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**EFFECT OF SEX, SEXUAL MATURITY,
AND EGG LAYING CAPACITY
ON BLOOD CONSTITUENTS IN FAYOUMI,
AND RHODE ISLAND RED CHICKENS**

BY

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SUMMARY

An investigation was carried out at the Animal and Poultry Breeding Experimental Farm, Faculty of Agriculture, Cairo University, Giza, Egypt, U.A.R., to study the relation between blood constituents of growing chickens and their age, date of sexual maturity and the first four months of egg laying, using 46 females and 15 males of the Fayoumi chickens and 26 females and 10 males of Rhode Island Reds. Relation between blood constituents and egg production was also studied using 50 Fayoumi pullets and 34 Rhode Island Reds. The estimated blood constituents were erythrocyte counts, hemoglobin content, total W.B.C., total blood calcium, phosphorus and protein. The following is the summary of the results obtained :

1. Before sexual maturity, there was no significant difference between the successive determination of blood constituents. However, total blood protein and W.B.C. showed a slight increase with age.
2. There was no apparent difference between immature sexes in the levels of the blood constituents, except for R.B.C. counts and hemoglobin content.

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3. The male chickens showed a highly significant increase in R.B.C. counts and hemoglobin content, while the other blood constituents were not affected by sexual maturity.

4. At onset of laying, the total blood calcium and phosphorus showed a significant increase.

5. After four months from the beginning of laying, total blood calcium and phosphorus reached lower levels than those before sexual maturity.

6. The increase in egg production is usually accompanied by a decrease in blood constituents. The egg weight was significantly negatively correlated with the hemoglobin and R.B.C. in both breeds, while the egg number decreased the calcium and phosphorus significantly in the Rhode Island Red.

INTRODUCTION

The remarkable increase in poultry production in Egypt, either through raising indigenous breeds or by importation of foreign breeds created many problems for the poultry keepers which need rapid solution. The study of the variation in blood picture and constituents in the fowls, sets an important foundation to the study of growth and egg production. Moreover, it helps in explaining the reaction of the newly imported breeds of poultry to their new habitat.

The present work was carried out in order to study the blood analysis in relation to the productive performance of the native and foreign poultry breeds under our local conditions.

REVIEW OF LITERATURE

The majority of the blood studies in chickens are related to sex, sexual maturity and egg production capacity, since these are the most economic characteristics.

A.—*Sex Differences in Blood Characteristics :*

Sex has no significant effect on blood hemoglobin or erythrocyte count till sexual maturity (Cook, 1937). Olson (1937) stated that

there was no sex difference in the leucocytes count; however, injection with male sex hormone increased the leucocytes count in females and capons (Herrtch *et al.*, 1954).

B.—Effect of Sexual Maturity on Blood Constituents :

Sexual maturity is accompanied by a greater concentration in erythrocytes count and hemoglobin content in male chickens than in females (Juhn and Domm, 1930 ; Domm and Tober, 1946 ; Newell and Shaffner, 1950). Hens and capons had approximately the same erythrocyte counts (about 2,500,000), while cocks had about 3,500,000. The R. B. C. of hens, poulard and capons reached the level of normal males by injection with male sex hormone, with a subsequent return to preinjection level after ceasing injection (Domm and Tober, 1946 and Herrtch, Lochart, Martin and Nusser, 1954). The mean value of total calcium in blood is almost stable in the immature birds (Greenberg *et al.*, 1936). At two days before the onset of laying, the blood calcium showed a great increase from 12 mg. percent to 31.6 mg. percent, followed by a gradual decrease to 23 mg. percent after two weeks of laying (Greenberg *et al.*, 1936). This increase is caused by the high level of estrogen at sexual maturity, which was proved by similar results induced by injection of estrogen in non-laying females, cocks and capons (Riddle, 1942 and Benoit *et al.*, 1950).

