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Review

Influence of reproductive cycle, sex, age and season on haematologic parameters in domestic animals: A review

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Haematologic parameters play a pivotal role in clinical diagnosis, the evaluation of patient before surgical intervention and in monitoring responses to therapy. The paper reviews haematologic parameters as influenced by exogenous and endogenous factors, including reproductive cycle, sex, age and season, with emphasis on domestic animals reared in the tropics. It is concluded that reproductive cycle, sex, age and season modulate haematologic parameters, and that they should be considered in order to ensure accurate interpretation of the parameters in domestic animals.

Key words: Haematology, reproductive cycle, age, sex and season.

INTRODUCTION

From time immemorial blood has been regarded by humans as the essence of life, the seat of the soul and the progenitor of psychic and physical strength (Ajibola and Ogunsanmi, 2004). Haematological and serum biochemical profiles provide reliable information on the health status of animals (Kral and Suchy, 2000; Cetin et al., 2009). They also reflect the responsiveness of an animal to its internal and external environments (Esonu et al*.,* 2001). Haematological tests have been widely used for the diagnosis of various livestock diseases (Tibbo et al., 2004; Cetin et al., 2009). The information obtained from blood parameters substantiates physical examination and, coupled with medical history, provide excellent basis for diagnosis of diseases (Tibbo et al., 2004). It is also useful in evaluating patients before commencing any surgical intervention and selecting appropriate treatment. For instance, haematocrit or packed cell volume (PCV), haemoglobin (Hb), total protein (TP), leucocyte count and whole blood coagulation time are important indices of animal health and production (Oladele et al*.,* 2005). PCV is a reliable indicator of the value of haemoglobin and circulating erythrocytes (RBCs), while changes in plasma globulins reflect the severity of a disease in birds and, thus, serve as the basis for prognosis (Oladele et al*.,* 2005). It also helps in distinguishing the normal state from the state of stress which can be nutritional, environmental or physical (Aderemi, 2004).

Several factors affect cellular and plasma haemodynamics. They include, age (Egbe-Nwiyi et al., 2000; Olayemi and Nottidge, 2007; Devi and Kumar, 2012), sex (Gabriel et al., 2004; Cetin et al., 2009), breed (Tibbo et al., 2004; Tibbo et al., 2008a; Tibbo et al., 2008b), season (Mira and Maria, 1994; Oladele et al*.*, 2005), pregnancy (Ozegbe, 2001; Kim et al., 2002; Farooq et al., 2011; Okonkwo et al., 2011a) and nutritional status (Ekenyem and Madubruke, 2000; Iyayi, 2001). Other factors that affect haematological parameters include lactation (Harewood et al., 2000), egg laying (Oyewale and Fajimi, 1988), blood volume (Probst et al., 2006), stage of oestrous cycle (Alavi-Shoustari et al., 2006; Chaudhari

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and Mshelia, 2006), biological rhythms (Hauss, 1994; Greppi et al., 1996; Azeez et al., 2009) and altitude (Wickler and Aderson, 2000). The aim of the present paper is to briefly review the current state of existing knowledge on the influence of reproductive cycle, sex, age and season on haematologic indices, with emphasis on domestic animals reared under tropical conditions.

SEX DIFFERENCE IN HAEMATOLOGIC PARAMETERS

Erythrocytic parameters

Sex has been found to influence haematological values in many animal species, and values in females are almost always lower than in males. Olayemi et al. (2006), observed no significant sex differences in PCV, RBC count and erythrocytic indices in the fruit bat (*Eidoln helvum*). The lack of sexual dimorphism in the RBC values observed was attributed to the fact that the bats were bled outside their breeding season, when the influence of hormone was minimal on the blood values. Higher values in males than females in parameters relating to RBCs were reported in pheasant birds (Hauptmanova et al, 2006), geese (Lazar et al., 1991), Japanese quails (Mihailov et al., 1999), budgerigars (Itoh, 1992), chickens (Oladele et al., 2000), ducks (Oladele et al., 2001a). and guinea fowls (Oladele et al., 2005; Obinna et al., 2011). In the mallard duck, PCV and Hb were reported to be higher in the male than female, with values of 41.5 % vs 39.0 %, and13.8 g% vs 13.00 g% for packed cell volume and haemoglobin, respectively (Oladele et al*.,* 2007). Oladele *and* Audu, (2010) reported insignificant lower PCV for female than male geese (*Anser anser*) in Zaria. Other studies by Oyewale and Ajibade (1990) and Awotwi and Boohene (1992) also showed that male birds have higher PCV and Hb than their female counterparts.

The rise in blood parameters in males in comparison with females is often attributed to the effect of androgens, which stimulate erythropoiesis and, thus, cause increase in the number of circulating RBCs, PCV and Hb concentration (Villiers and Dunn, 1998). Higher PCV, Hb and RBC values were also observed in the male Agora rabbit in comparison with the female (Cetin et al., 2009). Similar higher PCV, Hb, MCH and MCHC were reported in the male than female (Chineke et al., 2006). It was also reported that haemoglobin was higher in female New Zealand rabbits (Poljicak-Milas et al., 2009). However, a few other workers reported similar RBC values in male and female Nigerian laughing doves (Olayemi et al., 2006), pigeons, peafowls (Oyewale, 1994) and ducks (Olayemi et al*.,* 2002). In Red Sokoto goats, the males have been shown to have a higher PCV than the females (Tambuwal et al*.,* 2002; Okonkwo, 2011b). On the other hand, in West African Dwarf and Sahel goats, PCV values were reported to be similar for both sexes (Daramola et al., 2005; Okonkwo, 2011b). Adamu et al*.* (2010) did not obtain a significant effect of sex on PCV and total white blood cell count, but recorded significantly higher plasma fibrinogen in the female than male Polo horses.

