Egyptian J. Anim. Prod. (1997)Vol 34 (2)135-144.

RELATIONSHIP BETWEEN EGG PRODUCTION AND PLASMA ESTRADIOL, PROGESTERONE, TRIIODOTHYRONINE AND SOME BLOOD CONSTITUENTS IN LAYING HENS

Ahmed, Nagwa A., A. A. El-Far, M.A. Kicka and G.K. Mehaisen

Department of Animal Production, Faculty of Agriculture, Cairo University, Giza, Egypt

SUMMARY

One hundred, 3 month old brown Lohman Selected Leghorn (LSL) and one hundred Fayoumi hens were used in this study. Birds were individually housed and fed a corn-soybean laying diet. Productive performance was monitored during the period from sexual maturity to the peak of egg production. Blood plasma concentrations of progesterone (P4), estradiol (E2) and triiodothyronine (T3) were determined. Erythrocyte count (RBC's), Packed cell volume (PCV) and hemoglobin (Hb) concentration were also determined in blood. The LSL hens showed better productive performance, matured 37 days earlier and produced more egg number and mass than Fayoumi hens. Plasma P4 concentrations significantly increased at the age of sexual maturity and maintained its high level up to the peak of egg production in LSL and Fayoumi hens. Plasma E2 significantly rose at age of sexual maturity and reached its maximum level at peak of egg production. Fayoumi showed significantly higher plasma E2 concentrations than LSL hens during the period from sexual maturity up to the peak of egg production. Plasma T3 significantly decreased as age advanced. The LSL hens showed significant higher plasma T3 levels at 16 weeks of age than Fayoumi. Thenafter the Fayoumi had higher but not significant values. Total RBC's count, Hb concentrations and PCV values were lower in older hens and higher in Fayoumi than LSL hens.

Keywords: Laying hen, egg production, progesterone, estradiol, triiodothyronine, red blood cells, packed cell volume, hemoglobin

INTRODUCTION

A laying hen of very high productive capacity may produce 200 to 280 eggs a year, that is up to four times as much dry matter as in its body (Maynard and Loosli, 1962). This clearly coincides with intensive metabolic activities. Egg production is associated with increased rate of turnover of thyroid hormones. These hormones are decreased or increased, within physiological limits, to afford suitable metabolic conditions for the actions of gonadotrophins and female sex hormones. These collectively regulate egg formation from ovulation to oviposition (Beuving and

Vonder,1977). Tanabe *et al.* (1983) showed that the reproductive stage and productivity of hens are largely dependent on different hormonal levels.

Egg production in Egypt today is mainly from imported commercial layer strains. However, these strains are not adapted to the Egyptian conditions, specially if they are reared under open housing system. In addition, the Egyptian consumer still prefers local (Fayoumi) eggs in spite of their small size. Therefore, improvement of Fayoumi egg production is still important. Physiological traits could be used as determinants for improving egg production of Fayoumi fowl.

The objective of this study was to find out relationships between some physiological traits (hormonal and hematological) and egg production in a commercial strain (LSL) and a local breed (Fayoumi) under Egyptian conditions.

MATERIALS AND METHODS

The present study was carried out in The Poultry Research Farm and Laboratory of Poultry Physiology, Animal Production Department, Faculty of Agriculture, Cairo University.

Birds

One hundred, 3 months old Brown Lohman selected Leghorn (LSL) and one hundred Fayoumi hens were used. Birds were individually housed in wire cages in an open sided house. Starting from 18 weeks of age, birds were exposed to 14 hr light daily being increased half an hour every two weeks up to 17 hr daily. Birds were fed *ad. libitum* corn-soybean meal laying diet containing 17% crude protein, 2800 Kcal ME/Kg diet, 3.7% calcium and 0.66% total phosphorus according to NRC (1984) requirements. Egg production was recorded from the first laid egg up to the seventh month of production. Age and body weight at sexual maturity (S.M.) were also recorded for all birds.

Blood analysis

Blood samples were collected from 32 birds (16 of each strain) at 16 and 18 wks of age, at sexual maturity and during the peak of production to determine the hormonal changes and some related hematological properties. Samples of about 2 ml of blood were withdrawn from the brachial vein into a hyparinized syringe. Total RBC's count (10^6/ mm^3 blood), PCV value (%) and hemoglobin concentration (g/100 ml blood) were immediately determined for each individual bird. Blood samples were spent at 3000 rpm for 5 minutes to collect plasma which was stored at -20°C for latter analyses.

