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Haematological and biochemical values of the blood of pheasants (*Phasianus colchicus*) of different ages

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Abstract: This study was conducted to determine selected haematological and biochemical parameters of pheasants (*Phasianus colchicus*) bred in Konya city in Turkey. Forty-five healthy pheasants of different ages (1, 5, and 12 months old) were examined. In the blood samples taken from these animals, haematological and biochemical values were determined. Comparing the haematological and biochemical parameters among the age groups, red blood cell counts, haemoglobin amount, haematocrit values, lymphocyte percentage, and total protein and albumin levels increased with the advancement of age. However, glucose, length and width of erythrocyte, length and width of erythrocyte nucleus, and percentages of monocyte and basophile decreased with the advancement of age. Furthermore, the white blood cell counts of the chick and the adults, the plasma total cholesterol and triglyceride of the adults, and the plasma uric acid levels of the chicks were lower than those of the young pheasants. However, thrombocyte count of the chicks was higher than that of the young pheasants. The other parameters investigated, such as mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, the percentages of heterophils and eosinophils, and the plasma levels of aspartate aminotransferase, alanine aminotransferase, creatinine, and creatine kinase did not show significant differences related to age. Based on the results, it was concluded that some haematological and biochemical values were influenced by age differences of the pheasants and the data obtained in this study could be useful to establish some baseline values about haematological and biochemical parameters in pheasants.

Key words: Pheasant, haematological parameters, biochemical parameters

Farklı yaşlardaki sülünlerde (*Phasianus colchicus*) hematolojik ve biyokimyasal parametreler

Özet: Bu araştırma, Konya bölgesinde yetiştirilen sülünlerde bazı hematolojik ve biyokimyasal parametrelerin belirlenmesi amacıyla yapıldı. Çalışmada materyal olarak farklı yaşlarda (1, 5 ve 12 aylık) 45 sağlıklı sülün kullanıldı. Yaş grupları arasında hematolojik ve biyokimyasal parametreleri karşılaştırıldığında; alyuvar sayısı, hematokrit değeri, hemoglobin miktarı, lenfosit yüzdesi, total protein ve albümin seviyesi yaşla birlikte arttı. Buna rağmen glikoz, alyuvar boyu ve eni, alyuvar çekirdek boyu ve eni, monosit ve bazofil yüzdeleri yaşla birlikte azaldı. Ayrıca, civciv ve anaçların akyuvar sayısı, anaçların plazma total kolesterol ve trigliserit seviyesi ve civcivlerin plazma ürik asit miktarı palaz sülünlerinkinden daha düşüktü. Fakat civcivlerin trombosit sayısı palazlarınkinden daha yüksekti. Ortalama alyuvar hacmi, ortalama alyuvar hemoglobini, ortalama alyuvar hemoglobin derişimi, heterofil ve eozinofil yüzdesi, plazma aspartat aminotransferaz, alanin aminotransferaz, kreatinin, kreatinin kinaz konsantrasyonları gibi diğer araştırılan parametreler yaşla ilişkili önemli farklılıklar göstermedi. Sonuç olarak, sülünlerde yaş farklılıklarının bazı hematolojik ve biyokimyasal değerleri etkilediği ve elde edilen verilerin sülünlerin hematoljik ve biyokimyasal parametreleri ile ilgili bazı temel değerleri ortaya koyması bakımından faydalı olabileceği kanaatine varıldı.

Anahtar sözcükler: Sülün, hematolojik parametreler, biyokimyasal parametreler

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Introduction

The ring-necked pheasant (*Phasianus colchicus*) is the most suitable species for meat production. It originates from central and eastern Asia, and has been introduced nearly worldwide including North and South America, Europe, Australia, and New Zealand. The massive production of this species is increasing in many countries (1)

They have recently reached large numbers as an alternative poultry sector in farm animals bred for meat production. The developing pheasant industry has been thought to be the cause of flock problems such as viral, parasitic, and bacterial infections in related farming (2,3).