The inorganic phosphorus in the growing fowls decreased with increasing age; its concentration was 10.0 and 5.5 gm. at 19 and 165 days respectively (Greenberg *et al.*, 1936). At the onset of laying, the organic phosphorus of the blood increased, while there was no appreciable change in the inorganic phosphorus. This increase was attributed to the release of oestrogen from the ovary of the laying hens (Heller *et al.*, 1934 ; McDonald and Riddle, 1945 and Common *et al.*, 1948). The injection of oestrogen caused an increase in the blood phosphorus of immature chickens from 7.3 to 16.0 mg. per 100 ml. (Common *et al.*, 1948).

Plasma protein values were lower in males than in females, which suggests that gonadal hormones are involved (Rochlina, 1934 ; Brandt *et al.*, 1951 and Struckie and Newman, 1951).

C.—*The Relation between Egg Production and Blood Contents :*

Results obtained by different authors for the effect of egg production capacity on blood hemoglobin, vary to some extent. Cook and Harmon (1933), Maughan (1935) and Harmon (1936) stated that the increase in egg production was accompanied by a decrease in blood hemoglobin. On the contrary, Duckes and Schwarte (1931) and Winters (1936) reported that there was no difference in blood hemoglobin of laying and non-laying hens. Cook (1937) showed that the variation in erythrocytes count in birds was similar to that in hemoglobin content.

Knowles *et al.* (1935) reported that the activity of the shell gland in egg shell formation induced a decrease in plasma calcium. On the contrary, Winget and Smith (1957) reported that the calcium level was nearly equal in hens with active and with inactive shell glands.

The blood protein level decreases by 25 to 60% at oviposition (Rochlina, 1934). The progress of the ovum in the oviduct and the time of oviposition has no significant effect on the plasma protein concentration (Sturkie, 1951). Under the natural level of oestrogen, non-laying birds had higher values of total plasma protein than laying ones, being 5.34 and 4.64 gm./100 ml. respectively. Oestrogen administration at high level increased the protein content in both laying and non-laying hens. Moreover, fast moving protein component was found in the electrophoretic pattern of the serum in the laying hens, but not in non-laying females; this component may be related with egg formation (Brandt *et al.*, 1951).

MATERIAL AND METHODS

This work was carried out at the poultry Experimental Farm, Faculty of Agriculture, Cairo University, Giza, Egypt, U. A. R. The work was divided into two experiments :

The first experiment was designed to study the blood constituents of growing chickens in relation to their sex, sexual maturity and egg production during their first four months of laying. It comprised 46 and 26 females and 15 and 10 males of both Fayoumi and Rhode Island Red respectively. Individual records for blood hemoglobin, erythrocytes

and total leucocytes were monthly obtained beginning with three months old chickens, while group samples were taken for blood calcium, phosphorus and protein each month. As regards the age of sexual maturity, the Fayoumi females were arranged into three groups, early, medium and late maturing, owing to the onset of laying at 5, 6 and 7 months of age respectively.

The second experiment was arranged to investigate the relation between blood constituents and the annual egg production (number and weight of eggs). The experiment included 50 Fayoumi and 34 Rhode Island Red laying pullets. This experiment lasted for 12 months from October 1957 till September 1958. Monthly analyses were carried out for haemoglobin, erythrocytes and total leucocytes of each pullet, while seasonal estimates of calcium, phosphorus and protein were done in January, April, July and October.

The pullets were kept in concrete house with open yards, and treated due to the routine system of the Experimental Station. The concentrated ration comprised cotton seed cake (20 %), barley (29 %), rice polish (15 %), bran (15 %) and crushed maize (29 %). Fresh blood was added daily to the ration. Berseem (*Trifolium alexandrinum*) was offered from December till June, while green corn was available during summer months.

Sampling and procedure :

Blood samples were collected from vein puncture under the wing. Total erythrocytes and leucocytes count were done after Sadek (1955) using the haemocytometer.