Hormonal assays

Direct radio immunoassay (R.I.A.) technique was performed for plasma progesterone, estradiol (Etches *et al.*, 1981) and Triiodothyronine (May, 1978) assessments. Ready antibody coated tube kits (Diagnostic Product Corporation, Los Angeles) were used according to the procedure outlined by the manufacturer.

Crossreaction of progesterone antibody (at 50% displacement) was 100% with progesterone, while it was 2.2%, 3.4%, 9.0% and 3.2% with 11-Deoxycorticosterone, 17 α-Hydroxyprogesterone, 5 α-Pregnan-3,20-dione and 5 β-Pregnan-3,20-dione.

respectively. It also was less than 1.0% with corticosterone, 20 β-dihydroprogesterone, pregnenolone, midroxyprogesterone and testosterone, and less than 0.1% with any of the other steroids.

Estradiol antibody (at 50% binding) showed 100% crossreaction with estradiol, while it was 4.4%, 10.0% and 1.8% with d-equilenin, estrone and estrone-β-D-glucuronide and ethinyl estradiol, respectively. It was less than 1% with any of the other steroids.

Total T_3 antiserum is highly specific for triiodothyronine. The crossreactivity of total T_3 antiserum was 100% with T_3 , while it was 19.8% and 1.1% with triiodothyroacetic acid and D-thyroxine, respectively. It was less than 1% with any of the other natural compounds that might be presented in samples.

Statistical Analysis

Data collected were subjected to two factor- factorial analysis of variance (MSTAT, 1986). Differences among means were tested using Duncan Multiple Range Test (Duncan, 1955).

RESULTS

The LSL hens matured 37 days earlier with heavier body weight at sexual maturity than Fayoumi. Weight of the first egg, egg number, egg weight and egg mass through 100 days were significantly greater in LSL than Fayoumi hens. Days required to produce the first 10 eggs were significantly more in Fayoumi than LSL hens. (Table 1).

Progesterone (P_4) concentration significantly increased at age of sexual maturity and continued to increase until the peak of egg production in both breeds (Table 2 & Fig. 1a). At 18 weeks and sexual maturity, levels of Plasma P_4 of LSL hens were higher than Fayoumi, however, the differences were not significant (Table 2). Estradiol levels significantly increased by about 0.79 and 3.2 times in LSL and Fayoumi hens, respectively from 18 wks of age to the age of sexual maturity and reached its peak value at the peak of egg production (Fig. 1b). Plasma E_2 was higher in Fayoumi than LSL hens at peak of production. However, differences between the two strains at other time periods were not statistically significant (Table 2). Plasma T_3 significantly decreased with the advancement of production for both strains (Table 2 and Fig. 1 c). The T_3 concentrations were significantly higher in LSL than Fayoumi at 16 weeks of age, with no breed differences after that age (Table 2).

Table 1. Productive performance of LSL and Fayoumi hens

Item	LSL	Fayoumi	SE
Age at S.M. (day)	150 ^{b}	187 ^{a}	2
Body weight at sexual maturity(g)	1725^a	1441^b	110
Weight of first egg (g)	47.9 ^{a}	32.3 ^{b}	0.9
Days to produce first 10 eggs	11.6 ^{b}	16.3 ^{a}	0.4
Egg no. through 100 days	87.7 ^{a}	69.7 ^{b}	0.9
Egg wt. through 100 days (g)	55.8 ^{a}	39.6 ^{b}	0.4
Egg mass through 100 days (g)	4889 ^{a}	2756 ^{b}	49

^{a}, ^{b}Means followed by different letters ,in each row, differ significantly at P<0.05.