Leukocytic parameters

Circulating total leucocyte count represents the outcome of the dynamic production of bone marrow, the release of the cells to the peripheral circulation and the storage in different organs or pools. Sex differences in immune function are well established in vertebrates (Schuurs and Verheul, 1990; Kaushalendra, 2012). Male generally exhibit lower immune response than female and under pathogenic conditions (Schuurs and Verheul, 1990; Zuk and McKean, 1996). Male goats have higher lymphocyte count as compared to females, whereas the females have a higher neutrophil count as compared to the males (Tambuwal et al., 2002; Daramola et al*.*, 2005). Similarly, in the Red Sokoto goat, higher leucocyte count had been reported in females than in males (Tambuwal et al*.*, 2002).

No significant sex difference in total leucocyte count was observed in African Fruit bats (Olayemi et al., 2006), African White-bellied pangolins and guinea fowls (*Numida meleagris pallas*) (Oyewale et al., 1997). However, a significantly higher total leukocyte in male than female African Giant rats was observed (Oyewale et al., 1998). In rabbits, total leucocyte was significantly higher in females than males (Chineke et al., 2006). Total leucocyte are higher in females than in stallion, as reported in Spanish purebred horses (Hernandez et al., 2008), while other study failed to find significant differences between sexes (Lacerd et al., 2006).

Plasma proteins

Plasma proteins are the key components of plasma and they play crucial role in maintaining homeostasis. Plasma proteins consist of albumin, globulin and fibrinogen (Okonkwo et al., 2011b). These proteins have multiple functions; albumin is the most abundant and osmotically active plasma protein, and it is an important carrier of many substances in the peripheral circulation (Alberghina et al., 2010). Globulins are classified on the basis of their electrophoretic mobility as alpha-, beta- and gamma- globulins. While fibrinogen is important in blood clot formation (Harper et al., 1977), thereby preventing loss of blood from ruptured blood vessel.

The effect of sex on plasma proteins has been shown to vary in birds, depending on the breed of the birds. Significantly higher total protein level had been reported in the females than in male guinea fowls (Oladele et al*.*, 2005) and chickens (Oladele et al., 2000). However, no significant sex variation in total protein was observed in local ducks (Oladele et al., 2001a) and pigeons (Oladele et al., 2001b). In West African Dwarf goats, there were no significant sex effects on albumin and globulin, but the male had significant higher fibrinogen than the female. This is in contrast to the finding of Adamu et al. (2010), who documented higher fibrinogen in the female of Polo horses.

EFFECT OF AGE ON HAEMATOLOGIC PARAMETERS

Erythrocytic parameters

The influence of age on the blood parameters of animals has been determined in several species of mammals and birds in Nigeria, such as the New Zealand rabbits (Olayemi et al., 2007), local dogs (Awah and Nottidge, 1998), cats (Nottidge et al., 1999), African Giant rats (Nssien et al., 2002), goats (Egbe-Nwiyi et al., 2000; Addass et al., 2010b), local ducks (Olayemi et al., 2003) and exotic ducks (Oyewale and Ajibade, 1990; Hatipoglu and Bagci, 1996). Mean PCV, Hb and RBC indices were similar in young and adult New Zealand rabbits (Olayemi et al., 2007). A similar observation was made in Nigerian local cats (Nottidge et al., 1999). However, dogs that were more than three months' old were found to have lower PCV values than adult dogs (Oduye, 1978). Higher PCV values were observed in old than young goats (Addass et al., 2010b). Similarly, in sheep, PCV showed a gradual increase with age (Addass et al., 2010a), with lowest values occurring within the first three months of life (Egbe-Nwiyi et al., 2000). Furthermore, also documented an increase in PCV with advancing age in cattle. This trend is also true for donkeys with increasing RBC, PCV, Hb and erythrocytic indices with advancing age (Terkawi et al., 2002; Etana et al., 2011). This finding is also corroborated by the observation in buffalo (Patil et al., 1992; Jabbar et al., 2012). Jabbar et al. (2012) concluded that higher erythrocyte count was responsible for increased PCV value in growing buffalo heifers as compared to adult heifers; apparently due to high basal metabolic rate, leading to increased rate of erythropoiesis and hence increase in erythrocyte count. Contrary to the trend of erythrocyte count and PCV, haemoglobin concentration tends to be higher at birth when compared with the value in adults (Patil et al., 1992; Jabbar et al., 2012).