In order to facilitate and establish an easy method for haemoglobin estimation in bird's blood, it was proposed to use the well known haemoglobinometer used for estimating human haemoglobin. Since the haemoglobin value is lower in birds than in mammals, the usual standard acid hematin method (Fowler, 1949) was modified. The 1/10 N hydrochloric acid was used up to the 8 mark instead of the 10 mark. The reading of the haemoglobinometer was multiplied by a factor of 0.134, which was drawn by estimating the haemoglobin content chemically

(Wong, 1928) opposite to the haemoglobinometer reading in thirty blood samples.

The serum total calcium, phosphorus and protein contents were determined after Hawk *et al.* (1947). A photoelectric colorimeter was applied for estimating total phosphorus (by Roe and Kohn method) and calcium (by Fisk and Subba Row method). Total plasma protein was estimated by the specific gravity technique.

The statistical analysis was done after Snedecor (1953).

RESULTS

Sex Difference :

Both Fayoumi and Rhode Island Red cockerels had higher values for R. B. C. and haemoglobin, but lower values for W. B. C. counts and plasma protein than females. While blood calcium and phosphorus were lower in Fayoumi males than females, the contrary occurred in Rhode Island Reds (Table 1).

TABLE 1
Blood constituents in immature males and females in Fayoumi
and Rhode Island Reds.

Blood constituents	Fayoumi		R.I.R.	
	Males	Females	Males	Females
R. B. C. « Million »	3.710	3.294	3.835	3.379
Haemoglobin « gm. »	11.48	10.16	11.74	10.21
W. B. C. « Thousand »	74.00	75.00	86.00	91.00
Protein « gm. »	6.89	7.11	6.87	7.36
Calcium « mgm. »	13.09	14.29	15.05	11.62
Phosphorus « mgm. »	7.94	9.52	9.48	6.98

Sexual Maturity :

At the onset of laying, the erythrocytes and leucocytes concentration decreased in both breeds. However, the medium sexual maturity group showed an increase in the W. B. C. counts. While the haemoglobin decreased in accordance with the R. B. C. count in Fayoumi, the Rhode Island Reds showed a slight increase in the haemoglobin value. The blood protein decreased slightly in the Fayoumi breed, while it increased in the Rhode Island Red. In both breeds, blood calcium and phosphorus values showed a marked increase at sexual maturity, especially in the medium sexual maturity group of Fayoumi which showed 100 and 46 percent increase in blood calcium and phosphorus respectively (Fig. 1).

At the onset of laying, the group of moderate age at the sexual maturity possessed the highest mean values of the mentioned blood constituents, except total blood phosphorus. Meanwhile, the latest sexual maturity group had the lowest values of the studied constituents except total leucocyte and protein content (Table 2).

TABLE 2

The concentration of blood contents in the different groups of sexual maturity in Fayoumi fowls.

Blood contents	Early maturity	Moderate maturity	Late mat.
R. B. C.	3.077	3.412	2.929
Haemoglobin	9.84	10.350	9.37
W. B. C.	67.00	91.00	68.00
Protein.....	6.65	7.45	8.25
Calcium	21.75	27.50	10.80
Phosphorus	45.50	12.93	8.64