Table 2. Plasma P_4 (ng/ml), E_2 (pg/ml) and T_3 (ng/dl) hormones in LSL and Fayoumi hens at different productive stages

Item	P_4		E_2		T_3	
Age	LSL	Fayoumi	LSL	Fayoumi	LSL	Fayoumi
16 wks	0.106 ^{c}	0.138 ^{c}	39.76 ^{c}	40.33 ^{c}	237.0 ^{a}	191.7 ^{b}
18 wks	0.127 ^{c}	0.120 ^{c}	63.18 ^{c}	43.46 ^{c}	161.9 ^{b}	174.0 ^{b}
Sexual maturity	0.398 ^{b}	0.321 ^{b}	112.8 ^{b}	182.7 ^{ab}	91.0 ^{cd}	116.3 ^{c}
Peak	0.531 ^{a}	0.539 ^{a}	113.1 ^{b}	218.8 ^{a}	73.66 ^{d}	94.01 ^{cd}
S.E.	0.039		23.24		11.50	
Mean	0.291	0.280	82.22 ^{B}	123.13 ^{A}	140.89	144.00
S.E.	0.0190		11.62		5.75	

Means followed by different letters ,within each trait, differ significantly at $P<0.05$.

Average RBC's count (10^6/ mm^3), Hb concentration (g/ ml blood) and PCV value (%) significantly decreased with the progress of egg production in both breeds (Fig. 2). There was a significant increase in RBC's of Fayoumi hens at the peak of egg production (Table 3 and Fig. 2 a). In general, mean RBC's count, PCV percentage and Hb concentration were higher although not significantly in Fayoumi than in LSL hens (Table 3).

Table 3. RBC's count (10^6/mm^3), PCV (%) and Hb concentration (g/100 ml) in LSL and Fayoumi hens at different productive stages

Item	RBC's		PCV		Hb	
Age	LSL	Fayoumi	LSL	Fayoumi	LSL	Fayoumi
16 wks	3.06 ^{ab}	3.27 ^{a}	29.93 ^{b}	34.00 ^{a}	10.43 ^{ab}	11.09 ^{a}
18 wks	2.95 ^{bc}	2.73 ^{cd}	31.86 ^{b}	31.79 ^{b}	10.82 ^{a}	10.54 ^{ab}
Sexual maturity	2.49 ^{de}	2.41 ^{e}	26.86 ^{c}	25.57 ^{cd}	10.02 ^{b}	10.43 ^{ab}
Peak	2.30 ^{e}	2.93 ^{bc}	23.00 ^{e}	24.79 ^{de}	8.96 ^{c}	9.32 ^{c}
S.E.	0.11		0.66		0.22	
Mean	2.70	2.83	27.91 ^{B}	29.04 ^{A}	10.06	10.34
S.E.	0.05		0.33		0.11	

Means followed by different letters ,within each trait, differ significantly at $P<0.05$.

