Effects of Sex, Pregnancy and Season on some Haematological and Biochemical Blood Values in Angora Rabbits

by ***N. Çetin*[1]*, T. Bekyürek*[2]*, E. Çetin*[1]**

[1]Department of Physiology, Faculty of Veterinary Medicine, University of Erciyes, Kayseri, Turkey

[2]Department of Obstetric and Gynaecology, Faculty of Veterinary Medicine, University of Erciyes, Kayseri, Turkey

Summary

This study was undertaken to investigate the effect of sex, season and pregnancy on some blood parameters in Angora rabbits. A total of 45 Angora rabbits (15 males, 15 females and 15 pregnant rabbits), weighing 3.6- 5.3 kg were used in this study. Blood samples were collected from female rabbits in January, April, July and October, and male and pregnant rabbits in January.

Erythrocyte counts and haemoglobin concentrations of pregnant rabbits were lower ($p<0.05$) than those of normal non-pregnant rabbits, while mean corpuscular volume in pregnant rabbits was higher ($p<0.05$) than those of non-pregnant rabbits. Total leukocyte counts and lymphocyte ratios in pregnant females were lower ($p<0.05$) than those of normal non-pregnant rabbits. There were no significant differences ($p>0.05$) in the other haematological values between pregnant and non-pregnant rabbits. Total protein, albumin triglyceride, cholesterol, calcium, and (Inorganic) phosphorus were significantly lower ($p<0.05$) in pregnant rabbits than the other females, while the mean glucose level was significantly higher ($p<0.05$). It was determined that male rabbits had higher erythrocyte, haemoglobin and glucose values and lower total cholesterol level than females ($p<0.05$). Erythrocyte count, haemoglobin concentration, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration of female rabbits were lower ($p<0.05$) in July, whereas hematocrit level and mean corpuscular volume were higher ($p<0.05$) in the same month. Leukocyte count and lymphocyte ratio were significantly lower ($p<0.05$) in July and October. Albumin level was significantly higher ($p<0.05$) in July. Sex and pregnancy as well as season variously affected most haematology and serum biochemistry variables.

Introduction

Haematology and serum chemistry are becoming increasingly important diagnostic tools in veterinary medicine. Blood parameters in rabbits are used as an aid for the clinical diagnosis of organic, infectious and several parasitic diseases and to assess the metabolic condition of animals.

A variety of factors can affect the haematological and biochemical parameters in animals, including the breed, gender, age, reproductive status and seasonal variations (*Osage, 2001; Wells et al., 1999; Gill & Wanska, 1978; Mira & Mathias, 1994*).

Haematological data for several particular rabbit breeds, as well as for rabbits in general, are available (*Shalom et al., 1974; Karakılçık et al., 2002; Hewitt et al., 1989; Bartolotti et al., 1989; Barlet, 1980*), but no data have been published for the Angora Rabbits.

The aim of the current study was to determine some haematological and biochemical values and the influence of sex, season and pregnancy on these parameters in Angora rabbits.

**Correspondence*: Assoc. Prof. Dr. Nazmi Çetin
Department of Physiology, Veterinary Faculty, Erciyes University, 38090, Kocasinan, Kayseri, Turkey.
Tel. +90 352 338 00 06
Fax +90 352 337 27 40
E-mail cetin@erciyes.edu.tr

Materials and Methods

Animals

In all, 45 French Angora Rabbits, 15 males, 15 females (non-pregnant) and 15 pregnant rabbits on day 22 to 25 gestation, were examined. The study was carried out at the Angora Rabbits Farms in Kayseri, Turkey. The animals weighed between 3.6 and 5.3 kg and were 2-2.5 years old. The rabbits housed in individual stainless cages (60 x 80 x 50 cm high) received water and a standard pellet diet (C.P. Feed, Ankara, Turkey) *ad libitum*. The diet contained 18 % crude protein and 2400 kcal/kg metabolisable energy. Bedding material was not used. The photoperiod (light: dark), and temperature (minimum-maximum) at the sampling days were as follows: winter (January: 11 L: 13 D, 15-25 ºC), spring (April: 12 L: 12 D, 15-24 ºC), summer (July: 13 L: 11 D, 24-29 ºC) and autumn (October: 11 L: 13 D, 15-24 ºC). The humidity ranged between 40 and 60 %.