Leucocyte count

Total leucocyte count and lymphocyte counts (LC) are lower, but higher heterophil and eosinophil counts in adult than in young Hawaiian dark-rumped petrels (*Pterodoma phaepygia*) have been reported (Work, 1996). In addition, Addass et al. (2010a) reported a significant age effect on LC in Nigerian indigenous sheep. Similarly, decreased total leucocyte count and LC and increased NC and eosinophil count with age were obtained in Ethiopian indigenous goats (Tibbo et al., 2004). However, this is in contrast to the finding in indigenous goats in Nigeria, in which age had no significant influence on TLC in four breeds (West African dwarf, Red Sokoto, Kano Brown and Borno White goats) of goats (Addass et al., 2010b). This is in consonant with the finding in New Zealand rabbit in Nigeria (Olayemi and Nottidge, 2007). Furthermore, lower TLC and lymphocyte count in older pregnant Andalusian Carthusian strain were documented (Satue et al., 2009).

SEASONAL VARIATION IN HAEMATOLOGIC PARAMETERS

Erythrocytic parameters

Generally, the haematological profile is an important indicator of the physiological changes in animals (Jain, 1993; Kumar and Pachaura, 2000). Seasonal changes in the thermal environment influence the physiological responses of animals. Changes in haematological parameters such as total RBC count (Koubkova et al., 2002), PCV (El-Nouty et al., 1990) and RBC indices of mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) are of value in determining the adaptation of animals to the environment. Haemoglobin concentration (Kumar and Pachaura, 2000) and TLC are also indicative of adaptation to adverse environmental conditions. Indeed, haematological values are used to asses stress and welfare in animals (Anderson et al., 1999), especially the neutrophil/lymphocyte ratio (Stanger et al., 2005; Minka and Ayo, 2007).

An increase in body temperature of goats is usually associated with a rise in water intake and depression of food intake (Quartermain and Broadbent, 1997). Thermal stress causes the rostral cooling centre of the hypothalamus to stimulate the medial satiety centre, which inhibits the appetite centre, resulting in reduced feed intake (Albright and Allison, 1972). Under subtropical conditions, the water consumption of goats was greater in summer than winter and spring (Hadjipanayioton, 1995). Such nutritional changes influence the composition of blood in goats (Abdelatif et al., 2009). Furthermore, at high ambient temperature, peripheral vasodilatation and redistribution of cardiac output are associated with expansion of blood volume and haemodilution (Olson et al., 1995).

Aengwanich et al. (2009) reported no significant effect of season on haematological values of crossbred beef cattle at slaughterhouse in northern part of Thailand. However, Tibbo et al. (2004) showed that RBC, PCV and Hb values decreased more during the rainy than any other season. They attributed the decrease to a possible increase in parasite challenge and/or increased water intake through the lush grasses that were available for grazing in that season. Similarly, MCV, MCH and MCHC were higher in summer, while PCV was lower during winter (Kumar and Pachura, 2000). Abdelatif et al. (2009) reported the highest RBC count, PCV and Hb concentration during wet summer and lowest during dry summer; while MCV and MCH were significantly higher during winter than in either wet or dry summer in Nubian goats. The same trend was observed in RBC parameters of goats and in Angora rabbits (Cetin et al., 2009). However, the highest PCV and Hb were recorded during the rainy season in pigeons in Nigeria (Oladele et al., 2001).

Leucocyte count and biochemical parameters

Total leucocyte, lymphocyte and heterophil counts have been reported to be higher in Nigerian local ducks during the dry than wet season, but monocyte and eosinophil counts were not affected by season (Olayemi and Arowolo, 2009). Cetin et al. (2009) also demonstrated a decrease in leucocyte and lymphocyte ratio during the month of July and October in Agora rabbits. Abdelatif et al. (2009) did not observe any significant effect of season on TLC, but the monocyte ratio was significantly higher during the wet and dry summer, as compared to that of the winter.

REPRODUCTIVE CYCLE VARIATION IN HAEMATOLOGIC PARAMETERS

Variations in haematological parameters during the reproductive cycle

Haematological parameters vary with normal physiological and pathological status (Bobade et al*.,* 1985). Various workers have reported changes in haematological parameters during the different phases of the oestrous cycle (Harewood et al., 2000; Alavi-Shoushtari et al., 2006; Chaudhari and Mshelia, 2006). Significantly higher erythrocyte and leucocyte counts have been reported in oestrus in comparison with the dioestrus phase in cattle (Soliman and Zaki, 1963; Hussain and Daniel, 1991). The finding in RSG revealed no significant fluctuation of blood cellular component during the oestrous cycle (Yaqub et al., 2011a). Ijaz et al*.* (2003) reported an increase in Hb concentration, erythrocyte sedimentation rate, MCH, MCHC in cyclic as compared to non-cyclic cows. In bitches, Chudhari and Mshelia (2006) observed the highest RBC values at pro-oestrus and the lowest during pregnancy. WBC, PCV and Hb values showed increasing pattern from anoestrus to pro-oestrus and decreasing pattern with transition from pro-oestrus to estrus. Also in the study, the lowest TLC was recorded during pregnancy, while the highest was obtained during dioestrus. Harewood et al. (2000) observed a decrease in Hb, PCV and RBC, but an increase in MCV during pregnancy. By contrast, significant higher PCV was recorded in pregnant West African Dwarf ewes than either the lactating or dry ewes (Durotoye and Oyewale, 2000). Tewes et al. (2007) demonstrated significant cyclic changes in TLC, blood pH and total protein, but not in RBC and its indices in sows.

