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Hematological and Some Biochemical Values of Indigenous Chickens in Al-Ahsa, Saudi Arabia During Summer Season

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ABSTRACT

The uses of hematological and biochemical parameters in disease diagnosis are well documented. However, sex, age and nutrition are the major factors affecting avian hematology. The measurement of these parameters in relation to age and sexes in local Saudi chickens are limited. Therefore, a total of 80 local Saudi chickens of different age and sexes in summer season were divided into 4 groups. First and second groups constitute male chicks of one and three months old (n = 20 for each). Chicks of the third and fourth groups were females of one and three months old (n = 20 for each). The collected blood and separated plasma were used for determination of hematological and some biochemical parameters, respectively. Total Erythrocyte Counts (TEC), Total Leucocytes Counts (TLC) and Packed Cell Volume (PCV) were significantly ($p \leq 0.05$) higher in male than female chicks and were not age dependant. Hemoglobin and blood indices were not significantly ($p > 0.05$) differed in all birds. They were ranged as 9.5-11.7 g dL^{-1}, 97-108 m^3, 30.7-34.1 pg and 28.6-34.3%, respectively. The percentage of heterophil, lymphocyte, monocyte, eosinophil and basophile were age and sex independent in addition, their values are ranged as 41.8-46.2, 43.2-48.8, 3.9-4.9 and 3.1-4.4%, respectively. The examined biochemical parameters were comparable in all birds. In conclusion, sex in local Saudi chickens in summer season influenced on TEC, TLC and PCV. These results can be a guide for scientists in the Kingdom of Saudi Arabia on changes of hematological and some biochemical value during hot the summer season.

Key words: Local chicken, hematology, biochemistry, plasma, summer season, avian hematology

INTRODUCTION

Indigenous Saudi chickens have been raised in rural villages in Al-Ahsa for a long time. These birds are important to low-income people who live in the rural part of Al-Ahsa region. The poor performance of local Saudi chicken was reported (Al-Aqil, 1998). Dietary inclusion of 1.5% arginine and 1.2% lysine improved the egg productivity in this breed (Najib and Basiouni, 2004). The importance of hematological and biochemical parameters as diagnostic tools and physiological indicators in birds has been documented (Perelman, 1999; Harr, 2002; Hauptmanova *et al*., 2006). However, these parameters are greatly affected by sex, age and season (Fudge, 2000; Kececi and Col, 2011). Metabolic end product of protein metabolism is different in birds (uric acid) than that of mammals (blood urea nitrogen) which give the analyses of such metabolites in bird's great importance (Harr, 2002). Hematological and biochemical values were reported in many species of birds, particularly African and Asian reared chicken during summer season (Simaraks *et al*., 2004; Pampori and Iqbal, 2007; Ladokun *et al*., 2008; Melesse, 2011). In the other hand, many

researchers have evaluated normal hematological parameters of industrial and commercial hybrid chickens (Meluzzi *et al*., 1992; Talebi *et al*., 2005; Abdi-Hachesoo *et al*., 2011). However, there is no information about the hematology of Indigenous Saudi chicken. Therefore, this study was carried out to investigate hematology and some blood chemistry of local Saudi chickens during summer season.

MATERIALS AND METHODS

Birds: A total of 80 local Saudi chickens were used in the current experiment. Birds were divided into 4 groups. First group constitute male chicks of one month old (n = 20). Second group constitute male chicks of three month old (n = 20). Chicks of the third group were females of one month old (n = 20) while chicks of the fourth group were females of three months old (n = 20). The chicks were obtained from the farm of the Veterinary Research Station, King Faisal University, Al-Ahsa, Saudi Arabia. Blood samples were collected from all groups in heparinized tubes during summer season. The local Saudi chickens were housed in a floor pen. Feed and water were provided *ad libitum*. The ambient temperature and relative humidity during the experiment were 40°C±2 and 60±2, respectively.