The determination of haematological parameters and plasma metabolite levels may provide highly valuable information on the physiological state and form the cornerstone of the medical diagnosis of diseases (4,5). Clinical haematology and blood chemistry are known to be influenced by various factors such as diseases, nutritional status, body condition, sex, age, diet, circadian rhythms, and captivity (6). Therefore, knowledge of the blood constituents in birds is a relevant diagnostic tool in veterinary medicine, and these values can be used as physiological indicators (7). Additionally, different analyses (e.g., uric acid versus BUN) for haematological and biochemical values in birds compared with mammals due to the physiological and anatomical differences can be used. For this reason, it is also important to make appropriate interpretation of these parameters used in avian medicine (5).

The purpose of the present study was to present baseline values of selected blood haematological and biochemical parameters used as diagnostic tools in avian medicine in healthy pheasants (*Phasianus colchicus*) of different ages.

Materials and methods

Fifteen chicks (1 month old; 7 males and 8 females), 15 young pheasants (5 months old; 7 males and 8 females) and 15 adult pheasants (12 months old; 7 males and 8 females) were obtained from the farm of the Veterinary Medicine Faculty of Selçuk University. These 45 healthy pheasants (*Phasianus colchicus*) were used as materials in the study.

The pheasants were housed in a floor pen. Feed and water were provided ad libitum. The chicks received a turkey starter diet containing 28% crude protein and 3100 kcal ME/kg for the first 4 weeks; thereafter, a turkey grower diet containing 22% crude protein and 3100 kcal ME/kg was given. All animals were placed in a temperature controlled room at 32 °C. The temperature of the room was reduced 2 °C every week up to 4 weeks of age. After the fourth week, no heating was applied. For the first 4 weeks 24 h, and then until the end of the sixth week 22 h of light/day was provided in the room where the animals were placed. After the sixth week daylight was continuous.

For biochemical and haematological analyses approximately 3 mL blood samples were taken in a syringe with added ethylenediaminetetraacetic acid (EDTA) from the heart of the pheasants. All samples were collected between the same hours (1000 to 1100) to minimize any variation in blood chemicals caused by the circadian rhythm. The blood collection tubes were kept on ice in cool containers to avoid denaturation of proteins, and were taken to the laboratory within 2 h of blood withdrawal. While haematological parameters were determined immediately, the blood samples were centrifuged at 3000 rpm for 10 min and plasma was stored at –20 °C until used for biochemical analyses.

Plasma concentrations of total cholesterol (T.CHOL), triglyceride (TG), creatinine (CR), creatine kinase (CK), glucose, aspartate aminotransferase (AST), alanine aminotransferase (ALT), uric acid (UA), total protein (TP), and albumin (ALB) were determined on a computer process-controlled multiparametric autoanalyser (Tokyo boeki, TMS 1024) by using commercial kits (sprinreact SA, Spain).

In the laboratory, the microcapillary tubes were centrifuged at 13,000 rpm for 5 min and the haematocrit values was determined directly in a microhaematocrit reader. The red blood cell (RBC), white blood cell (WBC), and thrombocyte counts were determined with a haemocytometer using Natt-Herrick solution; haemoglobin amounts were measured by Sahli's haemoglobinometer; the mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular

haemoglobin concentration (MCHC) were calculated; differential leukocyte counts were determined. The morphometric determination of average RBC and their nucleus length and width were measured from selected smears using a micrometer (Nikon®, Japan). For this purpose, the smears were stained with May-Grünwald and Giemsa solutions; then the cells were examined using a 100× objective (oil immersion) and their dimensions including cell width (CW), cell length (CL), nucleus width (NW), and nucleus length (NL) were estimated by means of a calibrated eyepiece as described by Konuk (8).

Data for parameters were grouped and expressed as mean ± SD. The means obtained in the different age groups in the pheasants were subjected to analysis of variance; if appropriate ($P < 0.05$), post hoc analyses were carried out using Duncan's test for multiple comparisons. Statements of statistical significance are based on $P < 0.05$ (9).