In Baladi does, the blood cellular components decreased during the last four weeks of pregnancy, but leuco-cyte increased on the day of parturition (Azab and Abdel-Maksad, 1999). The erythrocytic indices of MCH and MCV increased during the last three weeks of pregnancy.

Effect of reproductive cycle phase on plasma protein concentrations

Some conditions such as dehydration, external haemorrhage, inflammatory disorders, stress, pregnancy, lactation (Thomas, 2000) and stage of oestrous cycle have been reported to affect plasma protein concentration (Alavi-Shoushtari et al., 2006). In cows, serum total protein was reported to be lower during the oestrus than other phases, and this was attributed to a reduction in serum α_1, γ_1 and γ_2 globulin during oestrus (Alavi-Shoushtari et al*.,* 2006). Similar low serum concentration of total protein was documented during oestral phase of oestrous cycle in Red Sokoto goats (Yaqub et al., 2011b). However, Khan et al*.* (2010) demonstrated significantly higher level of plasma globulin in normally cycling cows on day 0 of the cycle (3.82 ± 0.01 g/dl) in comparison with day 20 (3.58 ± 0.11 g/dl).

Repeat-breeder cows had significantly lower plasma proteins as compared to normal cycling cows, irrespective of the days of the cycle. In repeat breeding cows, highest and lowest concentrations of plasma proteins were recorded on day 5 and 20 of the cycle, respectively (Khan et al., 2010). In repeat breeding cows, lowest level of albumin was observed on day 15 of the cycle, and highest concentration on day 20; while the lowest and highest levels of globulin were recorded on day 20 and 5 of the cycle, respectively (Khan et al., 2010). Similar cyclic variation in plasma protein in repeat-breeders in comparison with normal cycling animals has been documented by many workers (El-Belely, 1993; Burle et al*.,* 1995; Jani et al*.,* 1995). However, Gandotra et al*.* (1993) and Ramakrishima (1996) observed no significant variation in protein levels between normal cycling and repeat breeding cows. High incidence of repeat breeding and anoestrous in cows has been attributed to a decrease in circulation of cholesterol (Kumar and Sharma, 1993), glucose (Jani et al*.,* 1995), total protein, albumin and globulin (Joe Arosh et al*.,* 1998).

There were no differences in plasma total protein and albumin between pregnancy and early lactation mares (Milinkovic-Tur et al., 2005). This finding is in congruent with the result obtained in Sahel goats during pregnancy (Waziri et al., 2010). In cows, there were differences in total protein, albumin and globulin fractions between pregnant and non-pregnant cows (Zvorc et al., 2000). In addition, many of the globulin fractions decreased during the last month of gestation.

CONCLUSIONS

Haematologic parameters of domestic animals are significantly influenced by reproductive cycle, sex, age and season. These factors should be considered when interpreting the parameters in order to ensure accuracy.

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RFERENCES

Abdelatif AM, Ibrahim YM, Hassan MY (2009). Seasonal variation in erythrocytic and leukocytic indices and serum proteins of female Nubian goats. Middle-East. J. Sci. Res. 4(3): 168 – 174.

Adamu S, Danladi BN, Mishelia WP, Esievo KAN (2010). Reference values and usefulness of determination of plasma fibrinogen level in polo horses. Zariya Vet. 7(1): 11-17.

Addass PA, Midau A, Babale DM (2010b). Haemato-biochemical findings of Indigenenous goats in Mubi, Adamawa State, Nigeria. J. Agric. Soc. Sci. 6(1): 14 – 16.

Addass PA, Perez KA, Midau A, Lawan, AU, Tizhe MA (2010a). Haemato-Biochemical findings of indigenous sheep breeds in Mubi Adamawa State, Nigeria. Global Vet. 4(2): 164-167.

Aderemi FA (2004). Effect of replacement of wheat bran with cassava root sieviate supplemented or unsupplemented with enzyme on the haematology and serum biochemistry of pullet chicks. Trop. J. Anim. Sci. 7: 147-153.

Aengwanich W, Chantritratikul A, Pamok S (2009). Effect of seasonal variations on haematological values and health monitor of crossbreed cattle at slaughterhouse in Northern eastern part of Thailand. American-Eurasian J. Agric. Environ. Sci. 5 (5): 644-648.

Ajibola OO, Ogunsanmi VT (2004). Comparative studies on erythrocyte calcium, potassium, haemoglobin concentration, osmotic resistance and sedimentation rates in grey duiker (*Sylvicapra grimma*), sheep and goats experimentally infected with *Trypanososma congolense.* Vet. Arhiv. 74(3): 201 - 216.

Alavi-Shoushtari SM, Asri-Rezai S, Abshenas J (2006). A study of the uterine protein variations during the estrous cycle in the cow: a comparison with serum proteins. Anim. Rep. Sci. 96 (1 - 2): 10 – 20.

Alberghina D, Casella S, Vazzana I, Ferrantelli V, Giannetto C, Piccione G (2010). Analysis of serum proteins in clinically healthy goats (Capra hircus) using agarose gel electrophoresis. Vet. Clin. Path. 317-321.

Albright JL, Allison CW (1972). Effects of varying the environment upon performance of dairy cattle. J. Anim. Sci. 32: 57- 66.