Sample collection: Approximately 3 mL blood samples were taken from the brachial vein in heparinized tubes. All samples were collected between the same hours (09:00 a.m. to 10:00 a.m.) to avoid the effect of 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. Plasma was stored at -20°C until the time of analyses.

Samples analysis: Blood samples were analyzed within 2 h of their collection for Total Erythrocyte Counts (TEC), Packed Cell Volume (PCV), hemoglobin (Hb) and differential leucocytes count according to the methods described by Dein (1984). Hemoglobin amounts were measured by Sahli's haemoglobinometer. Total Leucocytes Counts (TLC) was done in a haemocytometer chamber with Natt and Herric diluents (Natt and Herrick, 1952) to obtain a 1:200 blood dilution. Packed Cell Volume (PCV) was measured as micro haematocrit with 75×16 mm capillary tubes filled with blood and centrifuged at 2500 rpm for 5 min. The Differential leukocyte counts were made on monolayer blood films prepared and fixed in absolute methanol for 2 to 5 min. They were subsequently stained with May Grunwald Giemsa (Dacie and Lewis, 1975) and examined under a light microscope. Cells were classified as described by Lucas and Jamroz (1961). Mean corpuscular volume (MCV), Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC) were calculated from TEC, PCV and Hb (Ritchie *et al*., 1994), as:

$$MCV = \frac{\text{Hematocrite value} \times 10}{\text{Erythrocyte count}}$$

$$MCH = \frac{\text{Hemoglobing } L^{-1} \times 10}{\text{Erythrocyte count}}$$

and

$$MCHC = \frac{\text{Hemoglobing } L^{-1} \times 100}{\text{Hematocrite value}}$$

Commercial diagnostic kits (United Diagnostic Industry, UDI, Dammam, Saudi Arabia) were used for determination of total proteins (EP56-660), Albumin (EP03-570), Uric acid (EP61-620), Calcium (EP22-660), Phosphorus (EP46-660), on ELIPSE full automated chemistry analyzer (Rome, Italy). Concentration of the biochemical constituents was calculated according to the manufacture instruction.

Statistical analysis: Data for parameters were grouped and expressed as Mean±SD. Statements of statistical significance are based on $p<0.05$ (SAS, 2002).

RESULTS

The findings of the present study indicated that, some hematological values such as TEC, TLC and PCV were high in male compared with the female birds (Table 1, 2). However age of the birds did not affect these values. In the other hand, both age and sex did not affect the determined values of Hb, MCV, MCH, MCHC and all leucocytes types in all birds (Table 1).

As presented in Table 1, the present findings indicate that, TEC, TLE and PCV were significantly ($p\leq0.05$) higher in male than female. TEC in young ($3.5\pm0.7\times10^6$ mm^{-1}) and adult ($3.3\pm0.4\times10^6$ mm^{-1}) males were significantly ($p\leq0.05$) higher than young and adult females ($2.9\pm0.2\times10^6$ mm^{-1}). TLC in young ($29.5\pm1.4\times10^3$ mm^{-1}) and adult ($30.6\pm1.5\times10^3$ mm^{-1}) males were significantly ($p\leq0.05$) higher than young ($27.7\pm2.4\times10^3$ mm^{-1}) and adult ($26.8\pm1.2\times10^3$ mm^{-1}) females. PCV in young (34.5±4.9%) and adult (35.7±4.5%) males were significantly ($p\leq0.05$) higher than young (29.7±4%) and adult (28.4±3.5%) females. In addition, the determined values of TEC, TLC and PCV were not significantly ($p>0.05$) influenced by the age. Hemoglobin, MCV, MCH and MCHC were not significantly differed in all examined group. That means that, these values were age and sex independent. The values of Hemoglobin, MCV, MCH and MCHC were ranged as 9.5-11.7 g dL^{-1}, 97-108 m^3, 30.7-34.1 pg and 28.6-34.3%, respectively. The percentage of heterophil, lymphocyte, monocyte, eosinophil and basophile were not influenced by age and sex and they are ranged as 41.8-46.2, 43.2-48.8, 3.9-4.9 and 3.1-4.4%, respectively (Table 2). The