Results

In chicks, and young and adult pheasants, the values for RBC, haemoglobin, haematocrit, MCV, MCH, MCHC, and erythrocyte dimensions are shown in Table 1. The findings of WBC, differential leukocyte, and thrombocyte count are given in Table 2. The plasma concentration of cholesterol, triglyceride, creatinine, CK, glucose, AST, ALT, UA, TP, and ALB are given in Table 3.

Discussion

Reference intervals for haematological and biochemical parameters have been determined and reported in most domestic avian species (8,10). However, only a few studies on the haematology and blood chemistry values for the pheasants have been published so far (1,2,4). The haematological and blood biochemical parameters are routinely used to

Table 1a. Selected haematological parameters in chicks, and young and adult pheasants (n: 15 per group).

Age	RBC ($\times10^6$/mm^3)	HG (g/dL)	HT (%)	MCV (m^3)	MCH (pg)	MCHC (%)	Erythrocyte Dimensions (m)			
							CW	CL	NW	NL
Chick	1.96 ± 0.5^{b}	7.8 ± 0.8^{b}	28.6 ± 4.7^{b}	153 ± 40	41.7 ± 9.5	27.8 ± 3.4	6.92 ± 0.2^{a}	12.55 ± 0.4^{a}	2.75 ± 0.2^{a}	5.48 ± 0.1^{a}
Young	2.42 ± 0.5^{a}	9.1 ± 1.5^{a}	33.3 ± 4.3^{a}	143 ± 33	38.6 ± 7.1	27.8 ± 5.1	6.80 ± 0.3^{a}	11.84 ± 0.4^{b}	2.66 ± 0.2^{ab}	5.04 ± 0.2^{b}
Adult	2.61 ± 0.5^{a}	9.5 ± 1.5^{a}	35.7 ± 4.8^{a}	139 ± 16	36.9 ± 3.4	26.7 ± 2.4	6.58 ± 0.2^{b}	11.85 ± 0.4^{b}	2.57 ± 0.2^{b}	4.85 ± 0.2^{c}

$^{a, b, c}$ Values in each group as individual within columns with no common superscripts are significantly different ($P < 0.05$), according to Duncan's multiple range test.

Table 1b. Selected haematological parameters in pheasants of different age and sex (7 males (M) and 8 females (F) per group).

Age	Gender	RBC ($\times10^6$/mm^3)	HG (g/dL)	HT (%)	MCV (m^3)	MCH (pg)	MCHC (%)	Erythrocyte Dimensions (m)			
								CW	CL	NW	NL
Chick	M	1.82± 0.4^{b}	7.6± 0.7^{b}	27.9± 5^{c}	160± 46	43.7± 11	27.7± 4	6.87± 0.3a^{b}	12.6± 0.4^{a}	2.73± 0.2^{a}	5.48± 0.1^{a}
	F	2.12± 0.5^{ab}	8.1± 0.9^{ab}	29.4± 4^{c}	144± 33	39.6± 6	27.9± 3	6.97± 0.2^{a}	12.5± 0.4^{a}	2.77± 0.2^{a}	5.49± 0.1^{a}
Young	M	2.36± 0.5^{ab}	9.0± 1.7^{ab}	35.5± 4^{ab}	156± 36	39.4± 9	25.8± 6	6.85± 0.4^{ab}	11.8± 0.4^{b}	2.69± 0.2^{ab}	5.10± 0.2^{b}
	F	2.48± 0.5^{a}	9.2± 1.4^{a}	30.7± 3^{bc}	127± 21	37.7± 4	30.0± 2	6.74± 0.2^{ab}	11.9± 0.3^{b}	2.63± 0.2^{ab}	4.97± 0.2^{bc}
Adult	M	2.55± 0.5^{a}	9.4± 1.6^{a}	35.4± 5^{ab}	141± 16	37.1± 4	26.5± 2	6.58± 0.2^{b}	12.0± 0.4^{b}	2.61± 0.2^{ab}	4.85± 0.2^{c}
	F	2.67± 0.5^{a}	9.7± 1.5^{a}	36.0± 5^{a}	137± 16	36.7± 3	27.0± 3	6.58± 0.2^{b}	11.7± 0.4^{b}	2.52± 0.2^{b}	4.86± 0.2^{c}

$^{a, b, c}$ Values in each group as individual within columns with no common superscripts are significantly different ($P < 0.05$), according to Duncan's multiple range test.

