Agricultural Science
Volume 2, Issue 1 (2014), 37-47
ISSN 2291-4471 E-ISSN 2291-448X
Published by Science and Education Centre of North America

Haematological Parameters and Factors Affecting Their Values

NseAbasi N. Etim[1]*, Mary E. Williams[1], Uduak Akpabio[2], and Edem E. A. Offiong[1]

[1]Department of Animal Science, Akwa Ibom State University, Obio Akpa Campus, Akwa Ibom State, Nigeria

[2]Department of Veterinary Public Health and Preventive Medicine, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria

*Correspondence: NseAbasi N. Etim, Department of Animal Science, Akwa Ibom State University, Obio Akpa Campus, Akwa Ibom State, Nigeria. E-mail: etimbobo@yahoo.com

DOI: 10.12735/as.v2i1p37

Abstract

This article presents an overview of haematological parameters and factors affecting their values. Blood act as a pathological reflector of the status of the exposed animals to toxicants and other conditions. The examination of blood provides the opportunity to clinically investigate the presence of metabolites and other constituents in the body of animals and it plays a vital role in the physiological, nutritional and pathological status of an animal. Blood constituents change in relation to the physiological status of an animal. These changes are important in assessing the response of farm animals to various physiological situations. These changes are often caused by several factors; some of which are genetic and others, non-genetic. Age, sex, breed and management systems are among the factors that influence blood-based parameters of farm animals. It is important to establish baseline indices for these parameters on the basis of these factors and determine the effects of these factors on these indices.

Keywords: haematology, parameters, factors, values

1. Introduction

Haematology refers to the study of the numbers and morphology of the cellular elements of the blood – the red cells (erythrocytes), white cells (leucocytes), and the platelets (thrombocytes) and the use of these results in the diagnosis and monitoring of disease (Merck Manual, 2012). Haemtological studies are useful in the diagnosis of many diseases as well as investigation of the extent of damage to blood (Onyeyili, Egwu, Jibike, Pepple, & Ohaegbulam, 1992; Togun *et al.,* 2007). Haematological studies are of ecological and physiological interest in helping to understand the relationship of blood characteristics to the environment (Ovuru & Ekweozor, 2004) and so could be useful in the selection of animals that are genetically resistant to certain diseases and environmental conditions (Mmereole, 2008; Isaac, Abah, Akpan, & Ekaette, 2013). Haematological parameters are good indicators of the physiological status of animals (Khan & Zafar, 2005). Haematological parameters are those parameters that are related to the blood and blood forming organs (Waugh, Grant, & Ross, 2001; Bamishaiye, Muhammad, & Bamishaiye, 2009). Blood act as a pathological reflector of the status of exposed animals to toxicant and other conditions (Olafedehan *et al.,* 2010). As reported by Isaac *et al.* (2013) animals with good blood composition are likely to show good performance. Laboratory tests on the blood are vital tools that help detect any deviation from normal in the animal or human body (Ogunbajo, Alemede, Adama, & Abdullahi, 2009). The examination of blood gives the opportunity to investigate the presence of several metabolites and other constituents in the body of animals and it plays a vital role in the physiological, nutrition and pathological status of an organism (Aderemi, 2004; Doyle, 2006). According to Olafedehan *et al.* (2010) examining blood for their constituents can provide important information for the diagnosis and prognosis of diseases in animals. Blood constituents change in relation to the physiological conditions of health (Togun *et al.,* 2007). These changes are of value in assessing response of animals to various physiological situations (Khan & Zafar, 2005). According to Afolabi, Akinsoyinu, Olajide, and Akinleye (2010), changes in haematological parameters are often used to determine various status of the body and to determine stresses due to environmental, nutritional and/or pathological factors.

This review examined the effects of breed, age, sex, management systems among others on the haematological parameters of farm animals.

2. Haematological Components and Their Functions

Blood which is a vital special circulatory tissue is composed of cells suspended in a fluid intercellular substance (plasma) with the major function of maintaining homeostasis (Isaac *et al.*, 2013). Haematological components, which consist of red blood cells, white blood cells or leucocytes, mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration are valuable in monitoring feed toxicity especially with feed constituents that affect the blood as well as the health status of farm animals (Oyawoye & Ogunkunle, 2004). Red blood cells (erythrocytes) serve as a carrier of haemoglobin. It is this haemoglobin that reacts with oxygen carried in the blood to form oxyhaemoglobin during respiration (Johnston & Morris, 1996; Chineke, Ologun, & Ikeobi, 2006). According to Isaac *et al.* (2013) red blood cell is involved in the transport of oxygen and carbon dioxide in the body. Thus, a reduced red blood cell count implies a reduction in the level of oxygen that would be carried to the tissues as well as the level of carbon dioxide returned to the lungs (Ugwuene, 2011; Soetan, Akinrinde, & Ajibade, 2013; Isaac *et al,* 2013).