Blood samples were collected from the female rabbits in January (representing winter), April (representing spring), July (representing summer) and October (representing autumn). Blood samples of male and pregnant rabbits were collected in January. Blood was sampled from the marginal ear vein, two samples of blood from each rabbit: a 2-ml sample for haematology and a 4-ml sample for biochemical analyses. The study was approved by the local ethics committee and was performed in accordance with "Guide for the care and use of Laboratory Animals (National Research Council, 1996)".

Blood samples for haematological analyses were delivered to the laboratory within 4 h of collection and promptly assayed.

Haematological Evaluation

Haematologicall analyses were determined on the same day after the blood samples were taken from the rabbits. Total erythrocyte counts were counted using a Thoma chamber under a light microscope at 40 x 10 magnification. Blood samples were diluted to 200 times by Hayem's reagent before counting. Blood haemoglobin concentration was determined using a Shale hemometer. Micro Wintrobe hematocrit tubes and hematocrit centrifuge were used to determine the (PCV). Total leucocyte counts were detected using a Thoma chamber under a light microscope at 10 x 10 magnification after diluting blood samples to 10 times with Türk's solution. The percentage of various forms of leukocytes was determined by the method of Pappenheim (*Konuk, 1981*). Mean erythrocyte volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) for particular blood samples were also calculated.

Biochemical Evaluation

Serum samples were obtained by centrifugation of blood at 1300 x g for 15 min, and were divided into eppendorf tubes. Isolated sera were stored at -20oC until used for analyses. Total protein, albumin, total cholesterol (TC), triglyceride, glucose, calcium, phosphorus and magnesium levels were measured spectrophotometrically (Shimatzu, UV-1700) in serum using Chema commercial kits.

Statistics

Data were analyzed using the SPSS for Windows software, Version 10.0 (SPSS Inc., Chicago, IL, USA). The significant differences in particular blood indices between seasons in both sexes were determined by analyses of variance (ANOVA). When the differences were significant, the Tukey HDS test was performed. Statistical significances between males and females and between pregnant and non-pregnant animals were determined by Student's t-test. A p value less than 0.05 was considered significant.

Results

The mean haematological and biochemical values of male, female and pregnant rabbits examined are presented in Table 1 and Table 2. Tables 3 and 4 lists the values of all investigated haematological and biochemical indices for female rabbits in relation to the seasons.

Sex influence
Male rabbits had significant higher ($p<0.05$) RBC counts, haemoglobin and glucose values, and lower total cholesterol level than female rabbits.

Pregnancy influence
RBC and WBC counts, lymphocyte ratios and haemoglobin concentrations of pregnant rabbits were significantly decreased ($p<0.05$) when compared with those of non-pregnant rabbits. The MCV value of pregnant rabbits was significantly increased ($p<0.05$) in comparison with that of non-pregnant rabbits. There were no significant differences ($p>0.05$) in the other haematological indices between pregnant and non-pregnant. Total protein, albumin triglyceride, cholesterol, calcium, and phosphorus were significantly lower ($p<0.05$) in pregnant rabbits than the female. Mean glucose

Table 1. The haematological values of male, female and pregnant Angora Rabbits.