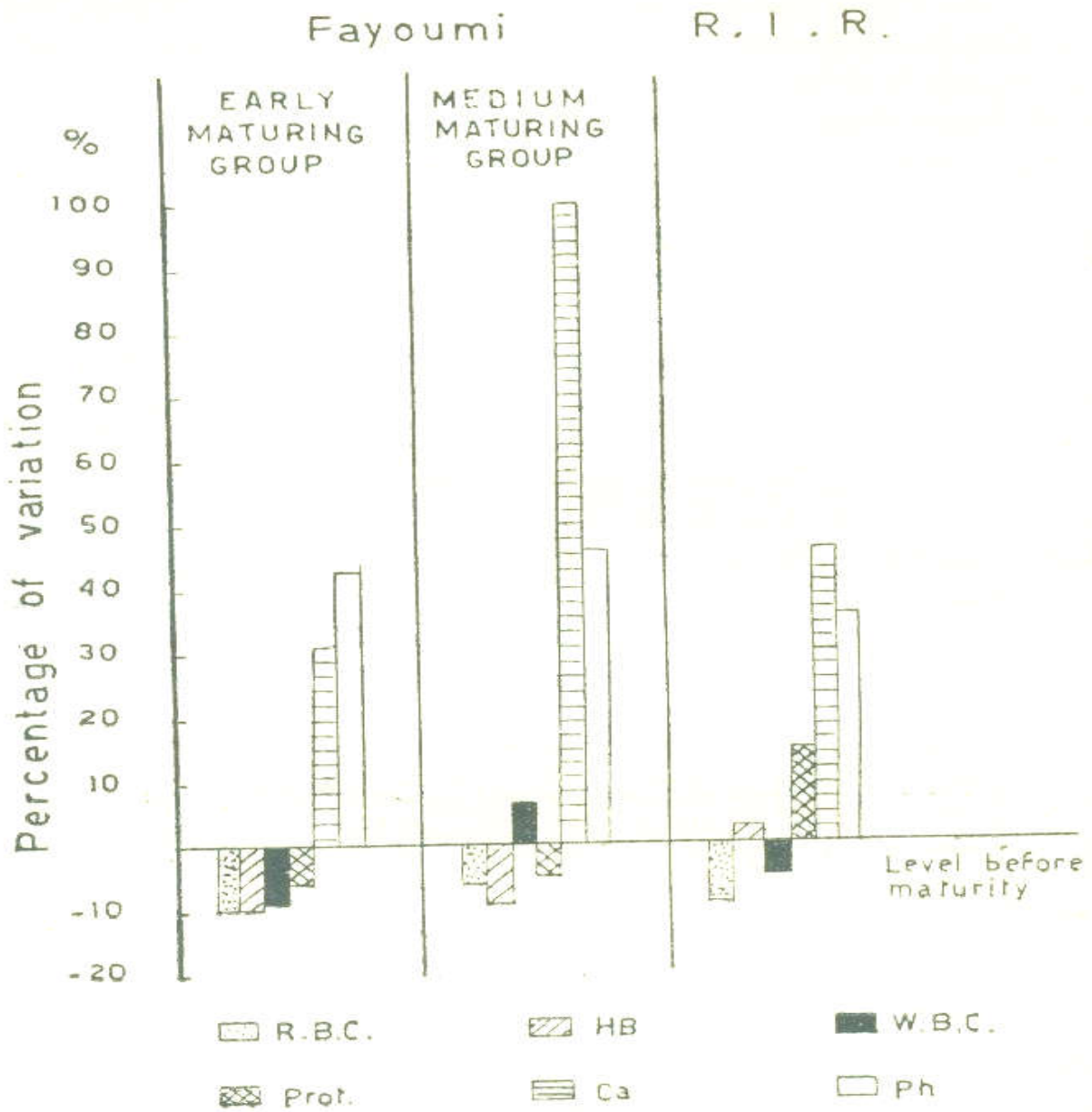


FIG. 1

Percentage of variation in blood constituents at the onset of laying

The male chickens in both Fayoumi and Rhode Island Red showed a great increase in R.B.C. counts, haemoglobine content, W.B.C. and protein at sexual maturity. While the phosphorus decreased in both breeds, the calcium decreased greatly in Fayoumi and increased in Rhode Island Red (Table 3).

TABLE 3

Blood contents in immature and mature male Fayoumi and R. I. R. chickens.

