372	28.95 ± 1.710	163.34 ± 9.709	2.37 ± 0.973	6.93 ± 0.566
Regression on age/day (*)	439		0.0078 ± 0.0056	0.2943 ± 0.0178	-1.8295 ± 0.1472	-0.1067 ± 0.0148	-0.0010 ± 0.0008

(*) Keeping the other variable (hatch) constant.

TABLE 2

*The analyses of variances of egg production, blood serum chemical traits and plasma non-protein-nitrogen traits
Analyses de variance pour la production d'œufs, les caractéristiques chimiques du sérum et l'azote non protéique du plasma*

Source of variance	M.S. values		Mean square values					
	D.F.	Egg production	D.F.	Inorganic phosphorus	Calcium	Glucose	Urea	Uric acid
Between hatches	8	8,695.21 (**)	8	2.1407 NS	437.65 (**)	15,212.3 (**)	105.06 (**)	6.7514 NS
Regression			1	3.7995 NS	5,382.68 (**)	208,935.5 (**)	708.78 (**)	0.0671 NS
Residual	430	1,229.76	429	1.9735	19.61	1,347.3	13.53	4.5797

NS : Not significant.
(**) Significant at the 1 p. 100 level.

TABLE 3

Least-squares means (\pm S.E.) of plasma proteins, cholesterol and bilirubin
Moyennes estimées par les moindres carrés, pour les protéines du plasma,
le cholestérol et la bilirubine

Classification	N	Total proteins (mg p. 100)	Albumen (mg p. 100)	Cholesterol (mg p. 100)	Bilirubin (mg p. 100)
Overall mean . . .	439	5.93 \pm 0.067	0.71 \pm 0.017	167.40 \pm 2.559	0.36 \pm 0.024
Hatches:					
1	86	6.07 \pm 0.172	1.95 \pm 0.043	183.73 \pm 6.592	0.71 \pm 0.063
2	58	5.78 \pm 0.152	0.97 \pm 0.038	170.69 \pm 5.819	0.47 \pm 0.056
3	62	5.79 \pm 0.136	0.80 \pm 0.034	165.08 \pm 5.230	0.38 \pm 0.050
4	38	5.56 \pm 0.175	0.71 \pm 0.043	168.37 \pm 6.709	0.39 \pm 0.065
5	58	5.77 \pm 0.148	0.71 \pm 0.037	163.18 \pm 5.670	0.43 \pm 0.054
6	67	5.97 \pm 0.150	0.61 \pm 0.037	166.03 \pm 5.754	0.22 \pm 0.055
7	41	5.56 \pm 0.189	0.47 \pm 0.047	166.38 \pm 7.282	0.21 \pm 0.070
8	12	6.28 \pm 0.139	0.50 \pm 0.079	161.26 \pm 12.227	0.19 \pm 0.118
9	17	6.59 \pm 0.283	0.38 \pm 0.070	161.93 \pm 10.861	0.21 \pm 0.104
Regression on age/ day (*)	439	0.0066 \pm 0.0043	— 0.0118 \pm 0.0011	— 0.4117 \pm 0.1647	— 0.0079 \pm 0.0016

(*) Keeping the other variable (hatch) constant.

TABLE 4

The analyses of variances of plasma proteins, cholesterol and bilirubin
Analyses de variance pour les protéines du plasma, le cholestérol et la bilirubine

Source of variance	D.F.	Mean square values			
		Total proteins	Albumen	Cholesterol	Bilirubin
Between hatches . . .	8	2.9848 NS	1.0481 (**)	1,361.33 NS	0.6162 (**)
Regression	1	2.7340 NS	8.6959 (**)	10,536.65 (**)	3.9746 (**)
Residual	429	1.1460	0.0708	1,686.37	0.1559

NS : Not significant.

(**) Significant at the 1 p. 100 level.