Table 1: Selected hematological parameters in local Saudi chickens of different age and sex

Age	Gender	TEC×10^6 (mm^{-1})	Hb (g dL^{-1})	PCV (%)	MCV (m^3)	MCH (pg)	MCHC (%)
Young	Male	3.5±0.7^a	11.7±1.2^a	34.5±4.9^a	99±5.8^a	34.1±5.6^a	34.3±4.2^a
	Female	2.9±0.2^b	9.8±1.4^a	29.7±4.0^b	102±6.6^a	33.8±3.0^a	33.2±3.6^a
Adult	Male	3.3±0.4^a	10.1±1.1^a	35.7±4.5^a	108±9.0^a	30.7±3.0^a	28.6±4.0^a
	Female	2.9±0.2^b	9.5±0.9^a	28.4±3.8^b	97±6.4^a	32.7±2.7^a	33.7±2.6^a

Values (Mean±SD) within a column with different superscripts are significantly different ($p<0.05$), TEC: Total erythrocyte counts, Hb: Hemoglobin, PCV: Packed cell volume, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, n = 40

Table 2: Differential leukocyte counts in local Saudi chickens of different age and sex

			Differential leukocyte counts (%)				
Age	Gender	TLC×10^3 (mm^{-1})	Heterophil	Lymphocyte	Monocyte	Eosinophil	Basophile
Young	Male	29.5±1.4^a	41.8±5.2^a	48.8±5.2^a	3.9±0.8^a	4.1±1.1^a	1.5±0.5^a
	Female	27.7±2.4^a	44.9±3.7^a	45.7±3.4^a	4.9±0.7^a	3.1±0.7^a	1.4±0.5^a
Adult	Male	30.6±1.5^a	41.9±3.7^a	48.7±4.3^a	4.4±0.5^a	3.6±0.5^a	1.4±0.5^a
	Female	26.8±1.2^a	46.2±4.6^a	43.2±4.0^a	4.2±0.8^a	4.4±1.3^a	2.0±0.7^a

Values (Mean±SD) within a column with different superscripts are significantly different ($p<0.05$), TLC: Total leucocytes counts, n = 40

Table 3: Some biochemical parameters of local Saudi chickens with different age and sex

Parameters	Young male	Old male	Young female	Old female
Total proteins (g dL^{-1})	3.4±0.8[a]	3.8±0.9[a]	3.6±1.0[a]	3.3±0.5[a]
Albumin (g dL^{-1})	1.6±0.3[a]	1.9±0.5[a]	1.8±0.3[a]	1.7±0.3[a]
Globulins (g dL^{-1})	1.9±0.7[a]	1.9±0.4[a]	1.8±0.9[a]	1.6±0.4[a]
Albumin/globulin ratio	0.9±0.5[a]	1.0±0.4[a]	1.3±0.9[a]	1.2±0.4[a]
Uric acid (mg dL^{-1})	5.2±1.9[a]	5.1±2.3[a]	3.7±1.0[a]	4.8±1.3[a]
Calcium (mg dL^{-1})	7.7±2.1[a]	10.3±2.4[a]	9.0±1.4[a]	9.5±1.4[a]
Phosphorus (mg dL^{-1})	4.4±2.0[a]	3.1±1.5[a]	4.2±1.9[a]	2.9±1.0[a]

Values (Mean±SD) within a column with different superscripts are significantly different ($p<0.05$), n = 20

obtained values of total proteins, albumin, globulins and albumin/globulin ratio were not significantly ($p>0.05$) differed in all examined birds (Table 3). Their values were ranged as 3.3-3.8 g dL^{-1}, 1.6-1.9 g dL^{-1} and 0.9-1.3, respectively. Uric acid was not significantly ($p>0.05$) differed in all examined birds and ranged from 3.7-4.8 mg dL^{-1} (Table 3). In addition, the level of Uric acid was lower than the reference range. The investigated electrolytes, Calcium and Phosphorus were not significantly ($p>0.05$) differed in all examined birds (Table 3) and were ranged as 7.7-10.3 and 2.9-4.4 mg dL^{-1}, respectively.