Blood contents	Fayoumi		R. I. R.	
	Immature	Mature	Immature	Mature
R. B. C.	2.829	3.699	3.699	3.808
Haemoglobin.....	8.36	11.39	10.77	12.90
W. B. C.	78.00	79.00	69.00	73.00
Protein.....	6.30	7.05	5.50	7.65
Calcium.....	11.63	9.39	12.50	13.85
Phosphorus.....	7.36	6.55	8.64	7.05

Egg Production :

The most apparent effect of egg production for a period of four months was the great reduction in blood calcium and phosphorus. This effect was more apparent in case of early and medium maturity in Fayoumi fowl than in both late maturing Fayoumi and the R.I.R. hens. While the early and late maturing females had an increase in the plasma proteins, the late maturing group and the R.I.R. showed a reduction in the protein (Table 4).

TABLE 4
The values of blood content in the blood of fowls at onset of laying (I) and after four months of egg laying (II).

Blood contents	Fayoumi						R.I.R.	
	Early maturing		Medium maturing		Late maturing		I	II
	I	II	I	II	I	II		
R.B.C.	3.077	3.396	3.412	3.266	2.929	3.344	2.855	3.445
Haemoglobin	9.84	9.85	10.35	9.85	9.37	10.10	9.38	10.07
W.B.C.	67	77	91	86	68	82	92	92
Protein	6.65	8.45	7.45	8.65	8.25	5.50	9.38	8.65
Calcium	21.75	12.63	27.50	12.11	10.80	9.94	17.58	12.36
Phosphorus	15.50	7.12	12.93	6.25	8.64	6.56	4.12	7.36

The egg weight was significantly related with R.B.C. and HB in both breeds, while egg number was not. The calcium level decreased significantly due to egg number in R. I. R. only (Table 5).

TABLE 5

The correlation between egg weight and egg number and blood constituents.

Items	Egg weight		Egg number	
	Fayoumi	R. I. R.	Fayoumi	R. I. R.
Erythrocytes	-0.174x	-0.290xx	-0.059	-0.015
Haemoglobin.	-0.194x	-0.226x	-0.158	-0.071
Total leucocytes	-0.018	0.104	-0.160	0.004
Protein.	-0.466	-0.549	-0.042	-0.259
Calcium	0.167	0.010	0.184	-0.683x
Phosphorus	-0.129	0.179	-0.504	-0.732x

The data of blood analysis and records of egg production through one year showed a negative relationship between both egg weight and egg number and blood constituents, except in few cases such as each of R. B. C. count and W. B. C. in R. I. R. and calcium in Fayoumi (Figs. 2 and 3).