Anderson BH, Watson DI, Colditz GI (1999). The effect of dexamethasone on some immunological parameters in cattle. Vet. Res. Comm. 23: 399-413.

Awah JN, Nottidge HO (1998). Serum biochemical parameters in clinically healthy dogs in Ibadan. Trop. Vet. 16: 123-129.

Awotwi EK, Boohene YG (1992). Haematological studies on some poultry species in Ghana. Bull. Anim. Health Prod. Afr. 40: 65 – 71.

Azab ME, Abdel-Maksad HA (1999). Changes in some haematological and biochemical parameters during prepartum and postpartum periods in female Baladi goats. Small Rum. Res. 34(1): 77-85.

Azeez OI, Oyagbemi AA, Oyewale JO (2009). Diurnal fluctuation in haematological parameters of the domestic fowls in the hot humid tropics. Int. J. Poult. Sci. 8(3): 247-251.

Bobade PA, Oduye OO, Helen O, Agbona O (1985). Haemogram of clinically normal dogs with particular reference to local (Nigerian) and German shepherd dogs. Nig. Vet. J. 14: 7 - 11.

Burle PM, Mangle NS, Kothekhan MD, Lalorey DR (1995). Blood biochemical profile on postpartum reproduction and energy balance in dairy cattle. J. Dairy Sci. 73: 2342-2349.

Cetin N, Bekyurek T, Cetin E (2009). Effect of sex, pregnancy and season on some haematological and biochemical blood values in Angora rabbits. Scand. J. Lab. Anim. Sci. 36 (2): 155-162.

Chaudhari SUR, Mshelia GD (2006). Evaluation of the haematological values of bitches in Northern Nigeria for the staging of pregnancy. Pak. J. Biol. Sci. 9 (2): 310 – 312.

Chineke CA, Ologun AG, Ikeobi CON. (2006). Haematological parameters in rabbit breeds and crosses in humid tropics. Pak. J. Biol. Sci. 9 (11): 2102 – 2106.

Daramola JO, Adeloye AA, Fatoba TA, Soladoye AO (2005). Haematological and biochemical parameters of West African Dwarf goats. Livestock Research for Rural Development, 17, Art. 95. Retrieved January 19, 2011, from http://www.lrrd.org/lrrd.org/lrrd17/8/dara17095. htm. 3:05 pm.

Devi R, Kumar MP (2012). Effect of ageing and sex on the ceruloplasmin (Cp) and the plasma protein levels. J. Clini. Diagn. Res. 6(4): 577-580.

Durotoye LA, Oyewale JO (2000). Blood and plasma volume in normal West African dwarf sheep. Afr. J. Biomed. Res. 3: 135-137.

Egbe-Nwiyi TN, Nwosu SC, Salami HA (2000). Haematological values of apparently healthy sheep and goats as influenced by age and sex in arid zone of Nigeria. Afr. J. Biomed. Res. 3: 109-115.

Ekenyem BU, Madubruke FN (2000). Haematological and serum biochemistry of grower pigs fed varying levels of *Ipomoea asarifolia* leaf meal. Pak. J. Nut. 6(6): 603-606.

El-Belely NS (1993). Progesterone, estrogen and selected biochemical constituents in plasma and uterine flushings of normal and repeat breeder buffalo cows. J. Agric. Sci. 120: 241-250.

El-Nouty FD, Al-Haidary AA, Salah MS (1990). Seasonal variation in hematological values of high and average yielding Holstein cattle in semi-arid environment. J. King Saud. Univ. 2(2): 173-182.

Esonu BO, Emenalom OO, Udedebie U, Herbert DF, Ekpori IC, Iheukwuemere FC (2001). Performance and blood chemistry of weaner pigs fed raw mucuna bean (velvet bean) meal. Trop. Anim. Prod. Invest. 4: 49 - 54.

Etana KM, Jenbere TS, Bojia E, Negusie H (2011). Determination of reference haematological and serum biochemical values for working donkeys of Ethiopia. Vet. Res. 4(3): 90-94.

Farooq H, Samad HA, Sajjad S (2011). Normal reference Haematological values of one-humped camels (Camelus Dromedarius) kept in Cholistan desert. J. Anim. Plant Sci. 21(2): 157-160.

Gabriel UU, Ezeri GNO, Opabunmi OO (2004). Influence of sex, source, health status and acclimation on the haematology of Clarias gariepinus. Afr. J. Biotech. 3(9): 460-467.

Gandotra VK, Chaudhary RK, Sharma RD (1993). Serum biochemical constituents in normal and repeat breeding cows and buffaloes. Indian Vet. J. 70: 84-85.

Greppi GF, Casini L, Gatta D, Orlandi M, Pasquini M (1996). Daily fluctuations of haematology and blood biochemistry in horses fed varying levels of proteins. Equine Vet. J. 28(5): 350-353.

Hadjipanayioton M (1995). Fractional outflow of soybean meal from the rumen, water intake and ruminal fermentation pattern in sheep and goats at different seasons and age group. Small Rum. Res. 17: 137-143.

Harewood WJ, Gillin A, Hennessys A, Armistead J, Horvath JS, Tiller DJ (2000). The effects of the menstrual cycle, pregnancy and early lactation on haematology and plasma biochemistry in the baboon (*Papio hamadryas*). J. Med. Primatol. 29: 415 – 420.