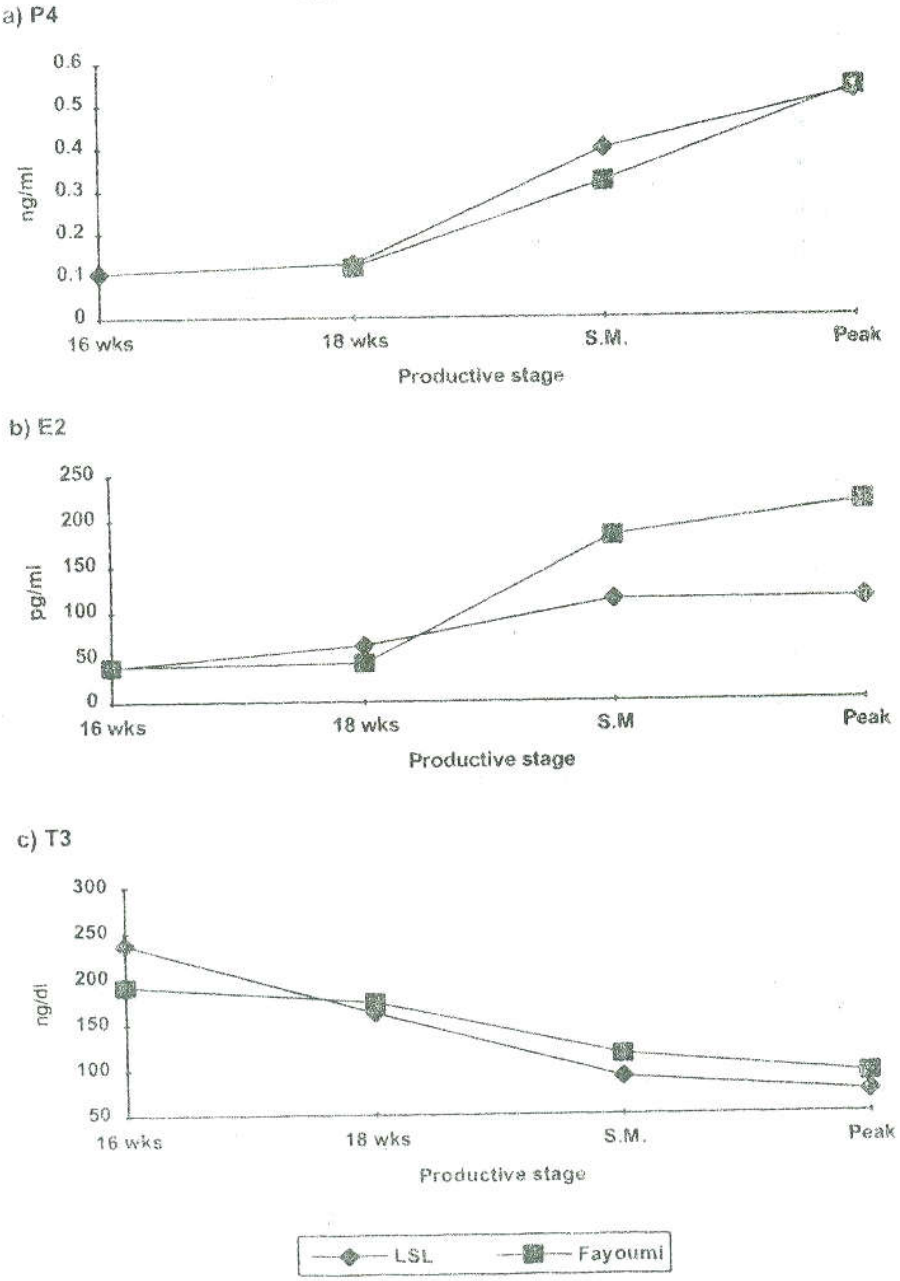

Figure 1 Plasma estradiol, progesterone and T_3 concentrations of LSL and Fayoumi hens