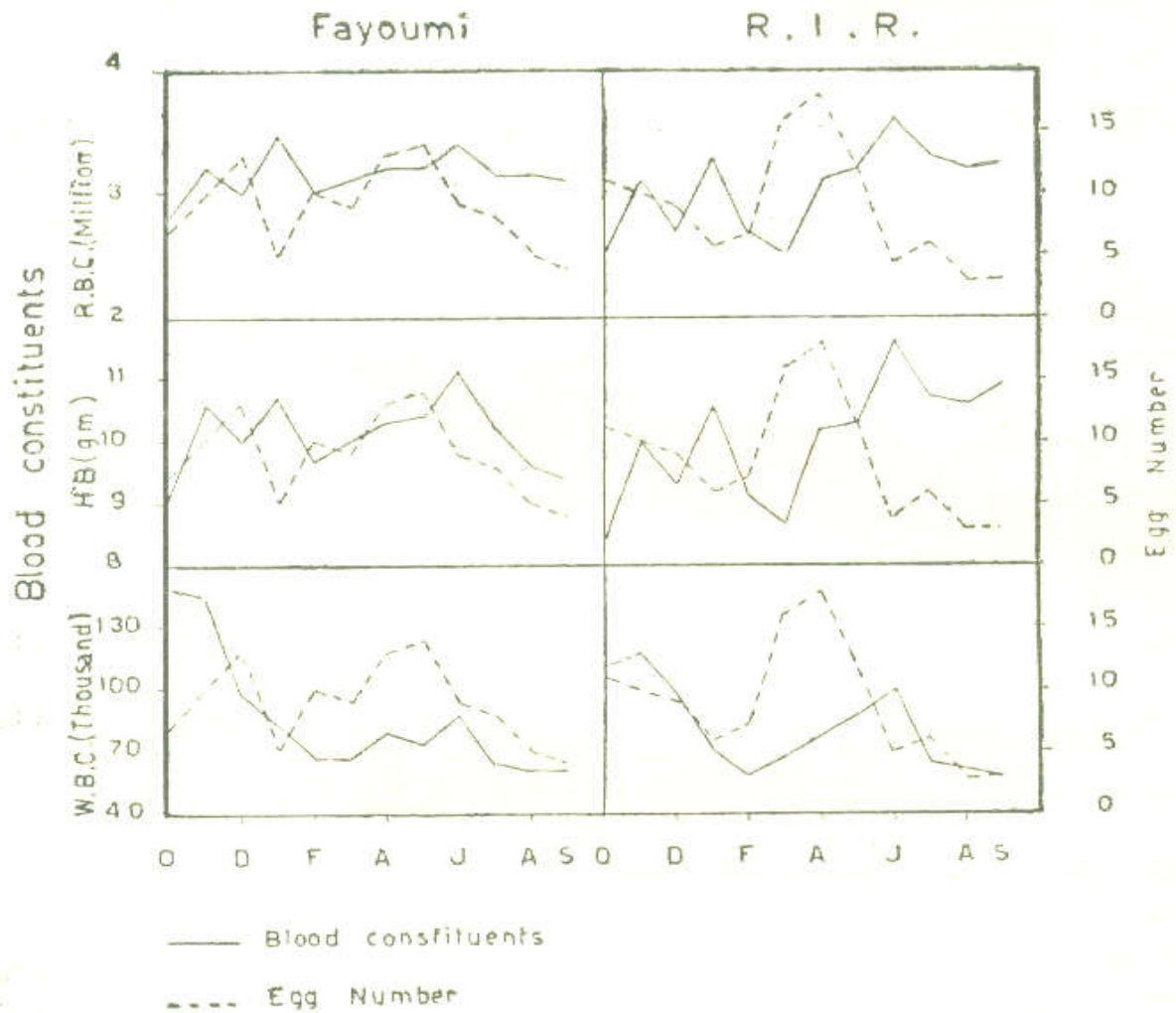


FIG. 2

Monthly egg number and values of blood constituents in Fayoumi and R. I. R. pullets