DISCUSSION

Although the reference values of avian hematological and biochemical indices have been recorded (Woodard *et al*., 1983; Kececi and Col, 2011), only a few studies on hematology and blood chemistry values for the local Saudi chickens have been published so far. Hematological parameters were used extensively in avian medicine as physiological indicators and disease diagnostic tools (Hauptmanova *et al*., 2006; Spinu *et al*., 1999; Quintavalla *et al*., 2001). Sex, age and nutrition are the major factors affecting avian hematology (Fudge, 2000; Islam *et al*., 2004). The difference in hematological values among local chickens reared in different region potentiate its investigation to diagnose the health status of the birds (Abdi-Hachesoo *et al*., 2011). The information gained from investigation of hematological values, disease diagnosis and managerial factors are the main tools for developing new lines of birds which are genetically able to resist different diseases (Shlosberg *et al*., 1996; Ladokun *et al*., 2008). For that reason, the main objective of this study was to determine normal baseline values for hematological and some biochemical parameters in male and female and young and adult local breed chicken reared in Eastern region, Al-Ahsa, Saudi Arabia.

The values of all examined hematological parameters were within the same reference range of broilers (Talebi *et al*., 2005). However, in the present study, these parameters were age independent which disagrees with Talebi *et al*. (2005) in broilers, Kececi and Col (2011) in Pheasant and Polo *et al*. (1992) in Birds of prey. The values of PCV were higher in male than that in female. These were similar to the report of Sturkie (1965) Simaraks *et al*. (2004) in Thai chickens and Abdi-Hachesoo *et al*. (2011) in chicken that PCV were influenced by androgens. Total erythrocyte counts and total leucocytes counts were higher in male than in female and theses findings disagree with previous researches demonstrating the both counts was sex independent in chicken (Talebi *et al*., 2005; Abdi-Hachesoo *et al*., 2011) and other birds (Palomeque *et al*., 1991; Polo *et al*., 1992; Pica *et al*., 1993; Simaraks *et al*., 2004; Kececi and Col, 2011). The present study demonstrated that hemoglobin values were not influenced by age and sex. However, previous researches in chicken reported higher hemoglobin values in male than that in female birds

(Simaraks *et al*., 2004; Talebi *et al*., 2005; Abdi-Hachesoo *et al*., 2011; Kececi and Col, 2011). The present hematological indices (MCV, MCH and MCHC) were the same in all birds and nearly the most of the previous research supported the present study (Palomeque *et al*., 1991; Polo *et al*., 1992; Pica *et al*., 1993; Simaraks *et al*., 2004; Talebi *et al*., 2005; Abdi-Hachesoo *et al*., 2011; Kececi and Col, 2011). The values of differential leucocytes counts were age and sex independent and that disagree with Simaraks *et al*. (2004) who reported that the percentage of lymphocytes in female was higher than in male chickens and in the contrary the percentage of eosinophil in male was significantly higher than female. The values for the TEC counts, Hb concentrations and PCV values were in accordance with those previously reported by Schmidt *et al*. (2007) and Kececi and Col (2011) for pheasants, Pica *et al*. (1993) for partridges and Palomeque *et al*. (1991) for ostrich but all of these parameters were, however, lower than those observed by Lloyd and Gibson (2006) and Hauptmanova *et al*. (2006) for pheasants and by Rico *et al*. (1977) for adult partridges. It was observed from the present findings that the RBC counts, Hb amounts and PCV values were not influenced by the advancement of age (Table 3). These results were in contrast with the age-related findings reported in previous researches as Schmidt *et al*. (2007) for pheasants, Palomeque *et al*. (1991) for Japanese quails, Puerta *et al*. (1989) for storks and Islam *et al*. (2004) for chickens. This may be attributed to differences in avian species and/or the management procedure. Total WBC numbers was not age dependant. This disagrees with some authors who have reported contrast results for various avian species such as pheasants (Schmidt *et al*., 2007), ostriches (Levi *et al*., 1999), pigeon guillemots (Seiser *et al*., 2000). However, the difference in differential leucocytes counts among avian species was documented (Perelman, 1999; Puerta *et al*., 1989). The present findings indicated that lymphocytes and heterophil were the main WBC type in local Saudi chicken equally. However, Kececi and Col (2011) observed that, lymphocytes were the main WBC type in the pheasants. The present results disagree with previously reported values in most other avian species such as the pheasant, partridge, hen, chicken and quail (Hauptmanova *et al*., 2006; Lloyd and Gibson, 2006; Schmidt *et al*., 2007).