II. — Genetic and phenotypic parameters

a) Egg production and group I of the serum traits :

The heritability values of egg production and group I of the serum traits beside the genetic and phenotypic correlations between them are given in Table 7. The genetic variance of inorganic phosphorus was negative and thus all the genetic

TABLE 5

Least-squares means (\pm S.E.) of the three plasma enzymes studied
Moyennes estimées par les moindres carrés pour les trois enzymes plasmatiques étudiés

	N	Alkaline phosphatase (m μ /ml)	Lactic dehydrogenase (m μ /ml)	Transaminase (m μ /ml)
Overall mean	439	1,023.32 \pm 15.43	666.87 \pm 10.41	168.72 \pm 2.52
Hatches:				
1	86	1,464.55 \pm 39.94	386.03 \pm 26.82	243.03 \pm 6.49
2	58	1,297.80 \pm 35.09	446.92 \pm 23.67	204.89 \pm 5.73
3	62	1,242.15 \pm 31.53	557.14 \pm 21.28	196.73 \pm 5.15
4	38	1,001.35 \pm 40.45	627.21 \pm 27.29	180.97 \pm 6.61
5	58	1,035.81 \pm 34.19	703.68 \pm 23.07	176.75 \pm 5.58
6	67	945.84 \pm 34.69	765.57 \pm 23.06	147.97 \pm 5.67
7	41	879.85 \pm 43.90	820.22 \pm 29.61	133.73 \pm 7.18
8	12	722.23 \pm 73.71	857.02 \pm 49.75	109.74 \pm 12.05
9	17	623.29 \pm 65.48	833.01 \pm 44.19	124.57 \pm 10.70
Regression on age/ day (*)		- 12.6190 \pm 0.9930	- 10.0577 \pm 0.6701	- 1.9302 \pm 0.1623

(*) Keeping the other variable (hatch) constant.

TABLE 6

The analyses of variances of the three plasma enzymes studied
Analyses de variance pour les trois enzymes plasmatiques étudiés

Source of variance	D.F.	Mean square values		
		Alkaline phosphatase	Lactic dehydrogenase	Transaminase
Between hatches	8	10,624.42 (**)	4,700.27 (**)	278.22 (**)
Regression	1	98,992.82 (**)	62,877.30 (**)	2,315.87 (**)
Residual	429	612.95	279.13	16.37

(**) Significant at the 1 p. 100 level.

correlations involving this trait are imaginary. The heritability values of calcium, glucose and uric acid are very high, uric acid showing the highest estimate of 0.75.

The genetic correlations among the five traits of Table 7 (that is; excluding inorganic phosphorus) are all positive except those involving calcium. Uric acid showed the highest genetic correlation with egg production (+ 0.9), explaining more than 80 p. 100 of its variance. Calcium, glucose and urea, the almost completely genetically correlated characters, showed genetic correlation values of more than 0.7 with egg production.

TABLE 7
Heritabilities (± S.E.) of, and genetic and phenotypic correlations (± S.E.) between egg production, blood serum chemical traits and plasma non-protein-nitrogen traits
Héritabilités et corrélations génétiques et phénotypiques concernant la production d'œufs, les caractéristiques chimiques du sérum sanguin et les caractéristiques liées à l'azote non protéique du plasma

	Egg production	Inorganic phosphorus	Calcium	Glucose	Urea	Uric acid
Egg production . . .	<u>0.224 ± 0.136</u>	— 0.009 ± 0.048	— 0.096 ± 0.048	0.067 ± 0.048	0.145 ± 0.047	0.178 ± 0.046
Inorganic phosphorus	⊕ ⊕	<u>— 0.057 ± 0.124</u>	0.301 ± 0.043	— 0.099 ± 0.047	— 0.161 ± 0.046	0.107 ± 0.047
Calcium	— 0.712 ± 0.117	⊕ ⊕	<u>0.656 ± 0.226</u>	— 0.840 ± 0.014	— 0.760 ± 0.020	0.059 ± 0.048
Glucose	0.791 ± 0.125	⊕ ⊕	— 0.989 ± 0.005	<u>0.639 ± 0.224</u>	0.739 ± 0.022	0.105 ± 0.047
Urea	0.750 ± 0.044	⊕ ⊕	— 1.004 ± 0.005	<u>1.029 ± 0.176</u>	<u>0.401 ± 0.195</u>	0.015 ± 0.048
Uric acid	0.901 ± 0.152	⊕ ⊕	— 0.474 ± 0.180	<u>0.524 ± 0.170</u>	<u>0.582 ± 0.183</u>	<u>0.752 ± 0.236</u>