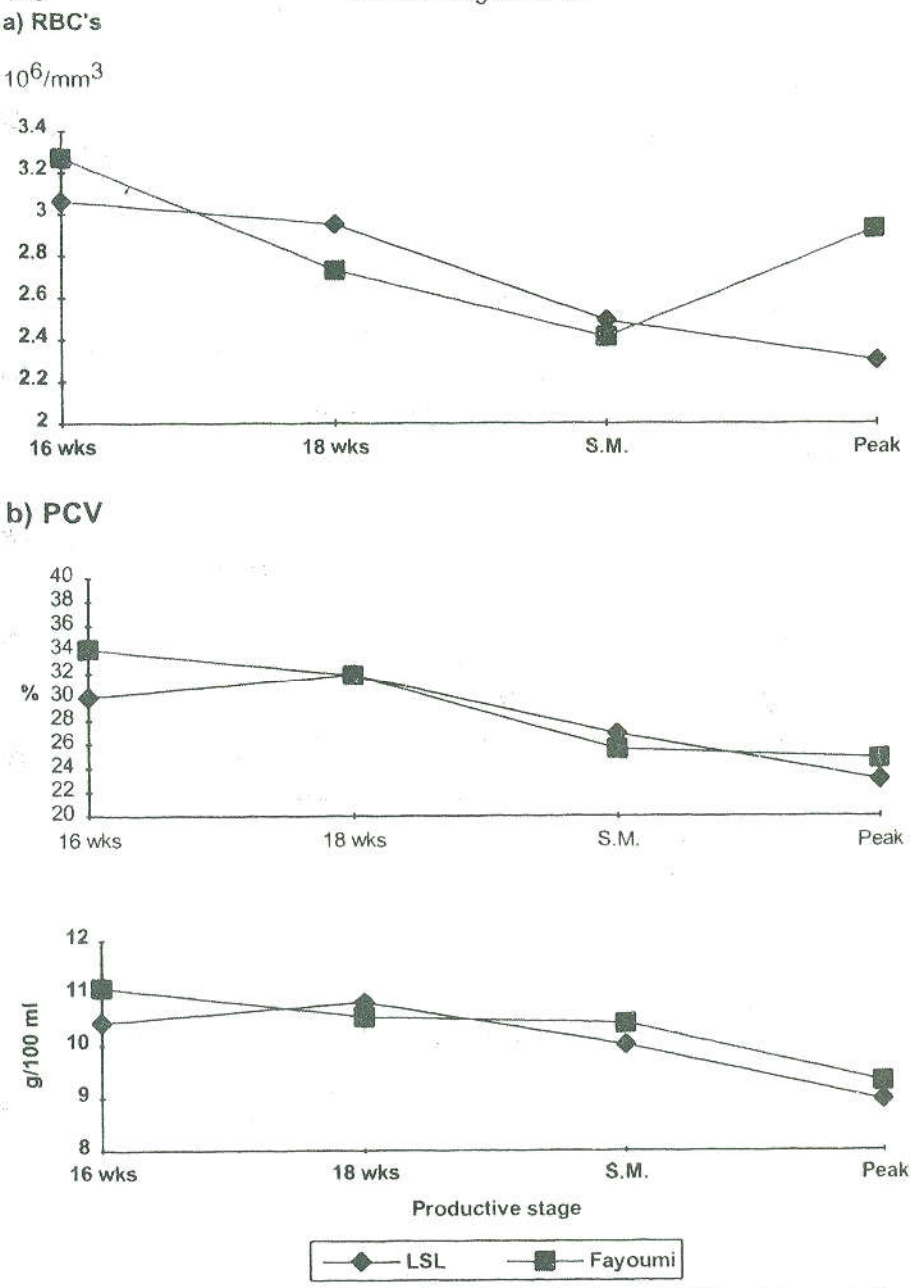

Figure 2. Red blood cell (RBC's) count, packed cell volume (PCV) and hemoglobin (Hb) concentration in LSL and Fayoumi hens.

DISCUSSION

The insignificant breed difference in the progesterone concentration in the present study was in agreement with Leszczynski *et al.* (1985). There was a tendency for high P_4 concentration for the LSL hens (the active producing breed) close at 18 weeks of age and at sexual maturity. The P_4 concentration in LSL plasma was 6% and 24% over that of Fayoumi plasma at 18 weeks of age and at sexual maturity, respectively. The increase in circulating level of P_4 in LSL hens at sexual maturity than Fayoumi may be related to the maturity of more ovarian follicles associated with the increased mass and number of granulosa cells (Etches, 1984). Moreover, there is evidence that the granulosa cells of not only the first follicle but also the second and third follicles have heightened sensitively to LH stimulus for P_4 synthesis and secretion in comparison with those from immature follicles (Hammond *et al.* 1981 and Calvo *et al.*, 1981).

The increase in Plasma P_4 concentration at sexual maturity (Fig. 1a) could be related to the increased release of gonadotropic hormones from pituitary gland. Mashaly and Wentworth (1974) found a relationship between the release of gonadotropic hormones and its stimulation of ovarian follicles progesterone secretion.

The significant increase in plasma E_2 concentration at sexual maturity and peak of egg production (Fig. 1b) may be due to the association between estradiol level, yolk-protein formation and deposition of egg shell calcium (Gruber, 1972). Tixier-Biochard *et al.* (1990) found that E_2 level peaked 2 wks before the first egg, remaining relatively constant thereafter . However, the significant differences between LSL and Fayoumi hens in plasma E_2 during the period from sexual maturity to the peak of egg production may be the reason for the difference in egg shell quality between the two strains (Shoukry, 1987). The higher production rate of LSL hens (20- 30 eggs per sequence) than Fayoumi (3- 5 eggs per sequence) might indicate that the ovary of Fayoumi hens has a high proportion of small follicles which mature at a slower rate than that of LSL hens. Yu *et al.* (1992) suggested that small follicles rather than large ones, are the main source of estrogen within the ovary of domestic fowl.

Data indicated that the advancement of hen productive stage is associated with a decrease in plasma T_3 hormone level. This result may be due to the effect of the thyroid hormone secretion rate during growth stage of birds. Sterling *et al.* (1984) found that plasma concentration of T_3 and T_4 were lower in adult than in juvenile birds. They added that the decrease in these hormones at sexual maturity and the peak of production may be due to the advance of productive status. However, Sharp and Klandorf (1981) attributed the decrease in T_3 hormone to the inverse relationship between gonadal steroid hormones and thyroid functions. The present results suggested rapid rate of thyroid hormone turnover to afford suitable metabolic conditions for egg production. The LSL, as high producing hens, showed greater decrease in plasma T_3, as egg production level increased, than the low producing Fayoumi hens .