Total protein of female Indigenous Saudi chicken birds was comparable to males and young ages to old one (Table 3). These results were disagreeing with previous results (Meluzzi *et al*., 1992). These authors reported that total protein of female was higher than males in broilers chickens. Total protein of female Thai indigenous bird was higher than in males (Simaraks *et al*., 2004). This might be attributed to environmental and seasonal factors. In addition, in female birds, a considerable increase in plasma total protein concentration occurs just prior to egg lying, which could be attributed to an estrogen-induced increase in globulins. The proteins were the yolk precursors (vitellogenin and lipoproteins), which were synthesized in the liver and transported *via* the plasma to the ovary where they were incorporated in the oocytes (Ritchie *et al*., 1994). However, local Saudi chickens females were not reached to laying period. Total proteins of local Saudi chickens were lower than the normal range of the domestic turkey (4.9-7.6 mg dL^{-1}) and pheasant (male = 5.65 mg dL^{-1}; female = 6.06 mg dL^{-1}), but at the same normal range of the guinea fowl (3.5-4.4 mg dL^{-1}) and common quail (3.4-3.6 mg dL^{-1}) (Ritchie *et al*., 1994).

In birds, uric acid is a major product of the catabolism of nitrogen. Age and diet may influence the concentration of blood uric in birds. In addition, high level of uric acid was reported during ovulatory activity (Ritchie *et al*., 1994). Simaraks *et al*. (2004) demonstrated increased serum uric acid of female Thai indigenous chickens as they started lying. The same authors added that, serum uric acids in female were significantly higher than in male indigenous birds. It has been reported that serum uric acid of mature females (5.40 mg dL^{-1}) was higher than that of males

(2.86 mg dL^{-1}) and serum uric acid of laying birds (0.76 mg dL^{-1}) was lower than in non-reproductive females (1.80 mg dL^{-1}) (Sturkie, 1965). However in the present study serum uric acid levels of local Saudi chickens were not significantly different between sex and ages.

Ovulating hens have significantly higher calcium levels than non-reproductive females (Ritchie *et al*., 1994). This agrees with other findings (Rico *et al*., 1977) that compared the levels of serum calcium between laying hens (18.10+2.64 mg dL^{-1}) and broilers (6.25-13.75 mg dL^{-1}). In this study the serum calcium levels in Indigenous Saudi chicken chickens were not different between the sexes and this was almost similar to that of broiler (Talebi *et al*., 2005) and Thai chick (Simaraks *et al*., 2004). Besides, serum calcium of local Saudi chickens was lower than in domestic turkey (11.7-38.7 mg dL^{-1}), domestic fowl (13.2-23.7 mg dL^{-1}) and bobwhite quail (14.1-15.4 mg dL^{-1}) (Ritchie *et al*., 1994). Serum Phosphorus levels in Indigenous Saudi chicken birds were lower than those of broiler (Ritchie *et al*., 1994) and were not significantly different between sexes (Table 3).