Underlined figures (on diagonal) are combined heritabilities, figures above diagonal are phenotypic correlations and below diagonal are genetic correlations.
 ⊕ ⊕ Imaginary values.

The phenotypic correlations among the six traits of Table 7 are less in size than the corresponding genetic correlations, though of the same signs. It can be observed that egg production had significant phenotypic correlations only with urea and uric acid. Calcium, glucose and urea showed again very high and significant phenotypic correlations among themselves.

b) *Egg production and group 2 of the serum traits:*

The heritabilities of the plasma proteins, cholesterol and bilirubin together with the genetic and phenotypic correlations among themselves and with egg production are given in Table 8. Among this group of serum traits, albumen showed the highest and significant heritability value (of 0.56 ± 0.21). Total proteins had the lowest value of heritability (0.114 ± 0.154) and showed no significant genetic correlations with any of the characters studied, except bilirubin, with which the genetic correlation was complete (see also Tables 9 and 11).

Bilirubin showed complete genetic correlations also with all the other characters of Table 8, including egg production. Egg production had also very high genetic correlations with albumen (0.9) and cholesterol (0.8).

Phenotypic correlations of group 2 of the serum traits with egg production are all significant and have the highest value of 0.23 with albumen.

c) *Correlations between serum traits of group 1 and group 2:*

The genetic and phenotypic correlations between the serum traits of group 1 and those of group 2 are presented in Table 9. Total proteins, as discussed above, are not significantly correlated genetically with any of the serum traits of group 1. So is also uric acid, except for its high genetic correlation with cholesterol (0.84 ± 0.11). Calcium showed significant negative correlations with all the serum traits of group 2, except total proteins. Albumen and bilirubin showed complete, or almost complete genetic correlations with calcium, glucose and urea. Cholesterol had complete genetic correlation with urea and was very highly genetically correlated with calcium and glucose.

The phenotypic correlations of calcium, glucose and urea with albumen, cholesterol and bilirubin are all significant; those involving albumen showed the highest values followed by those involving bilirubin. Inorganic phosphorus showed significant phenotypic correlations only with total proteins and cholesterol.

d) *Egg production and group 3 of the serum traits:*

The heritability estimates of the three blood serum enzymes studied are presented in Table 10, together with their genetic and phenotypic correlations, among themselves and with egg production. The blood serum enzymes had very high and significant estimates of heritability, alkaline phosphatase showing the highest heritability value of 0.73 ± 0.23 . The estimate reported by WILCOX, VANVLECK and SHAFFNER (1962) for the heritability of alkaline phosphatase in the blood serum of 6-weeks old pullets (0.36) is just half the value estimated here.

Alkaline phosphatase, lactic dehydrogenase and transaminase are completely or almost completely genetically correlated, lactic dehydrogenase being negatively

TABLE 8

Heritabilities (\pm S.E.) of, and genetic and phenotypic correlations (\pm S.E.) between egg production, plasma proteins, cholesterol and bilirubin
Héritabilités, corrélations génétiques et phénotypiques concernant la production d'œufs, les protéines du plasma, le cholestérol et la bilirubine