Harper HA, Rodwell VW, Mayer PA (1977). Review of Physiological Chemistry, 6^{th} (eds). Lange Medical Publication, California.

Hatipoglu S, Bagci C (1996). Some haematological values from Pekin ducks. Berl. Munch. Tierarztl Wschr. 109: 172-176.

Hauptmanova K, Maly M, Literak I (2006). Changes of haematological parameters in common pheasants throughout the year. Vet. Med. 51(1): 29 - 34.

Hauss E (1994). Chronobiology of circulating blood cells and platelets. In: Biological Rhythms in clinical and laboratory Medicine. Touitou, Y. 8 Hauss, E. (eds)., Springer-Verlag. pp. 504-526

Hernandez AM, Satue K, Lorente C, Garces C, Oçonnor JE (2008). The influence of age and gender on haematologic parameters in Spanish Horses. Proceeding of Veterinary European equine meeting – XIV SIVE congress, Venice (Italy).

Hussain AM, Daniel RCW (1991). Studies on some aspects of neutrophil functions and uterine defences in cows during the oestrous

cycle. Rep. Dom. Anim. 26: 290 - 296.
Ijaz A, Gohar NA, Ahmad M (2003). Haematological profile in cyclic and non-cyclic and endometric cross-breed cattle. Int. J. Agric. Biol. 5(3): 332-334.
Itoh N (1992). Some haematologic values in budgerigar. J. Rakuno Gakuen Univ. 17: 61-64.
Iyayi EA (2001). Cassava leaves as supplements for feeding weaner swine. Trop. Anim. Prod. Invest. 4: 141-150.
Jabbar L, Cheena A, Riffat S (2012). Effect of different dietary energy levels, season and age on haematological indices and serum electrolytes in growing buffalo heifers. J. Anim. Plant Sci. 22(3 Suppl): 279-283.
Jain NC (1993). Essentials of Veterinary Haematology (1st Edition), Lea and Febiger, Philadelphia. pp. 1-18.
Jani RG, Prajapati BR, Dave MR (1995). Hematological and biochemical changes in normal fertile and infertile Surti buffaloe heifers. Indian J. Anim. Rep. 5: 14-22.
Joe-Arosh K, Devanathan AD, Rajasundaram TG, Rajasekaran J (1998). Blood biochemical profile in normal cyclical and anoestrous cows. Indian J. Anim. Sci. 68: 1154-1156.
Kaushalendra CH (2012). Correlation between peripheral melatonin and general immune status of domestic goat, Capra hircus: A seasonal and sex dependent variation. Small Rum. Res. 107: 147-156.
Khan S, Thangawel A, Selvasubramaniyan S (2010). Biochemical profile in repeat breeding cows. Tamilnadu J. Vet. Anim. Sci. 6(2): 75-80.
Kim JC, Yun HI, Chas SW, Kim KH, Koh WS (2002). Haematological changes during the normal pregnancy in New Zealand White rabbis. Comp. Clin. Pathol. 11: 98-106.
Koubkova M, Knizkova I, Kunc P, Hartlova H, Flusser J, Dolezal O (2002). Influence of high environmental temperatures and evaporative cooling on some physiological, haematological and biochemical parameters in high-yielding dairy cows. Czech J. Anim. Sci. 47: 309-318.
Kral I, Suchy P (2000). Haematological studies in adolescent breeding cocks. Acta. Vet. Brno. 69: 189 - 194.
Kumar B, Pauchaura SP (2000). Haematological profile of crossbred dairy cattle to monitor herd health status at medium elevation in central Himalayas. Res. Vet. Sci. 69: 141-145.
Kumar S, Sharma P (1993). Hematological changes during fertile and nonfertile estrous in rural buffaloes. Buffaloe J. 9: 69-73.
Lacerd L, Compos R, Sperb M, Soares E, Barbosa E, Rerreira R, Santos V, Gonzalez FH (2006). Haematologic and biochemical parameters in three high performance horse breeds from southern Brazil. Archiv. Vet. Sci. 11(2): 40-44.
Lazar V, Pravda D, Stavkova J (1991). Analysis of the sources of variability of the haematological characteristics of geese (in Czech). Zivocisma Vyroba, 36 : 517-523.
Mihailov R, Lasheva V, Lashev L (1999). Some haematological values in Japanese quails. Bulg. J. Vet. Med. 2: 137 – 139.
Milinkovic-Tur S, Peric V, Stojevic Z, Zdelar-Tuk M, Pirljin J (2005). Concentrations of total proteins and albumins, and AST, ALT and GGT activities in the blood plasma of mares during pregnancy and early lactation. Vet. Arhiv. 75(3): 195-202.
Minka NS, Ayo JO (2007). Physiological responses of transported goats treated with ascorbic acid during hot dry season. Anim. Sci. J. 78(2): 164-172.
Mira A, Maria ML (1994). Seasonal effects on the haematology and blood plasma proteins of two species of mice *Mus musculus domesticus* and *M. spretus* from Portugal. Hystririx 5: 63-72.
Nottidge HO, Taiwo VO, Ogunsanmi AO (1999). Haematological and serum biochemical studies of cats in Nigeria. Trop. Vet. 17: 9-16.