Table 2a. WBC, differential leukocyte counts, and thrombocyte count in chicks, and young and adult pheasants (n: 15 per group).

Age	WBC ($\times 10^3/mm^3$)	Differential leukocyte counts (%)					Thrombocyte ($\times 10^3/mm^3$)
		Heterophil	Lymphocyte	Monocyte	Eosinophil	Basophil	
Chick	21.1 ± 7.0 [b]	28.3 ± 8.6	62.0 ± 9.2 [b]	4.4 ± 2.0 [a]	3.2 ± 2.0	2.13 ± 1.1 [a]	36.3 ± 11 [a]
Young	30.5 ± 7.4 [a]	24.2 ± 12.0	68.5 ± 12.8 [ab]	3.1 ± 1.7 [b]	2.9 ± 1.7	1.40 ± 1.2 [ab]	29.1 ± 6 [b]
Adult	24.6 ± 8.0 [b]	21.1 ± 11.3	73.3 ± 11.1 [a]	2.5 ± 1.1 [b]	2.4 ± 1.1	0.73 ± 0.7 [b]	31.2 ± 9 [ab]

[a, b,] Values in each group as individual within columns with no common superscripts are significantly different ($P < 0.05$), according to Duncan's multiple range test.

Table 2b. WBC, differential leukocyte counts, and thrombocyte count in pheasants of different age and sex (7 males (M) and 8 females (F) in per groups).

Age	Gender	WBC ($\times 10^3/mm^3$)	Differential leukocyte counts (%)					Thrombocyte ($\times 10^3/mm^3$)
			Heterophil	Lymphocyte	Monocyte	Eosinophil	Basophil	
Chick	M	20.8 ± 7 [c]	28.4 ± 9	62.1 ± 9 [b]	3.8 ± 2 [ab]	3.1 ± 2	2.6 ± 1.2 [a]	38.5 ± 12 [a]
	F	21.4 ± 7 [bc]	28.1 ± 9	61.9 ± 10 [b]	5.1 ± 2 [a]	3.3 ± 2	1.6 ± 0.8 [ab]	33.9 ± 11 [ab]
Young	M	30.6 ± 9 [a]	24.4 ± 11	68.3 ± 13 [ab]	3.1 ± 2 [b]	2.9 ± 2	1.4 ± 1.5 [b]	30.0 ± 7 [ab]
	F	30.4 ± 6 [a]	24.0 ± 14	68.7 ± 14 [ab]	3.0 ± 1 [b]	2.9 ± 1	1.4 ± 1.0 [b]	28.0 ± 5 [b]
Adult	M	28.8 ± 8 [ab]	24.8 ± 12	69.4 ± 11 [ab]	2.8 ± 1 [b]	2.3 ± 1	0.9 ± 0.8 [b]	34.1 ± 10 [ab]
	F	19.9 ± 4 [c]	17.0 ± 9	77.7 ± 11 [a]	2.1 ± 1 [b]	2.6 ± 1	0.6 ± 0.5 [b]	27.9 ± 6 [b]

[a, b,c] Values in each group as individual within columns with no common superscripts are significantly different ($P < 0.05$), according to Duncan's multiple range test.

Table 3a. Selected biochemical parameters in chicks, and young and adult pheasants (n: 15 per group).