The drop in RBC's count, PCV values and Hb concentration during the period immediately prior to the onset of laying was in harmony with the findings of Freeman (1971) and Wood *et al.* (1971). They suggested that the stage of production was the apparent factor which contributed to the significant higher count in the young versus that in the adult birds. Sturkie (1986) reported that Hb concentration was higher in

immature female, then it drastically decreased when they started laying. At the peak of egg production, RBC's of Fayoumi were significantly higher than those in LSL which may be due to the differences in their egg production level (Table 1). Freeman (1971) stated that RBC's count increased at the end of laying period due to the low rate of egg production. Sturkie and Textor (1960) and Nirmalan and Robinson (1972) reported that the decrease in these hematological traits at sexual maturity may be due to the high level of E_2 and P_4 and the low level of T_3 hormones.

It can be concluded that the changes in P_4, E_2 and T_3 hormones, RBC's count, Hb and PCV values before or at sexual maturity could be used as indicators to predict egg production stage. Moreover, such physiological traits could be used as a base for selection for genetic improvement in Fayoumi hens.

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العلاقة بين إنتاج البيض والإستراديول والبروجستيرون والتراى أيودوثيرونين فى البلازما وبعض مكونات الدم فى الدجاج البياض

نجوى عبد الهادى أحمد - أحمد عبد اللطيف الفار - مختار عبد الفتاح قيقة وجمال كامل محيسن

قسم الإنتاج الحيوانى - كلية الزراعة - جامعة القاهرة - الجيزة - مصر

إستخدمت مائة دجاجة بياضة LSL ومائة دجاجة فيومى عمر ثلاثة شهور لدراسة العلاقة بين إنتاج البيض والإستراديول والبروجستيرون والتراى أيودوثيرونين فى البلازما وبعض مكونات الدم الأخرى، وضعت الطيور فى بطاريات بصورة فردية وسجلت المقاييس الإنتاجية فى الفترة من النضج الجنسى وحتى قمة الإنتاج. كما قدر تركيز كل من هرمونات الإستراديول والبروجستيرون والتراى أيودوثيرونين فى بلازما الدم وأيضا تم تقدير عدد كرات الدم الحمراء ونسبة المكونات الخلوية وتركيز الهيموجلوبين فى الدم عند عمر ١٦ أسبوع و ١٨ أسبوع وعند النضج الجنسى وعند قمة إنتاج البيض. وكان دجاج LSL متفوقا فى إنتاج البيض وأبكر فى النضج الجنسى بسبعة وثلاثين يوما عن الفيومى. و أظهرت النتائج أن هناك زيادة معنوية فى مستوى هرمون البروجستيرون فى البلازما عند النضج الجنسى و استمرت هذه الزيادة حتى قمة إنتاج البيض فى كل من الدجاج الفيومى ودجاج LSL ، كما أرتفع مستوى هرمون الإستراديول فى البلازما إرتفاعا معنويا عند النضج الجنسى وبلغ أقصى مستوى عند قمة الإنتاج. وكان مستوى هرمون الإستراديول فى بلازما دم الدجاج الفيومى أعلى من دجاج LSL خلال الفترة من النضج الجنسى الى قمة الإنتاج. كما حدث إنخفاض فى مستوى هرمون التراى أيودوثيرونين مع تقدم الدجاج فى العمر . وكان مستوى هذا الهرمون أعلى معنويا فى دجاج LSL عن الدجاج الفيومى عند ١٦ أسبوع ثم حدث العكس بعد ذلك. ولوحظ إنخفاض فى العدد الكلى لكرات الدم الحمراء ونسبة المكونات الخلوية وتركيز الهيموجلوبين بتقدم عمر الدجاج وكانت القيم المسجلة للدجاج LSL أقل من منها فى الدجاج الفيومى. ويتضح من البحث وجود علاقة بين مستويات الهرمونات الثلاثة ومكونات الدم من ناحية وبين مرحلة إنتاج البيض فى كل من دجاج LSL والدجاج الفيومى.