The major functions of the white blood cell and its differentials are to fight infections, defend the body by phagocytocis against invasion by foreign organisms and to produce or at least transport and distribute antibodies in immune response. Thus, animals with low white blood cells are exposed to high risk of disease infection, while those with high counts are capable of generating antibodies in the process of phagocytocis and have high degree of resistance to diseases (Soetan *et al*., 2013) and enhance adaptability to local environmental and disease prevalent conditions (Kabir, Akpa, Nwagu, Adeyinka, & Bello, 2011; Okunlola, Olorunisomo, Aderinola, Agboola, & Omole, 2012; Iwuji & Herbert, 2012; Isaac *et al.,* 2013).

Blood platelets are implicated in blood clotting. Low platelet concentration suggests that the process of clot-formation (blood clotting) will be prolonged resulting in excessive loss of blood in the case of injury. Packed Cell Volume (PCV) which is also known as haematocrit (Ht or Hct) or erythrocyte volume fraction (EVF), is the percentage (%) of red blood cells in blood (Purves, Sadava, Orians, & Heller, 2003). According to Isaac *et al.* (2013) Packed Cell Volume is involved in the transport of oxygen and absorbed nutrients. Increased Packed Cell Volume shows a better transportation and thus results in an increased primary and secondary polycythemia. Haemoglobin is the iron-containing oxygen-transport metalloprotein in the red blood cells of all vertebrates (Maton *et al.,* 1993) with the exception of the fish family, channichthyldae (Sidell & O’ Brien, 2006) as well as tissues of invertebrates. Haemoglobin has the physiological function of transporting oxygen to tissues of the animal for oxidation of ingested food so as to release energy for the other body functions as well as transport carbon dioxide out of the body of animals

(Ugwuene, 2011; Omiyale, Yisa, & Ali-Dunkrah, 2012; Soetan *et al.,* 2013; Isaac *et al.,* 2013). According to Peters, Gunn, Imumorin, Agaviezor, and Ikeobi (2011), previous reports stated that Packed Cell Volume, haemoglobin and mean corpuscular haemoglobin are major indices for evaluating circulatory erythrocytes, and are significant in the diagnosis of anaemia and also serve as useful indices of the bone marrow capacity to produce red blood cells as in mammals (Awodi, Ayo, Atodo, & Dzende, 2005; Chineke *et al.,* 2006). Furthermore, Chineke *et al.* (2006) posited that high Packed Cell Volume (PCV) reading indicated either an increase in number of Red Blood Cells (RBCs) or reduction in circulating plasma volume. Mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration indicate blood level conditions. A low level is an indication of anaemia (Aster, 2004).

3. Normal Haematological Values for Various Species of Farm Animals

Haematological values could serve as baseline information for comparison in conditions of nutrient deficiency, physiology and health status of farm animals (Daramola, Adeloye, Fatoba, & Soladoye, 2005). According to Research Animal Resources [RAR] (2009) (see table 1) the values below are subjectively averaged from a variety of sources. There is a great range of values. This may be accounted for by variation in age, sex, breed or strain, sampling techniques, and testing methodology. As such, the range limits are not firm boundaries and should be used as guidelines.

Table 1. Reference Values for Farm Animals

	Swine	**Sheep**	**Cow**	**Rabbit**	**Guinea Pig**
PCV (%)	32 – 50	24 – 45	24 – 48	30 – 50	37 – 48
Hgb (g/dl)	10 – 16	8 – 16	8 – 15	10 – 15	11 – 15
MCV (fl)	50 – 68	23 – 48	40 – 60	78 – 95	67 – 77
MCH (pg)	17 – 23	8 – 12	11 – 17	-	-
MCHC (g/dl)	30 – 36	31 – 38	30 – 36	27 – 37	30 – 34
WBC (x1000)	7 – 20	4 – 12	4 – 12	4.5 – 11	5 – 8.9
Diff (%)					
Lymphocytes	40 – 60	40 – 70	40 – 70	40 – 80	39 – 72
Monocyte	2 – 10	0 – 6	1 – 6	1 – 4	2 – 6
Eosinophils	0 – 10	0 – 10	0 – 4	0 – 4	0 – 5
Basophils	0 – 2	0 – 3	0 – 2	1 – 7	0 – 3

Adapted from: Research Animal Resources [RAR] (2009)

Mitruka and Rawnsley (1977) reported the normal range of value for rabbits as follows: PCV: 30 – 35%, Hb: 9.3 – 19.3g/dl and RBC: 4.00 – 8.60x10^6mm^3. Anonymous (1980) reported the following range of values for rabbits: PCV: 31.0 – 50.0%, RBC: 5.0 – 8.0(x10^6/mm^3), WBC: 3.0 – 12.5(x10^6/mm^3), Hb: 8.0 – 17.0(g/dl). Postgraduate Committee in Veterinary Sciences [PCVS] (1990) stated a standard WBC range of values of 2.5 – 12.5(x10^3mm^3). White Blood Cells Count (WBC) of 5 – 13(x10^9/l) is considered to be within the normal range by Burke (1994) for rabbit. Poole (1987) reported a PCV range of 30 – 50% for rabbits.