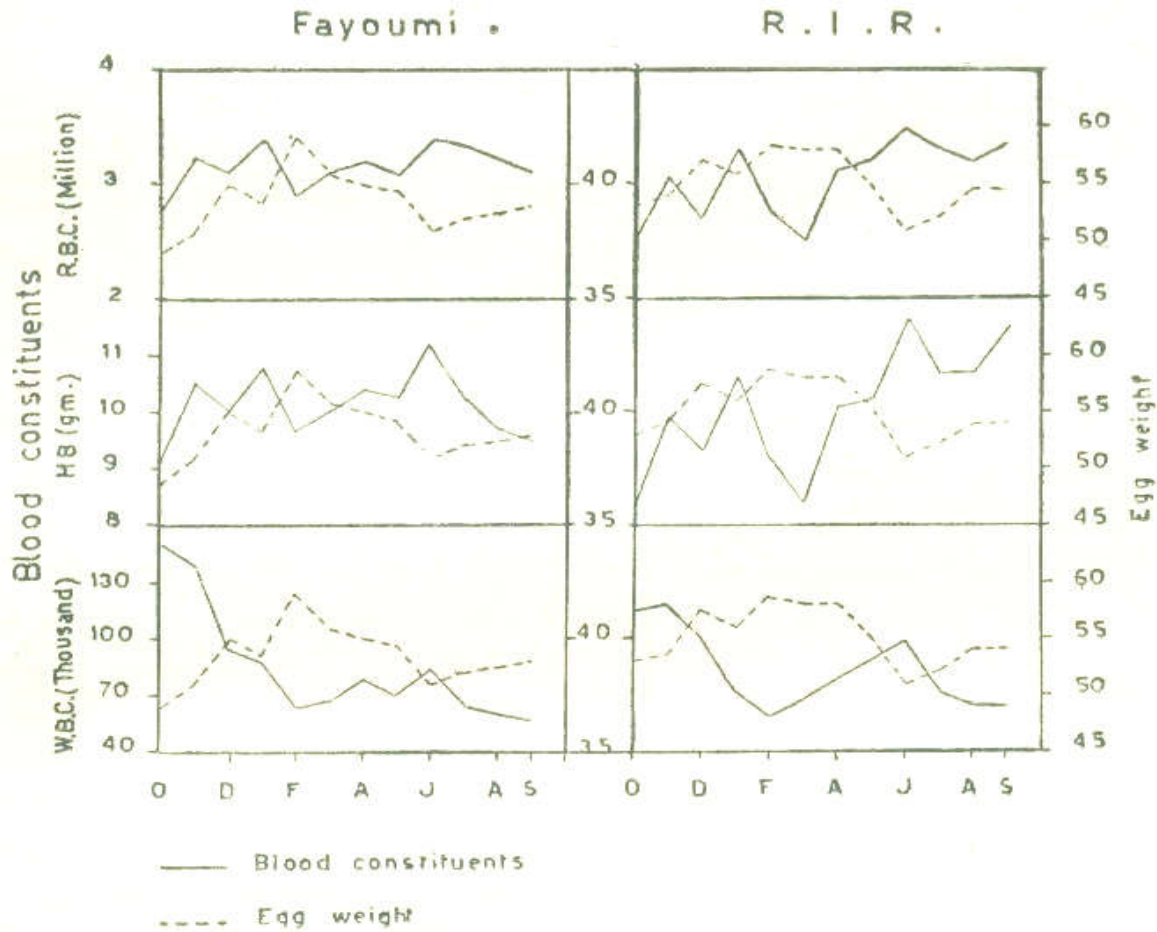


FIG. 3

Monthly egg weight and values of blood constituents
 in Fayoumi and R. I. R. pullets

DISCUSSION

The present study agrees with most of the authors in excluding the effect of sex on the blood picture before sexual maturity.

At sexual maturity, males showed higher values of both haemoglobin and R. B. C. than females. It could be concluded that this difference is a direct result of the hormonal difference between the two sexes. The same results were arrived at by Domm and Taber (1946) and Herrtch *et al.* (1954). In case of females, the sexual maturation exerted no change in haemoglobin and R. B. C. denoting that the increase in the estrogen level had no effect on both haemoglobin and R. B. C. as stated by Domm and Taber (1946).

At sexual maturity, the female chicken showed a great increase in blood calcium and phosphorus, in accordance with Greenberg *et al.* (1936) and Common *et al.* (1948); this may be due to the effect of the increase in estrogen secretion at the onset of ovulation. On the other hand, the male sex hormone showed no effect on blood calcium and phosphorus.

With continued egg laying necessary elements for egg formation were drawn from the blood constituents, causing a gradual decrease in its percentage to the prematurity level.

The late maturing females had the lowest values of all blood constituents. This may be one of the main factors which retarded sexual maturity.

The egg laying capacity is greatly related to the blood constituents. Heavy laying hens showed lower values of haemoglobin and R. B. C. count than poor laying ones. Egg weight had a significant effect on the haemoglobin and R. B. C. Calcium decreased in accordance with the increase of egg number per unit time, significantly in case of R. I. R.

Since the shell gland is not a calcium storage organ (Winget and Smith 1958), heavy laying will increase the rate of calcium mobilization, for shell formation from blood, causing a decrease in its values (Knowles *et al.*, 1935; Winget and Smith, 1957).