Parameter	Female	Pregnant	Male
Erythrocyte ($x10^6/mm^3$)	6.20 ± 0.36	4.52 ±0.11*	8.05 ± 0.51[a]
Haemoglobin (g/100 ml)	9.75 ± 0.18	8.16 ± 0.13*	10.20 ± 0.33
Hematocrit (%)	34.90 ± 0.85	32.51 ± 0.78	38.66 ± 0.85[a]
MCV(fl)	57.20 ± 3.75	67.83 ± 1.74*	56.94 ± 3.27
MCH (pg)	15.72 ± 0.90	17.70 ± 0.42	15.17 ± 0.80
MCHC (g/dl)	27.16 ± 0.60	26.91 ± 0.85	26.03 ± 1.29
Leukocyte ($x10^3/mm^3$)	6.44 ± 0.73	4.90 ± 0.49*	9.55 ± 0.58[a]
Lymphocyte (%)	66.80 ± 3.04	57.90 ± 2.72*	59.80 ± 4.14
Heterophil (%)	26.80 ± 2.88	36.90 ± 2.10	34.30 ± 3.83
Monocyte (%)	3.50 ± 0.74	5.00 ± 0.44	3.40 ± 0.65
Eosinophil (%)	1.90 ± 0.64	0.80 ± 0.32	1.50 ± 0.54
Basophil (%)	1.20 ± 0.44	0.10 ± 0.10	1.00 ± 0.44

Data are expressed as means ± SEM. Significantly different from female: * [a]: $p<0.05$.

Table 2 .The biochemical values of male, female and pregnant Angora Rabbits.

Parameter	Female	Pregnant	Male
Total Protein (g/dl)	4.49 ± 6.84	4.27 ± 1.26*	4.39 ± 1.42
Albumin (g/dl)	3.7 ± 0.16	2.8 ± 0.24*	2.9 ± 0.14
Triglyceride (mg/dl)	158.76 ± 5.74	133.20 ± 2.99*	149.56 ± 2.94
Cholesterol (mg/dl)	126.07 ± 6.03	53.18 ± 0.82*	99.38 ± 8.02[a]
Glucose (mg/dl)	104.24 ± 3.25	115.09 ± 1.38*	115.30 ± 1.88[a]
Calcium (mg/dl)	15.57 ± 0.36	13.06 ± 0.24*	14.66 ± 0.36
Magnesium (mg/dl)	2.03 ± 0.01	2.07 ± 0.02	2.16 ± 0.06
Phophorus (mg/dl)	5.15 ± 0.20	4.02 ± 0.21*	5.50 ± 0.38

Data are expressed as means ± SEM. Significantly different from female: * [a]: $p<0.05$.

Table 3. The effect of seasons on the haematological values of female Angora Rabbits.

Parameter	January	April	July	October
Erythrocyte ($x10^6/mm^3$)	7.05 ± 0.51^a	6.95 ± 0.17^a	6.05 ± 0.12^b	6.57 ± 0.23^{ab}
Haemoglobin (g/dl)	10.90 ± 0.33^a	10.86 ± 0.21^a	9.23 ± 0.12^b	10.21 ± 0.23^{ab}
Hematocrit (%)	37.66 ± 0.85^a	38.25 ± 1.11^a	42.43 ± 0.81^b	37.12 ± 0.32^{ab}
MCV (fl)	56.94 ± 3.27^a	57.11 ± 0.37^a	62.32 ± 0.53^b	58.12 ± 0.74^{ab}
MCH (pg)	17.17 ± 0.80^a	16.75 ± 0.19^a	15.64 ± 0.65^b	16.20 ± 0.54^{ab}
MCHC (g/dl)	29.03 ± 1.29^a	28.46 ± 0.30^a	26.43 ± 1.21^b	27.63 ± 1.13^{ab}
Leukocyte ($x10^3/mm^3$)	11.85 ± 0.58^a	10.98 ± 1.34^a	8.71 ± 0.53^b	9.42 ± 1.06^b
Lymphocyte	59.80 ± 4.14^a	58.10 ± 0.58^a	54.10 ± 0.45^b	55.52 ± 0.45^b
Heterophil (%)	34.30 ± 3.83	35.20 ± 0.97	36.95 ± 0.54	36.15 ± 0.54
Monocyte (%)	3.40 ± 0.65	4.30 ± 0.55	5.90 ± 0.74	4.95 ± 0.74
Eosinophil (%)	1.50 ± 0.54	1.70 ± 0.15	1.85 ± 0.11	1.98 ± 0.11
Basophil (%)	1.00 ± 0.44	0.70 ± 0.15	1.20 ± 0.16	1.40 ± 0.16

Data are expressed as means ± SEM.