CONCLUSION

Hence in local Saudi chickens in summer season sex influenced total erythrocyte counts, total leucocyte counts and packed cell volume. These results can be a guide for scientists in the Kingdom of Saudi Arabia for the determination of hematological and biochemical changes of chicks during hot the summer season.

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REFERENCES

Abdi-Hachesoo, B., A. Talebi and S. Asri-Rezaei, 2011. Comparative Study on Blood Profiles of Indigenous and Ross-308 Broiler Breeders. Global Vet., 7: 238-241.

Al-Aqil, A.M., 1998. Biological and physiological responses to baladi and exotic layers to seasonal changes in temperature. M.Sc. Thesis, Department of Animal Sciences, Faculty of Agricultural Sciences and Food, King Faisal University.

Dacie, J.U. and S.M., Lewis, 1975. Practical Haematology. Churchill Livingstone, UK.

Dein, F.J., 1984. Laboratory Manual of Avian Haematology. Association of Avian Veterinarian, East North Port, USA.

Fudge, A.M., 2000. Laboratory Medicine: Avian and Exotic Pets. W.B. Saunders Company, Philadelphia.

Harr, K.E., 2002. Clinical chemistry of companion avian species: A review. Vet. Clin. Path., 31: 140-151.

Hauptmanova, K., M. Maly and I. Literak, 2006. Changes of haematological parameters in common pheasant throughout the year. Vet. Med., 51: 29-34.

Islam, M.S., N.S. Lucky, M.R. Islam, A. Ahad, B.R. Das, M.M. Rahman and M.S.I. Siddiui, 2004. Haematological parameters of fayoumi, assil and local chickens reared in Sylhet region in Bangladesh. Int. J. Poult. Sci., 3: 144-147.

Kececi, T. and R. Col, 2011. Haematological and biochemical values of the blood of pheasants (*Phasianus colchicus*) of different ages. Turk. J. Vet. Anim. Sci., 35: 149-156.

Ladokun, A.O., A. Yakubu, J.R. Otite, J.N. Omeje, O.A. Sokunbi and E. Onyeji, 2008. Haematological and serum biochemical indices of naked neck and normally feathered Nigerian indigenous chickens in a sub humid tropical environment. Int. J. Poult. Sci., 7: 55-58.

Levi, A., B. Perelman, T. Waner, M. van Grevenbroek, C. van Creveld and R. Yagil, 1999. Haematological parameters of the ostrich (*Struthio camelus*). Avian Pathol., 18: 321-327.

Lloyd, S. and J.S. Gibson, 2006. Haematology and biochemistry in healthy young pheasants and red-legged partridges and effects of spironucleosis on these parameters. Avian. Pathol., 35: 335-340.

Lucas, A.M. and C. Jamroz, 1961. Atlas of Avian Hematology, Issue 25. USDA, Washington DC., USA., Pages: 271.

Melesse, A., 2011. Performance and physiologica responses of naked-neck chickens and their F Crosses 1 with commercial layer breeds to long-term high ambient temperature. Global Vet., 6: 272-280.

Meluzzi, A., G. Priniceri, R. Giordani and G. Fobris, 1992. Determination of blood constituents reference values in broilers. Poult. Sci., 71: 337-345.

Najib, H. and G. Basiouni, 2004. Determination of the nutritional requirements of baladi chickens: 1. Effect of Arginine inclusion, in excess of the leghorn requirement, on performance of the Saudi baladi chickens. Sci. J. King Faisal Univ. Basic Applied Sci., 5: 131-144.

Natt, P.M. and C.A. Herrik, 1952. A new blood diluent for counting the erythrocytes abd leucocytes of chicken. Poult. Sci., 31: 735-738.

Palomeque, J., D. Pinto and G. Viscor, 1991. Hematologic and blood chemistry values of the Masai ostrich (*Struthio camelus*). J. Wildlife Dis., 27: 34-40.