	Egg production	Total proteins	Albumen	Cholesterol	Bilirubin
Egg production	<u>0.224 \pm 0.136</u>	0.186 \pm 0.046	0.231 \pm 0.045	0.168 \pm 0.046	0.177 \pm 0.046
Total proteins	— 0.393 \pm 0.626	<u>0.114 \pm 0.154</u>	— 0.031 \pm 0.048	0.017 \pm 0.048	— 0.115 \pm 0.047
Albumen	0.904 \pm 0.054	— 0.581 \pm 0.338	<u>0.561 \pm 0.215</u>	0.416 \pm 0.039	0.779 \pm 0.019
Cholesterol	0.820 \pm 0.147	— 0.505 \pm 0.566	0.805 \pm 0.143	<u>0.197 \pm 0.168</u>	0.318 \pm 0.043
Bilirubin	1.009 \pm 0.152	— 1.107 \pm 0.176	1.050 \pm 0.042	<u>1.013 \pm 0.016</u>	<u>0.187 \pm 0.166</u>

Underlined figures (on diagonal) are combined heritabilities, figures above diagonal are phenotypic correlations and below diagonal are genetic correlations.

TABLE 9

Genetic and phenotypic correlations (\pm S.E.) between plasma proteins, cholesterol and bilirubin and each of the serum chemical traits and plasma non-protein-nitrogen traits

Corrélations génétiques et phénotypiques entre les protéines du plasma, le cholestérol et la bilirubine et chacune des caractéristiques chimiques du sérum et de l'azote non protéique du plasma

	Total proteins	Albumen	Cholesterol	Bilirubin
	<i>Genetic correlations</i>			
Inorganic phosphorus .	⊕ ⊕	⊕ ⊕	⊕ ⊕	⊕ ⊕
Calcium	0.322 \pm 0.490	0.996 \pm 0.002	0.777 \pm 0.153	1.194 \pm 0.170
Glucose	— 0.407 \pm 0.463	1.002 \pm 0.001	0.901 \pm 0.074	1.128 \pm 0.111
Urea	— 0.349 \pm 0.567	1.012 \pm 0.007	1.095 \pm 0.091	1.100 \pm 0.099
Uric acid	— 0.478 \pm 0.414	0.442 \pm 0.201	0.839 \pm 0.112	0.449 \pm 0.313
	<i>Phenotypic correlations</i>			
Inorganic phosphorus .	0.269 \pm 0.044	— 0.043 \pm 0.048	0.188 \pm 0.046	— 0.062 \pm 0.048
Calcium	0.363 \pm 0.041	— 0.825 \pm 0.015	— 0.325 \pm 0.042	— 0.635 \pm 0.028
Glucose	— 0.168 \pm 0.046	0.839 \pm 0.014	0.353 \pm 0.041	0.609 \pm 0.030
Urea	— 0.136 \pm 0.046	0.774 \pm 0.019	0.285 \pm 0.044	0.664 \pm 0.027
Uric acid	0.211 \pm 0.046	0.073 \pm 0.047	— 0.014 \pm 0.048	0.041 \pm 0.048

⊕ ⊕ Imaginary values.

TABLE 10

Heritabilities (\pm S.E.) of, and genetic and phenotypic correlations (\pm S.E.) between egg production and the three plasma enzymes studied

Héritabilités, corrélations génétiques et phénotypiques concernant la production d'œufs et les trois enzymes plasmatiques étudiés

	Egg production	Alkaline phosphatase	Lactic dehydrogenase	Transaminase
Egg production . . .	<u>0.224 \pm 0.136</u>	0.137 \pm 0.047	— 0.089 \pm 0.047	0.179 \pm 0.046
Alkaline phosphatase .	0.847 \pm 0.101	<u>0.732 \pm 0.234</u>	— 0.807 \pm 0.017	0.893 \pm 0.010
Lactic dehydrogenase .	— 0.858 \pm 0.107	— 0.985 \pm 0.007	<u>0.625 \pm 0.223</u>	— 0.786 \pm 0.018
Transaminase	0.799 \pm 0.137	1.023 \pm 0.011	— 0.988 \pm 0.006	<u>0.622 \pm 0.222</u>