^{a,b}: Mean values with different superscripts in the line are significantly different ($p < 0.05$).

Table 4. The effect of seasons on the biochemical values of female Angora Rabbits.

Parameter	January	April	July	October
Total Protein (g/dl)	4.94 ± 1.42	4.30 ± 2.27	4.35 ± 3.21	4.31 ± 2.54
Albumin (mg/dl)	2.80 ± 0.21^a	2.90 ± 0.25^a	4.70 ± 0.34^b	3.10 ± 0.54^a
Triglyceride (mg/dl)	143.16 ± 4.54	145.20 ± 2.12	149.15 ± 2.24	146.21 ± 2.15
Cholesterol (mg/dl)	84.38 ± 8.02	75.69 ± 2.08	78.54 ± 8.02	89.38 ± 8.02
Glucose (mg/dl)	119.30 ± 1.88	117.90 ± 0.45	116.90 ± 0.35	117.10 ± 0.41
Calcium (mg/dl)	15,92 ± 0.52	16,97 ± 0.64	16.54 ± 0.51	15.45 ± 0.21
Phosphorus (mg/dl)	6,07 ± 0.21	6,36 ± 0.45	5.84 ± 0.10	6.13 ± 0.25
Magnesium (mg/dl)	2,11 ± 0.02	2,35 ± 0.04	1,99 ± 0.03	2.41 ± 0.05

Data are expressed as means ± SEM.

^{a,b}: Mean values with different superscripts in the line are significantly different ($p < 0.05$).

level was significantly higher ($p<0.05$) in pregnant rabbits compared with female.

Season influence

Erythrocyte count, haemoglobin concentration, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration of female rabbits were lower ($p<0.05$) in July, whereas hematocrit level and mean corpuscular volume were higher ($p<0.05$) in the same month. Leukocyte count and lymphocyte ratio were significantly lower ($p<0.05$) in July and October. On the other hand, the highest value of albumin level was observed in July.

Discussion

The sex and pregnancy of a rabbit, as well as the season, variously affected most haematology and serum biochemistry variables in this study.

The reduction in erythrocyte count and haemoglobin values observed in pregnant Angora rabbits were in accordance with previously reported values in New Zealand rabbits (*Kim et al., 2002; Wells et al., 1999*). Unlike the results of Wells et al. (*1999*), a significant reduction in the hematocrit value was not recorded in this study. The reduction in the erythrocyte count and haemoglobin values in pregnant animals may be related to the physiological anaemia occurring due to hemodilution (*Ozegbe, 2001; Nuwayhid, 1979*). Additionally, a shorter erythrocyte life span within the circulation during gestation with respect to non-pregnants was reported to be another cause of the reduction in the erythrocyte count (*Brecher and Stohlman, 1961*). Similarly, a reduction in erythrocyte count, haemoglobin and hematocrit values and mean haemoglobin concentration in pregnant rats near delivery has been reported (*LaBorde et al., 1999*).

The reduction in erythrocyte count and haemoglobin value detected in pregnant Angora rabbits in this study was in accordance with the results of Kabata et al. (*1991*). On the other hand, it was reported that the haematological parameters in New Zealand rabbits were not influenced by sexuality (*Schalm et al., 1975*) and gestation (*Bortolotti et al., 1989*). We observed that leukocyte count and lymphocyte ratios in pregnant animals were lower than in non-pregnant rabbits. These findings were similar to those reported by Kim et al. (*2002*). On the contrary, Bortolotti et al. (*1989*) found no significant difference between adult and pregnant haematological profiles. This difference may originate from the gestation period and the race. The increase detected in the mean corpuscular volume (MCV) value of pregnant animals in this study was not consistent with the reports of Bortolotti et al. (*1989*). The increase in MCV suggests an increase in the number of immature erythrocytes, which would be in accordance with findings in pregnant rabbits and in women (*Kim et al., 2002; Lurie, 1993*).