Pampori, Z.A. and S. Iqbal, 2007. Haematology, serum chemistry and electrocardiographic evaluation in native chicken of Kashmir. Int. J. Poult. Sci., 6: 578-582.

Perelman, B., 1999. Health Management and Veterinary Procedures. In: The Ostrich, Biology, Production Health. Deeming, D.C. (Ed.). CABI Publishing, New York, USA., pp: 321-346.

Pica, A., A. Lodato, M.C. Grimaldi, F.D. Corte and U. Galderisi, 1993. A study of the bone marrow precursors and hemoglobin of the blood cell of the red-legged partridge (*Alectoris rufa rufa* L.). Ital. J. Anat. Embryol., 98: 277-292.

Polo, F.J., J.F. Celdran, V.I. Peinado, G. Viscor and J. Palomeque, 1992. Hematological values for four species of birds of prey. Condor, 94: 1007-1013.

Puerta, M.L., R.M. Pulido, V. Huecas and M. Abelanda, 1989. Hematology and blood chemistry of chicks of white and black storks (*Ciconia ciconia* and *Ciconia nigra*). Comp. Biochem. Physiol. A Comp. Physiol., 94: 201-204.

Quintavalla, F., E. Bigliardi and P. Bertoni, 2001. Blood biochemical baseline values in the ostrich (*Struthio camelus*). Universita degli Studi di Parma Annali della Facolta di Med. Vet., 21: 61-71.

Rico, A.G., J.P. Braun, P. Benard and V. Burgat-Sacaze, 1977. Biometry, hematology, plasma biochemistry and plasma and tissues enzymology of the red partridge (*Alectoris rufa*). Ann. Rech. Vet., 8: 251-256.

Ritchie, B.W., J.G. Harrison and R.L. Harrison, 1994. Avian Medicine. Wingers Publishing, Inc., Florida.

SAS, 2002. Statistical Analysis Systems User's Guide: Statistics. SAS Institute, Cary, New York.

Schmidt, E.M.S., A.C. Paulillo, R.L. Dittrich, E. Santin, P.C.L. da Silva, O. Beltrame and E.G. de Oliveira, 2007. The effect of age on hematological and serum biochemical values on juvenile ring-necked pheasants (*Phasianus colchicus*). Int. J. Poult. Sci., 6: 459-461.

Seiser, P.E., L.K. Duffy, A.D. McGuire, D.D. Roby, G.H. Golet and M.A. Litzow, 2000. Comparison of pigeon guillemot, *Cepphus columba*, blood parameters from oiled and unoiled areas of Alaska, eight years after the Exxom Vadex oil spill. Mar. Pollut. Bull., 40: 152-164.

Shlosberg, A., M. Bellaiche, G. Zeitlin, M. Yaacobi and A. Cahaner, 1996. Haematocrit values and mortality from ascites in cold-stressed broiler from parents selected by haematocrit. Poult. Sci., 75: 1-5.

Simaraks, S., O. Chinrasri and W. Aengwanich, 2004. Hematological, electrolyte and serum biochemistry values of the Thai indigenous chickens (*Gallus domesticus*) in northeastern, Thailand. Songklanakarin J. Sci. Technol., 26: 425-430.

Spinu, M., O. Spinu and A.A. Degen, 1999. Haematological and immunological variables in a domesticated and wild subspecies of ostrich (*Struthio camelus*). Br. Poult. Sci., 40: 613-618.

Sturkie, P.D., 1965. Avian Physiology. 2nd Edn., Cornell University Press, USA.

Talebi, A., S. Asri-Rezaei, R. Rozeh-Chai and R. Sahraei, 2005. Comparative studies on haematological values of broiler strains (Ross, Cobb, Arbor-acres and Arian). Int. J. Poult. Sci., 4: 573-579.

Woodard, A., P. Vohra and B. Mayeda, 1983. Blood parameters of one year old and seven year old partridges (*Alectoris chukar*). Poult. Sci., 62: 2492-2496.