Nssien MAS, Olayemi FO, Onwuka SK, Olusola A (2002). Comparison of some plasma biochemical parameters in two generations of African giant rat (*Cricetomys gambianus*, Waterhouse). Afr. J. Biomed. Res. 5: 63-67.
Obinna, OVM, Emmanuel OU, Princewill OI, Helen O, Christopher E (2011). Effect of sex and systems of production on the haemato-logical and serum biochemical characters of helmeted guinea fowls (*Numida meleagris pallas*) in South Eastern Nigeria. Int. J. Biosci. 1(3): 51-56.
Oduye OO (1978). Haematological studies on clinically normal dogs in Nigeria. Zentralblalt Fur Veterina Medizine 25: 548-555.
Okonkwo JC, Okonkwo IF, Ebyh GU (2011a). Effect of breed, sex and source within breed on the haematological parameters of the Nigerian goats. Online J. Anim. Feed Res. 1(1): 8-13.
Okonkwo JC, Omeje JS, Okonkwo IF (2011b). Effect of source and sex on blood protein fractions of West African dwarf goats (WADG). Res. Opin. Anim. Vet. Sci. 1(3): 158-161.
Oladele SB, Audu SB (2010). Packed cell volume, haemoglobin, total protein and whole blood coagulation time of the geese (*Anser anser*) reared in Zaria, Northern Nigeria. Zariya Vet. 7(1): 1 – 10.
Oladele SB, Ayo JO, Esievo KAN, Ogundipe SO (2000). Effect of season and sex on packed cell volume, haemoglobin and total protein of indigenous chickens in Zaria, Nigeria. J. Med. Allied Sci. 3: 173-177.
Oladele SB, Ayo JO, Esievo KAN, Ogundipe SO (2001a). Seasonal and sex variations in packed cell volume, haemoglobin and total protein of indigenous duck in Zaria, Nigeria. J. Trop. Biosci. 1(1): 84-88.
Oladele SB, Ayo JO, Ogundipe SO, Esievo KAN (2005). Seasonal and sex variations in packed cell volume, haemoglobin and total protein of the guinea fowl (*Numida meleagris*) in Zaria, Northern Guinea Savannah zone of Nigeria. J. Trop. Biosci. 5 (2): 67- 71.
Oladele SB, Isa IH, Sambo SJ (2007). Haematocrit, haemoglobin, total protein and whole blood coagulation time of the Mallard duck, Niger Vet. J. 28 (1): 14 – 20.
Oladele SB, Ogundipe S, Ayo JO, Esievo KAN. (2001b). Effects of season and sex on packed cell volume, haemoglobin and total protein of indigenous pigeons in Zaria, Northern Nigeria. Vet. Arhiv. 71(5): 277-286.
Olayemi F, Oyewale J, Rahman S, Omolewa O (2003). Comparative assessment of the white blood cell values, plasma volume and blood volume in the young and adult Nigerian duck (*Anas platyrhynchos*). Vet. Arhiv. 73(5): 27 – 276.
Olayemi FO, Arowolo ROA (2009). Seasonal variations in the haema-tological values of the Nigerian Duck (*Anas platyrhynchos*). Int. J. Poult. Sci. 8(8): 813-815.
Olayemi FO, Nottidge HO (2007). Effect of age on the blood profiles of the New Zealand rabbit in Nigeria. Afr. J. Biomed. Res. 10: 73 – 76.
Olayemi FO, Ojo EA, Fagbohun OA (2006). Haematological and plasma biochemical parameters of the Nigerian Laughing dove (*Anas platyrhynchos*), Vet. Arhiv, 76 (2); 145 – 151.
Olayemi FO, Oyewale JO, Omolewa OF (2002). Plasma chemistry values in the young and adult Nigerian duck (*Anas platyrhynchos*). Israel. J. Vet. Med. 57: 1 - 5.
Olson K, Joaster-Hermelin M, Hossaini-Hilali J, Hydbrig E, Dahlborn K(1995). Heat stress causes excessive drinking in feed and food-deprived pregnant goats. Comp. Bioch. Physiol. *(A),* 110 (4): 309-317.
Oyewale JO (1994). Further studies on osmotic resistance of nucleated erythrocyte: observation with pigeon, peafowl, lizard and toad erythrocyte during changes in temperature and pH. J. Vet. Med. 41: 62 – 71.
Oyewale JO, Ajibade HA (1990). Osmotic fragility of erythrocytes of the white Pekin duck. Vet. Arhiv, 60: 91-100.
Oyewale JO, Fajimi JL (1988). The effect of egg lying on haematological and plasma biochemistry of guinea hen. Bull. Anim. Health Prod. Afr. 36: 229 - 232.
Oyewale JO, Okewumi TO, Olayemi FO (1997). Haematological changes in West African Dwarf goats following haemorrhage. J. Vet. Med. 44: 619-624.
Oyewale JO, Olayemi FO, Oke OA (1998). Haematology of the wild adult African giant rat (Cricetomys gambianus, Water-house). Vet. Arhiv. 68: 91-99.
Ozegbe PC (2001). Influence of pregnancy on some erythrocyte biochemical profile in the rabbits. Afr. J. Biomed. Res. 4: 135-137.
Patil MD, Talvelker BA, Joshi VG, Deshmukh BT (1992). Haematologic studies during the oestrous cycle in Murrah buffalo heifers. Indian Vet. J. 69: 894-897.
Poljicak-Milas N, Kardum-Skelin, I, Vudan M, Marenjak TS, Ballarin-Perharic A, Milas Z (2009). Blood cell count analyses and erythrocyte morphometry in New Zealand white Rabbits. Vet. Arhiv. 79(6): 561-571.
Probst RJ, Jenny ML, Bird DN, Pole GL, Aileen KS, John RC (2006).