In our study there were fewer leukocytes in pregnant animals than in non-pregnants, which corresponded with the results obtained by Wells et al. (*1999*) and Kim et al. (*2002*). The reduction detected in lymphocyte rates was consistent with the findings of various researchers (*Bortolotti et al., 1989, Kim et al., 2002; Kuhnert et al., 1998*). Similarly, the reduction of lymphocyte rates was also reported in pregnant rats (*Kim et al., 2000*). However, in contrast to our results, an increase leukocyte count was not detected in pregnant women by Kuhnert et al. (*1998*). This difference may originate from the difference in species.

Reduction in the levels of triglyceride, cholesterol, total protein, albumin, calcium and phosphate and increase in the glucose level, observed in pregnant animals during our study was concurrent with the results of Wells et al. (*1999*). Conversely the reduction they observed in the level of glucose in pregnant rats was not concurrent with our results; however, the reduction in the total protein, albumin and calcium seen by LaBorde et al. (*1989*) were concurrent with our results. On the other hand, similar to our results Verma et al. (*1984*) emphasized that the cholesterol level decreased in cows. Similar to our results, in various investigations on pregnant rabbits (*Wells et al., 1999; Barlet, 1980*) calcium and phosphorus levels were reported to be lower than that of non-pregnants.

The season was show to have a significantly effect on the haematological parameters in this study. Though the erythrocyte, haemoglobin, MCH and MCHC values reached the highest point during winter months, they descend to the lowest levels in the summer, conversely hematocrit amount and MCV increased during summer months and decreased during winter and spring months. These results were consistent with the results obtained in chinchillas by Jacubov et al. (*1984*). In various studies, erythrocyte, haemoglobin and hematocrit values were reported to reach the highest values during winter months in different rodents (*Rewkiewiccz-Dziarska, 1975*); conversely these values were reported to be at the lowest level during winter months in large animals such as horses (*Gill and Wanska, 1978*) and cows (*Rusoff et al., 1954*). This difference may originate from the different adaptation skills of animal species against temperature changes.

On the other hand, Scelza and Knoll (*1982*) reported that in desert rodents erythrocyte count was at the highest level during summer months whereas it progressed to lower levels during winter months. The summer season may decrease the oxygen-carrying capacity of blood by changing erythrocyte count and haemoglobin concentration. Cold weather, on the other hand, displays an effect providing a better blood circulation. Increase in the amount of haemoglobin during winter months may be considered as a method of increasing the oxygen-carrying capacity. Additionally, changes in the environment temperature and photoperiod are the most important factors affecting the erythrocyte count, haemoglobin and hematocrit values (*Rewkiewiccz-Dziarska, 1975*). On the other hand, others found the erythrocyte count to be higher in summer but haemoglobin and hematocrit values to remain the same both in summer and winter (*Rietkerk et al., 1994*).

Finding Mean MCH and MCHC values to be higher in winter may be a sign of an increase in erythropoietic activity of the rabbits. Additionally factors such as activity, diet, environment temperature and sex may also affect erythropoietic activity. In this study, leukocyte count and lymphocyte rate were lower during summer and autumn months than in winter months. These findings were in agreement with the results obtained in chinchillas by Jakubov et al. (*1984*). According to Barkova et al. (*1992*), in rats there was an increase in leukocyte and lymphocyte counts in spring, in eosinophil count in autumn and in neutrophile and monocyte count in winter. Seasonal differences observed in lymphocyte counts and types may be due to photoperiod. In field mice, a long-term photoperiod was reported to stimulate hemopoiesis, whereas constant light was reported to suppress hemopoiesis (*Dobrowolska and Gromadzka-Ostrowska,1983*).