Underlined figures (on diagonal) are combined heritabilities, figures above diagonal are phenotypic correlations and below diagonal are genetic correlations.

correlated with the other two serum enzymes. The three enzymes are highly correlated genetically with egg production. The genetic correlations with egg production of alkaline phosphatase and transaminase were positive (0.85 and 0.80 resp.) and of lactic dehydrogenase was negative (-0.86). WILCOX *et al.* (1962) reported a genetic correlation estimate of $+0.5$ between serum alkaline phosphatase level of 6-week old pullets and their egg production. It may be noted that egg production in the present study showed significant negative genetic correlations only with calcium and lactic dehydrogenase. As described above, the means of these last two characters, unlike egg production, increased in the late hatches and with the advancement of age.

The phenotypic correlations between the three blood enzymes showed also high significant values of the same signs as the corresponding genetic correlations. Alkaline phosphatase and transaminase had very low but significant positive phenotypic correlation values with egg production. The correlation of lactic-

TABLE II

Genetic and phenotypic correlations (\pm S.E.) between the three plasma enzymes and each of the serum chemical traits, plasma non-protein-nitrogen traits, proteins, cholesterol and bilirubin

Corrélations génétiques et phénotypiques entre les trois enzymes plasmatiques et chacune des caractéristiques chimiques du sérum, de l'azote non protéique du plasma, les protéines, le cholestérol et la bilirubine.

	Alkaline phosphatase	Lactic dehydrogenase	Transaminase
<i>Genetic correlations</i>			
Inorganic phosphorus	⊕ ⊕	⊕ ⊕	⊕ ⊕
Calcium	-1.001 ± 0.001	0.994 ± 0.003	-0.996 ± 0.002
Glucose	0.998 ± 0.001	-0.988 ± 0.006	1.023 ± 0.012
Urea	0.973 ± 0.015	-1.045 ± 0.027	1.012 ± 0.007
Uric acid	0.402 ± 0.192	-0.543 ± 0.193	0.433 ± 0.169
Total proteins	-0.397 ± 0.443	0.095 ± 0.550	-0.494 ± 0.418
Albumen	1.025 ± 0.013	-1.019 ± 0.010	0.987 ± 0.007
Cholesterol	0.779 ± 0.147	-0.807 ± 0.137	0.728 ± 0.184
Bilirubin	1.010 ± 0.155	-1.101 ± 0.098	1.009 ± 0.146
<i>Phenotypic correlations</i>			
Inorganic phosphorus	-0.131 ± 0.047	0.117 ± 0.047	-0.106 ± 0.047
Calcium	-0.876 ± 0.011	0.884 ± 0.010	-0.859 ± 0.012
Glucose	0.839 ± 0.014	-0.876 ± 0.011	0.823 ± 0.015
Urea	0.708 ± 0.024	-0.726 ± 0.020	0.707 ± 0.024
Uric acid	0.070 ± 0.047	0.037 ± 0.048	0.049 ± 0.048
Total proteins	-0.245 ± 0.045	0.246 ± 0.045	-0.188 ± 0.046
Albumen	0.798 ± 0.017	-0.865 ± 0.012	0.808 ± 0.017
Cholesterol	0.314 ± 0.043	-0.410 ± 0.040	0.347 ± 0.042
Bilirubin	0.549 ± 0.033	-0.653 ± 0.027	0.608 ± 0.031

⊕ ⊕ Imaginary values.

dehydrogenase with egg production was negative and insignificant (-0.089 ± 0.047). WILCOX *et al.* (1962) reported a phenotypic correlation estimate of 0.01 between egg production and serum alkaline phosphatase level.

e) *Correlations between serum enzymes and serum traits of group 1 and group 2 :*