Age	T.CHOL (mg/dL)	TG (mg/dL)	AST (U/L)	ALT (U/L)	GLU (mg/dL)	CR (mg/dL)	CK (U/L)	UA (mg/dL)	TP (g/dL)	ALB (g/dL)
Chick	94.9 ± 22[ab]	82.2 ± 18[ab]	270 ± 33	18.07 ± 5.4	260.3 ± 45[a]	0.220 ± 0.11	3824 ± 111	3.07 ± 0.94[b]	3.12 ± 0.88[b]	1.93 ± 0.51[b]
Young	102.9 ± 24[a]	90.8 ± 22[a]	261 ± 37	19.93 ± 9.0	244.6 ± 83[ab]	0.313 ± 0.14	3720 ± 143	4.16 ± 1.70[a]	3.73 ± 0.78[a]	2.18 ± 0.46[b]
Adult	82.7 ± 18[b]	69.5 ± 15[b]	246 ± 54	15.20 ± 5.0	209.7 ± 58[b]	0.247 ± 0.12	3409 ± 107	3.77 ± 1.40[ab]	4.19 ± 0.75[a]	2.55 ± 0.50[a]

[a, b] Values in each group as individual within columns with no common superscripts are significantly different ($P < 0.05$), according to Duncan's multiple range test.

Table 3b. Selected biochemical parameters in pheasants of different age and sex (7 males (M) and 8 females (F) per group).

Age	Gender	T.CHOL (mg/dL)	TG (mg/dL)	AST (U/L)	ALT (U/L)	GLU (mg/dL)	CR (mg/dL)	CK (U/L)	UA (mg/dL)	TP (g/dL)	ALB (g/dL)
Chick	M	96.3 ± 24	83.9 ± 18 ^{ab}	273 ± 27	19.0 ± 6 ^{ab}	260 ± 43	0.238 ± 0.13 ^{b}	4004 ± 896	3.04 ± 0.9 ^{b}	3.30 ± 0.9 ^{b}	1.96 ± 0.5 ^{b}
	F	93.4 ± 21	80.3 ± 20 ^{b}	267 ± 42	17.0 ± 4 ^{ab}	260 ± 51	0.200 ± 0.08 ^{b}	3618 ± 1360	3.10 ± 1.1 ^{b}	2.91 ± 0.9 ^{b}	1.89 ± 0.5 ^{b}
Young	M	106.1 ± 23	80.9 ± 23 ^{b}	269 ± 39	23.0 ± 10 ^{a}	243 ± 71	0.388 ± 0.12 ^{a}	4201 ± 1612	4.95 ± 1.7 ^{a}	3.69 ± 1.0 ^{b}	2.15 ± 0.6 ^{b}
	F	99.3 ± 27	102.1 ± 16 ^{a}	252 ± 36	16.4 ± 6 ^{ab}	247 ± 100	0.229 ± 0.09 ^{b}	3170 ± 1030	3.27 ± 1.3 ^{b}	3.77 ± 0.6 ^{b}	2.21 ± 0.3 ^{b}
Adult	M	83.3 ± 22	73.6 ± 15 ^{b}	262 ± 50	16.5 ± 5 ^{ab}	217 ± 58	0.263 ± 0.13 ^{b}	3542 ± 1402	3.65 ± 1.6 ^{ab}	4.63 ± 0.5 ^{a}	2.81 ± 0.4 ^{a}
	F	82.0 ± 16	64.9 ± 15 ^{b}	228 ± 55	13.7 ± 4 ^{b}	201 ± 61	0.229 ± 0.11 ^{b}	3257 ± 565	3.92 ± 1.3 ^{ab}	3.69 ± 0.7 ^{b}	2.26 ± 0.5 ^{b}

^{a,b,} Values in each group as individual within columns with no common superscripts are significantly different ($P < 0.05$), according to Duncan's multiple range test.

determine the health status of the body in caged birds and to reveal stresses created by various reasons such as environmental, nutritional, and pathological factors (4,11-14). These parameters are also influenced by species, age, sex, season, geographical area, diet, and physiological status (6,7,15). For that reason, the main objective of this study was to determine normal baseline values for selected haematological parameters and blood chemistries in chicks, and young and adult pheasants.