Albumin values obtained in our study increased in summer in accordance with previous reports in house mice (*Mira and Mathias, 1994*) and chinchillas (*Gromadzka-Ostrowska and Zalewska, 1985*). On the contrary, in field mice the lowest values of albumin were observed in summer (*Dobrowolska and Gromadzka-Ostrowska, 1983*). This difference may be related to animal species and the effect of the photoperiod. The reason for the increase of albumin amount during summer months is due to the increase in the osmotic pressure exerted by albumin, which is responsible for the osmotic pressure of the blood to a great extent, so preventing the discharge of water from the blood vessels. Total protein and glucose values in laboratory rats were found to be at a maximum in May and at minimum in February (*Mikeska and Petrasek, 1977*). Whereas cholesterol, triglyceride, calcium, magnesium and phosphorus levels were not influenced by seasons. In the study carried out on mice, although cholesterol level decreased during winter months, no difference was detected in glucose levels (*Berezkin et al., 1987*). On the other hand, Gündüz et al. (*2000*) and O'Kelly (*1972*) reported that serum cholesterol level was at the highest level in cows during winter months. In a study carried out on reindeer (*Larsen et al., 1985*), it was found that the glucose level was low in November-February and high but variable in March-October; conversely triacylglycerols, total and HDL-bound cholesterol were all low in November-March, but increasing in April and reaching a peak in August-September. These differences may originate from animal, species, environment temperature, age, sex, hormonal changes and the seasonal changes in food intake.

In conclusion, we have demonstrated the effect of sex, pregnancy and seasons on some haematological and biochemical parameters in Angora Rabbits, and have compared our findings with those reported in other species. We hope that our findings will be helpful when interpreting laboratory results in Angora Rabbits.

Acknowledgements

This study was supported by Erciyes University Research Foundation (project number: VA.03.01)

References

Barkova EN, LN Shatilovich & EA Kashuba: Seasonal characteristics of the circadian rhythm of peripheral blood leukocyte content in Wistar rats. Bull Exp Biol Med, 1992, 113, 306- 308.

Barlet JP: Plasma calcium, inorganic phosphorus and magnesium levels in pregnant and lactating rabbits. Reprod Nutr Dev, 1980, *20*, 647- 651.

Berezkin MV, IN Gratsinskii, VF Kudinova & TS Chusovkova: Seasonal and circadian fluctuations of the biochemical indices of the blood in mice. Bull Exp Biol Med, 1987, *104*, 646- 649.

Bortolotti A, D Castelli & M Bonati: Hematology and serum chemistry values of adult, pregnant and newborn New Zealand rabbits. Lab Anim Sci, 1989, *39*, 437- 439.

Brecher G & JF Stohlman: Reticulocyte size and erytropoietic stimulation. Proc Soc Exp Biol Med, 1961, *107*, 887- 891.

Dobrowolska A & J Gromadzka-Ostrowska: Influence of photoperiod on morphological parameters, androgen concentration, haematological indices and serum protein fractions in common vole (Microtus arvalis). Comp Biochem Phys A, 1983, *74*, 427- 433.

Gill J & E Wanska: Seasonal changes in erytrocyte, haemoglobin and leukocyte indices in barren mares of thoroughbred horses. Bull Acad Pol Sci, 1978, *26*, 347- 353.

Gromadzka-Ostrowska J & B Zalewska: Seasonal fluctations in plasma protein fraction levels of chinchillas (Chinchilla laniger, M.). Comp Biochem Phys A, 1985, *80*, 215- 224.

Gündüz H: Holştayn ineklerinde bazı biyokimasal parametrelerin mevsimsel değişimleri. Y Y Ü Vet Fak Derg , 2000, *11*, 50- 53.

Hewitt CD, DJ Innes, J Savory & MR Wills: Normal biochemical and haemtological values in New Zealand White rabbits. Clin Chem, 1989, *35*, 1777- 1779.