The genetic and phenotypic correlations between the three blood serum enzymes and each of the serum traits of group 1 and group 2 are presented in Table 11. It can be seen, here also, that the genetic (or phenotypic) correlation of each of the different serum traits of group 1 or 2 with either alkaline phosphatase or transaminase has a different sign from the corresponding correlation with lactic dehydrogenase. All genetic correlations of any of the three enzymes with uric acid and total proteins are insignificant. Otherwise, all genetic correlations are significant. It can be noticed that the three correlations of any of the serum traits with the three enzymes are almost of the same magnitude. Calcium, glucose, urea, albumen and bilirubin have complete, or almost complete genetic correlations with the serum enzymes.

The phenotypic correlations are all of lower magnitudes compared to their corresponding genetic correlations, and are all significant except those involving uric acid. Inorganic phosphorus showed significant phenotypic correlations, though of very low magnitudes, with the three blood serum enzymes.

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Résumé

Paramètres génétiques et phénotypiques de la production d'œufs et de certains constituants du sérum sanguin chez des pondeuses Fayoumi

Un total de 439 pondeuses *Fayoumi* issues de 9 lots d'éclosion, d'un âge compris entre 12 et 19 mois, ont été utilisées pour étudier (1) la production d'œufs; puis les constituants suivants du sérum sanguin : (2) phosphore inorganique, (3) calcium, (4) glucose, (5) urée, (6) acide urique, (7) protéines totales, (8) albumine, (9) cholestérol, (10) bilirubine, (11) phosphatase alcaline, (12) déshydrogénase lactique, (13) transaminase. Ces pondeuses étaient les filles de 40 pères et 241 mères. Les analyses sur le sérum étaient faites à l'aide de l'auto-analyseur Séquentiel Multiple, SMA-12/60. La moyenne estimée par les moindres carrés pour le nombre d'œufs produit par poule jusqu'à 70 semaines d'âge était 78. Les moyennes des moindres carrés des paramètres du sérum sanguin mentionnés plus haut étaient dans l'ordre : (2) 5,55 mg p. 100, (3) 21,62 mg p. 100, (4) 196 mg p. 100, (5) 3,96 mg p. 100, (6) 5,66 mg p. 100, (7) 5,93 mg p. 100, (8) 0,71 mg p. 100, (9) 167,4 mg p. 100, (10) 0,36 mg p. 100, (11) 1 023 mu/ml, (12) 667 mu/ml, (13) 169,7 mu/ml.

Le lot d'éclosion avait des effets statistiquement significatifs sur tous les caractères étudiés excepté le phosphore inorganique, l'acide urique, les protéines totales et le cholestérol. L'âge de la poule affectait de façon significative tous les caractères du sérum sanguin excepté le phosphore inorganique, l'acide urique et les protéines totales.

Les données étaient corrigées pour l'effet du lot d'éclosion, et, dans le cas des caractéristiques du plasma, pour l'effet de l'âge, préalablement aux analyses hiérarchiques de variance et de covariance destinées à évaluer les héritabilités et les corrélations génétiques et phénotypiques. Les estimations combinées de l'héritabilité des caractères étudiés étaient dans l'ordre : (1) 0,224 \pm 0,136, (2) $-0,057 \pm 0,124$, (3) 0,656 \pm 0,226, (4) 0,639 \pm 0,224, (5) 0,401 \pm 0,195, (6) 0,752 \pm 0,236, (7) 0,114 \pm 0,154, (8) 0,561 \pm 0,215, (9) 0,197 \pm 0,168, (10) 0,187 \pm 0,166, (11) 0,732 \pm 0,234, (12) 0,625 \pm 0,223, (13) 0,622 \pm 0,222.

Des corrélations génétiques significatives (d'une valeur supérieure ou égale à $\pm 0,7$) étaient trouvées entre la production d'œufs et tous les caractères du sérum sanguin excepté le phosphore inorganique et les protéines totales.

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