The values for the RBC counts, haemoglobin concentrations, and haematocrit values were in accordance with those previously reported by Schmidt et al. (1) for pheasants, and by Keskin et al. (16) and Pica et al. (17) for partridges, but all of these parameters were, however, lower than those observed by Lloyd and Gibson (2) and Hauptmanova et al. (4) for pheasants and by Rico et al. (18) for adult partridges. In addition, although these parameters of the pheasants were within the range of most avian species such as the hen (19), chicken, turkey (8), quail (20), and ostrich (12), the same values were lower than those determined for the pigeon guillemot (*Cepphus columba*) (21) and macaw (*Ara rubrogenys*) (22). It was observed from the present findings that the RBC counts, haemoglobin amounts, and haematocrit values increased with the advancement of age, being lowest in the chicks and highest in the adults (Table 1). The age-related findings were substantiated by reports by Schmidt et al. (1) for pheasants, Palomeque et al. (12) for ostriches, Keskin et al. (20) for Japanese quails, Puerta et al. (23) for storks, and Islam et al (15) for chickens, but it was in contrast with those reported for partridges by Keskin et al. (16), who did not find any age-related differences. This may be ascribed to differences in avian species, the management procedure, and the physical and environmental conditions. The age-related increase in these values might be due to the greater oxygen demand for activity. Moreover, Palomeque et al. (12) reported that the increased haemoglobin content per unit of volume of blood may have been a reflection of the decreased volume of blood per unit body weight. Moreover, while the findings in the present study for the average RBC length and width with the average nucleus length and width were slightly lower than those reported by Palomeque et al. (12) for ostriches. These values were slightly larger than the findings published Keskin et al. (16) for partridges. In addition, our results were similar to those previously reported for some avian species such as the hen, goose, duck (8) and quail (20), but it was seen that the erythrocyte size of pheasants like other birds was larger when compared with other vertebrate classes (24). These differences are a physiological advantage for gas exchange in birds (25). It was determined from the present results that erythrocyte dimensions decreased with the advancement of age, being lowest in adults and highest in chicks (Table 1). The age-related findings were in agreement with those reported by Keskin et al. (20) for quails, but it was in contrast with others

reported by Keskin et al. (16), who did not show differences with age for partridges.

The average WBC counts found in this study were within the normal limits of the common range (15-30 $\times$ 10^3 cells/mm^3) listed for the majority of avian species (8,24). Total WBC numbers was significantly higher in the young pheasants than in the adults and chicks. Although some authors have reported similar results for various avian species such as pheasants (1), ostriches (26), pigeon guillemots (21), Keskin et al. (16) did not detect differences in WBC with age at partridges. The differential leukocyte counts differ among avian species (7,23,24). We observed lymphocytes as the main WBC type in the pheasants. Results determined from the pheasant were consistent with previously reported values in most other avian species such as the pheasant, partridge, hen, chicken, and quail (1,2,4,8,24), but those findings were in contrast with the reports by some authors in other avian species such as the ostrich (26), pigeon (21), macaw (22), and stork (23). In the present study, while the adults had a greater lymphocyte percentage and a lower basophil percentage than the chicks ($P < 0.05$), chicks had a higher monocyte percentage than the adults and young pheasants.

Thrombocytes were usually clumped and so it was very difficult to count them accurately. No information about the thrombocyte count of the pheasants was found. However, in comparison to various avian species, it was observed that the thrombocyte count of the pheasants had a close similarity with those described for some species such as the partridge (17), quail, macaw (22), hen, goose, and quail (8), but it was significantly lower than that of the stork (23). Furthermore, we found that the chicks presented higher thrombocyte counts than the young pheasants, but these values of the chicks were not significantly different than those of the adults (Table 2).

Mean plasma total cholesterol and triglyceride levels of the pheasants were found to be close to the ranges previously determined in various avian species such as the pheasant (2,27), quail (20), broiler (28), turkey (11) and ostrich (26). Nevertheless, the mean total cholesterol concentration was below the values reported by Rico et al. (18) and Woodard et al. (10) in partridges. The cholesterol metabolism in avian species is similar to that of mammals, but plasma cholesterol level can significantly increase during vitellogenesis and egg formation in birds (5). It was reported that wide variation of cholesterol and triglyceride levels among avian species may depend on the circadian rhythms and the effect of diet (5,12,29). Both compounds are influenced by diet, and animal-protein-rich diets cause low plasma cholesterol and triglyceride levels (29). In this investigation, both plasma total cholesterol and triglyceride concentrations were significantly higher in the young pheasants than in the adults. This difference may be related to the energy reserves required for growth and maturation. Similar findings were observed by Palomeque et al. (12), who showed high levels of cholesterol in juveniles when compared with adults. Moreover, Keskin et al. (20) have noted that Japanese quails 8 weeks of age had higher cholesterol level than quails 1 week of age.