Jakubow K, J Gromadzka-Ostrowska & B Zalewska: Seasonal changes in the haematological indices in peripheral blood of chinchilla. Comp Biochem Phys A, 1984, *78*, 845- 853.

Kabata J, A Grathwol, A Tichelli, L John & P Speck: Hematologic values of New Zealand White rabbits determined by automated flow cytometry. Lab Anim Sci, 1991, *41*, 613- 619.

Karakılçık Z, M Zerin, M İriadam & Vural H: Yerli tavşanlarda alyuvar ve akyuvar seri değerleri ile bazı biyokimyasal parametre düzeylerinin araştırılması. EÜ Sağ Bil Derg, 2002, *11*, 15-20.

Kim JC, HI Yun, SW Cha, KH Kim & WS Koh: Haematological changes during normal pregnancy in New Zealand White Rabbits. Comp Clin Pathol, 2002, *11*, 98-106

Kim JC, HI Yun & LH Lim: Haematological values during normal pregnancy in Sprague- Dawley rats. Comp Hematol, 2000, *10*, 74- 79.

Kuhnert M, R Strohmeier & M Stegmuller: Changes in lymphocytes subsets during normal pregnancy. Eur J Obstet Gynecol Reprod Biol, 1998, 76,147- 151.

LaBorde JB, KS Wall & B Bolon: Heamtology and serum chemistry parameters of the pregnant rat. Lab Anim, 1999, *33*, 275- 287.

Larsen TS, H Lagercrantz , RA Riemersma & AS Blix: Seasonal changes in blood lipids, adrenaline, noradrenaline, glucose and insulin in Norwegian reindeer. Acta Physiol Scand, 1985, *124*, 53- 59.

Lurie S: Changes in age distribution of erythrocytes during pregnancy: a longitudinal study. Gynecol Obstet Invest, 1993, *36*, 141- 144.

Mira A & ML Mathias: Seasonal effects on the hematology and blood plasma proteins of two species of mice mus musculus domesticus and m. spretus from Portugal. Hystrix, 1994, *5*, 63-72.

Nuwayhid B: Hemodynamic changes during pregnancy in the rabbit. Am J Obstet Gynecol, 1979, *35*, 590- 596.

O'Kelly JC: Seasonal variation in the plasma of genetically different types of cattle; Grazing Steers. Comp Biochem Phys A, 1972, *43*, 283-294.

Ozegbe PC: Influence of pregnancy on some erythrocyte biochemcal profiles inthe rabbits. Afr J Biomed Res, 2001, *4*, 135- 137.

Rewkiewiccz-Dziarska A: Seasonal cahnges in hemoglobin and erythrocyte indices in Microtus arvalis. Bull Acad Polon Sci, 1975, *23*, 481-486.

Rietkerk FE, EC Delima & SM Mubarak: The hematological profile of the mountain gazelle: variation with sex, age, capture method, season, and anesthesia. J Wildl Dis, 1994, *30*, 69-76.

Rusoff L, JE Johnston & C Bronton: Blood studies on breeding dairy bulls. Hematocrit, hemoglobin, plasma calcium, plasma inorganic phosphorus, alkaline phosphatase values, erythrocyte count and leukocyte count. J Dairy Sci, 1954, *37*, 30- 36

Scelza J & J Knoll: Seasonal variation invarious blood indices of the kangaroo rat, Dipodomys panaminitus. Comp Biochem Physiol A, 1982, *71*, 237- 241.

Schalm OW, NC Jain & EJ Carrol: Veterinary hematology (3rd ed), Lea and Febiger, Philadelphia, 1975.

Verma RP, HK Bhagi, RG Garg RR Mishra: Biochemical studies on reproductive status of Hariana cows. Livestock Advisor, 1984, *9*, 29- 34.

Wells MY, CP Decobecq, DM Decouvelaere, C Justice & Guittin P: Changes in clinical pathology parameters during gestation in the New Zealand white rabbit. Toxicol Pathol, 1999, *27*, 370- 379.