As phosphorus is directly correlated with calcium metabolism, the decrease in blood calcium level at heavy egg production was accompanied by a decrease in blood phosphorus content. Greenberg *et al.* (1936) have recorded similar results. Moreover, Halman (1925) has pointed out that egg production is associated with increased phosphorus catabolism, and that during egg production the phosphorus lost from the body is much greater than contained in the egg laid. Halman's observations have been confirmed by Common (1932) who found that egg production was correlated with relatively heavy excretion of phosphorus in the feces.

In agreement with Sturkie (1951), plasma proteins were not affected by heavy egg laying. Probably egg proteins are synthesized from the free amino acids of blood with no interference with blood protein.

However, the variation in the blood constituents due to egg laying is not always noticed since the depletion of any element from the blood is compensated as rapidly as possible from the body stores of this element. Therefore, the variation in the blood constituents is temporary and slight. These results agree with those of Harmon (1936) and Schultze *et al.* (1936).

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المخلص

تأثير الجنس والنضج الجنسي ودرجة إنتاج البيض على مكونات الدم في الدجاج الفيومي والروود ايلاندر

أجريت تجربتان بمركز أبحاث الدواجن بكلية الزراعة جامعة القاهرة سنة ١٩٥٨ - ١٩٥٩ ، وكان الهدف في التجربة الأولى دراسة علاقة بعض مكونات الدم بجنس الكناكيت وعمر النضج الجنسي في البدارى ودرجة إنتاج البيض لمدة أربعة شهور بعد الوضع في الدجاج البياض . وقد شملت هذه التجربة نوعى الفيومي والروود ايلاندر بالأعداد الآتية على الترتيب :

٤٦ ، ٢٦ من الإناث و ١٥ ، ١٠ من الذكور ابتداء من عمر ثلاثة شهور . أما التجربة الثانية فكان هدفها دراسة العلاقة بين إنتاج البيض عدداً ووزناً على مدار العام وبعض مكونات الدم . وقد شملت ٥٠ ، ٣٤ من دجاج الفيومي والروود ايلاندر على الترتيب ، والمكونات التى درست في الدم خلال هاتين التجربتين هي :

كرات الدم الحمراء ، كرات الدم البيضاء ، الهيموجلوبين ، الكالسيوم ، الفسفور والبروتين . ويمكن تلخيص أهم النتائج التى أدت إليها هذه التجارب فيما يلى :

١ - لم يكن هناك تغير محسوس في المعدلات الشهرية لمكونات الدم السابقة من عمر ٣ شهور حتى النضج الجنسي وإن كان البروتين الكلى وكرات الدم البيضاء قد ارتفعت نسبياً بتقدم العمر .

٢ - لم يكن هناك اتجاه واضح لتأثير الجنس في مرحلة النمو على مكونات الدم إلا في حالة الهيموجلوبين وكرات الدم الحمراء حيث كانت الذكور أعلى في معدلاتها عن الإناث .

٣ - عند النضج الجنسي في الذكور ارتفعت معدلات الهيموجلوبين وكرات الدم الحمراء بدرجة معنوية على حين لم تتغير المعدلات الأخرى تغيراً يذكر .

٤ - عند النضج الجنسي في الإناث ارتفعت معدلات الكالسيوم الكلى والفسفور في الدم بدرجة معنوية .

٥ - بعد أربعة شهور من بدء إنتاج البيض كان المتوسط الشهرى للمعدلات الخاصة بالكالسيوم الكلى والفسفور منخفضاً عما قبل إنتاج البيض .

٦ - كلما تقدم إنتاج البيض على مدار الموسم كلما انخفض معدل المكونات السابقة في الدم . كما ثبت وجود تلازم معنوى سلبي بين وزن البيض من جهة ومعدل الهيموجلوبين وكرات الدم الحمراء في الدم في نوعى الدجاج . على حين أن زيادة عدد البيض في دجاج الروود ايلاندر كان يصاحبها انخفاض معنوى في معدل الكالسيوم والفسفور بالدم .