Since plasma enzymes are characterised by a very wide range of activity, the interpretation of variations of these enzymes is difficult. Nevertheless, these enzymes may be adversely affected by factors such as muscular injury, rupture of organs, nutritional status, physical activity, hemolysis, treatment, and conservation of plasma samples, and their levels in blood can increase and these enzymes can be an important diagnostic tool in veterinary medicine (5,7,14). AST activity currently is considered a very sensitive but nonspecific indicator of hepatocellular disease in avian species, and is frequently used with the muscle-specific enzyme creatine kinase to differentiate between liver and muscle damage. ALT activity differs in several tissue according to species. This enzyme is found in hepatocyte cytosol as well as in muscle and other tissues of birds. For this reason, ALT has poor diagnostic value in organopathies (5,7). In this study, the mean plasma AST, ALT, and CK concentrations of pheasants were a little higher than the ranges previously described for broilers (28), macaws (22), canaries, ducks, partridges, and pigeons (5). It was considered that the high values are probably due to muscular activity during restraint of the birds for the collection of blood specimens. On the other hand, there were no significant differences in AST, ALT, or CK activity among the age-related groups of the pheasants in the present study.

Uric acid and urea are the main products of the nitrogen metabolism of birds. Uric acid is the major nitrogenous waste product of birds (5,7,14). In land birds, uric acid is the main nitrogen waste (90%) and ammonia comprises only 3%-4%. However, in water birds, like ducks, uric acid comprises only 50% of the nitrogen waste and ammonia 30% (30). Furthermore, in raptors, blood uric acid levels are similar to or lower than urea concentrations (25). Since avian species are urecotelic, it was reported that urea nitrogen is not a useful test of renal function in birds (12). Plasma uric acid levels were close to those levels in the previous literature for pheasants (1). Although there is a great variability across different species of birds, uric acid level was similar to those reported by previous authors for most avian species (5,18). In the present study, plasma uric acid levels of the young pheasants were higher than those of the chicks ($P < 0.05$). These higher values were possibly due to high protein content in the feed. Starvation decreases the levels of uric acid in plasma and increases the ammonia levels. In addition, serum uric acid level changes with water consumption and impaired renal function (14). Creatinine level is normally low in birds (5). Creatinine is an important indicator of protein metabolism and renal integrity. Derived from the breakdown of phosphocreatinine in muscle, creatinine increases with high levels of activity, such as flying, and is influenced by diet. The values determined in this study were within the range recorded by Rico et al. (18) for partridges, Harr et al. (5) for pigeons, and Quintavalla et al. (14) for ostriches, and did not differ significantly among the chicks, and young and adult pheasants.

Plasma glucose, total protein, and albumin concentrations measured in this study were close to those previously reported for various avian species such as the pheasant (1,2,27), pigeon (21), duck, canary (5), wild turkey (11), partridge (10,18), macaw (22), Japanese quail (20), and ostrich (12). In our investigation, the total protein and albumin values increased with age. This may be ascribed to their greater demand for proteins and amino acids during growth for the chicks and young pheasants. Glucose concentration varies widely among avian species, and it was documented that this could be due to the absorptive state of the animal, age, gender, different time of day, stress, starvation, or feeding time (5,12). Age had a significant effect on glucose level, and glucose in the chicks was significantly higher than that in the adults ($P < 0.05$).

In conclusion, the results of this study may be useful as a complementary diagnostic tool in clinical evaluations of pheasants, and could contribute to physiological knowledge on some baseline values of haematological and biochemical parameters in chicks, and young and adult pheasants.

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