Gender differences in the blood volume of conscious Sprague-Dawley rats. J. Am. Assoc. Lab. Anim. Sci. 45(2): 49-52.
Quartermain AR, Broadbent MP (1997). Some patterns of response to climate by Zambian goats. East Afr. Agric. Forest J. 40: 115-124.
Ramakrishima KV (1996). Microbial and biochemical profile in repeat breeder cows. Indian J. Anim. Rep. 17: 30-32.
Satue K, Blanco O, Munoz A (2009). Age-related differences in the haematological profile of Andalusian broodmares of Carthusian strain. Vet. Med. 54: 175-182.
Schuurs AH, Verheul HA (1990). Effects of gender and sex steroids on the immune response. J. Steroid Biochem. 35(2):157-172.
Soliman MK, Zaki K (1963). Blood picture of Friesian cows during the oestrous cycle and pregnancy. J. Arab Vet. Med. Assoc. 4: 343 - 54.
Stanger KJ, Ketheesan AJ, Parker CJ (2005). The effect of transportation on the immune status of *Bos indicus* steers. J. Anim. Sci. 83: 2632-2636.
Tambuwal FM, Agale BM, Bangana A (2002). Haematological and biochemical values of apparently healthy Red Sokoto goats. Proceeding of the 27th Annual Conference of the Nigerian Society for Animal Production, Federal University of Technology, Akure, *Nigeria*. pp. 50-53.
Terkawi AD, Tabba D, Al-Omari A (2002). Estimation of normal haematology values of local donkeys in Syria. Proceedings of the 4th International Colloquium on working Equines, April 20-25, Spana-Alabaata University, Hama, Syria. pp. 115-118.
Tewes H, Steinbach J, Smidt D (2007). Investigations on the blood composition of sows during the reproductive cycle. Rep. Domest. Anim. 12(3): 117 - 124.
Thomas JS (2000). Overview of plasma protein. In: Feldman, B. F., Zinkl, J. G. and Jain, N. C. (Editors), Schalm's Veterinary Haematology, Fifth Edition, Lippincott Williams and Winlkins, Philadelphia. pp. 891-909.
Tibbo M, Jibril T, Woldemeskel M, Dawo F, Aragaw K, Rege JEO (2004). Factors affecting haematological profiles in three Ethiopian indigenous goat breeds. Intern. J. Appl. Res. Vet. Med. 2(4): 297 – 309.
Tibbo M, Jibril Y, Woldemeskel M, Dawo F, Argaw K, Rege JEO (2008a). Serum enzyme levels and influencing factors in three indigenous Ethiopian goats breeds. Trop. Animl. Health Prod. 40: 657-666.
Tibbo M, Woldemeskel M, Argaw K, Rege JEO (2008b). Serum enzyme levels and influencing factors in three indigenous Ethiopian sheep breeds. Comp. Clin. Pathol. 17 (3): 149-155.
Villiers E, Dunn JK (1998). Basic haematology. *In*: Davidson, M., Else, R. and Lumsden, J. (Editors). *Manual of Small Animal Clinical Pathology*, Shurdngton, Cheltenham, United Kingdom. pp. 33-60.
Waziri AM, Ribadu AY, Sivachelvan N (2010). Changes in the serum proteins, haematological and some srum biochemical profiles in the gestation period in the Sahel goats. Vet. Arhiv. 80(2): 215-224.
Wickler SJ, Aderson TP (2000). Haematological changes and athletic performance in horses in response to high altitude (3800 m). Am. J. Physiol. – Regul. Intergr. Comp. Physiol. 279: 1176-1181.
Work TM (1996). Weight, haematology and serum chemistry of seven species of free-ranging tropical pelagic seabird. J. Wildlife Dis. 13: 1051-1055.
Yaqub LS, Ayo JO, Rekwot PI, Onyeanusi BI, Kawu MU, Ambali SF, Unchendu C (2011a). Changes in haematologic parameters and erythrocyte osmotic fragility during oestrous cycle in Red Sokoto goats. Book of Abstract 48th Annual Congress of NVMA, Kwara, Kwara State government Banquet Hall, Ilorin, Nigeria.
Yaqub LS, Ayo, JO, Rekwot, PI, Oyeanusi BI, Kawu MU, Ambali SF, Shittu M, Abdullahi A (2011b). Changes in serum proteins and urea during the oestrous cycle in Red Sokoto goats. Adv. Appl. Sci. Res. 2(6): 197-205.
Zuk W, Mckean KA (1996). Sex difference in parasites infections: pattern and process. Int. J. Parasitol. 26: 1009-1024.
Zvorc Z, Matijatko V, Beer B, Forsek J, Bedrica L, Kucer N (2000). Blood serum proteinograms in pregnant and non-pregnant cows. Vet. Arhiv. 70(1): 21-30.