Merck Manual (2012) documented the following range of values for cow (table 2):

Table 2. Reference Value for Cow

Parameters	Values
PCV (%)	30 – 45
PCV (X10)	24 – 34
Hb (g/dl)	10 – 15
RBC ($x10^6/mm^3$)	5.0 – 10.0
Reticulocytes	0 – 0.6
MCV (fl)	39 – 55
MCH (Pg)	13 – 17
MCHC (gldl)	30 – 36
Platelets	300 – 800

Adapted from: Merck Manual (2012)

4. Factors Influencing Haematological Parameters of Farm Animals

The genetic and non-genetic factors affecting haematological parameters of farm animals have been observed (Agaie & Uko, 1998; Kleinbeck & McGlorie, 1999; Svoboda, Eichlerova, Horak, & Hradecky, 2005; Xie *et al.*, 2013). Several factors including physiological (Alodan & Mashaly, 1999), environmental condition (Vecerek, Strakova, Suchy, & Voslarova, 2002; Graczyk, Pliszczak-Król, Kotonski, Wilczek, & Chmielak, 2003), dietary content (Odunsi, Onifade, & Babatunde, 1999; Yeong, 1999; Kurtoğlu, Kurtoğlu, Celik, Keçeci, & Nizamlioğlu, 2005; Iheukwumere and Herbert, 2002), fasting (Lamošová, Máčajová, & Zeman, 2004), age (Forlan, Macari, Malheiros, Moraes, & Malheiros, 1999; Seiser *et al.,* 2000), administration of drugs (Khan, Szarek, Koncicki, & Krasnodebska-Depta, 1994), anti-aflatoxin treatment (Oguz, Kececi, Birdane, Önder, & Kurtoglu, 2000) and continuous supplementation of vitamin (Tras *et al.,* 2000) affect the blood profile of healthy animal. Swenson (1970) and Addass, David, Edward, Zira, and Midau (2012) also observed that factors such as age, nutrition, health of the animal, degree of physical activity, sex and environmental factors affect blood values of animals. According to Daramola *et al.* (2005) age and sex of farm animals affect haematological parameters. Schalm, Jain, and Carroll (1975) reported that blood pictures of animals might be influenced by certain factors such as nutrition, management, breeds of animal, sex, age, diseases and stress factors. Dukes (1955) and Afolabi (2010) posited that haematological values of farm animals are influenced by age, sex, breed, climate, geographical location, season, day length, time of day, nutritional status, life habit of species, present status of individual and other factors. Carlson (1996), and Johnston and Morris (1996) reported that besides physiological and environmental factor that might affect blood values as: age of the animal, factors such as oestrus cycle, pregnancy and parturition, genetics, method of breeding, breeds of animal, housing, feeding, fasting, extreme climatic conditions, stress, exercises, transport, castration and diseases have been identified.

4.1 Genetic Factors

4.1.1 *Breed and Genotype*

In a study on haematological parameters of rabbit breeds and cross in humid tropics conducted by chineke *et al.* (2006) it was reported genotype influence on PCV, WBC, MCH and ESR; RBC, HBC and MCHC values were identical in all genotypes, pointing similar cellular haemoglobin content in blood samples obtained. In a s study conducted by Peters *et al.* (2011) on variation in haematological parameters of Nigerian native chickens; normal-feathered birds had higher mean values compared to frizzled feather and native neck genotype. Peters *et al.* (2011) observed some strain differences which were consistent with Agaie and Uko (1998), Islam *et al.* (2004) and Chineke *et al.* (2006) strengthening the argument for interest of genetic differences. According to Peters *et al.* (2012), sufficient genetic variation therefore exists for haematological parameters among Nigerian native chickens that may represent indicator traits for study.

Isaac *et al.* (2013) in a study on haematological properties of different breeds (Chinchilla, New Zealand White and Dutch) of rabbit reported that Chinchilla had the highest value for WBC, lymphocytes, monocytes, RBC, Hb, PCV and MCV. New Zealand White had the highest value in MCHC and MCH while Dutch had the highest values in neutrophils, eosinophils, basophils and platelets. Isaac *et al.* (2013) further reported that there was no significant difference among the breeds. Schalm (1975) reported significant breed differences in haematological values for New Zealand White and wild jack rabbit. Durai, Maruthai, Arumugam, and Venugopal (2012) conducted a study on haematological profile and erythrocyte indices of different breeds of poultry and observed variation in results which was suggested to be due to differences in breeds. Durai *et al.* (2012) further documented that the significant differences in haematological profile and erythrocyte indices among the different breeds of poultry can be considered as reference values and may serve as a guide to assess the state of health in the monitored birds. Ekiz and Yalcintan (2013) in a study on haematological parameters in goats kids reported that breed had significant effect on PCV. Schalm *et al.* (1975) stated that haematological studies of farm animals either showed significant or no significant breed effect. Ologunowa *et al.* (2000) reported that no significant breed effect on the blood parameters, in his study.

4.2 Non-Genetic Factors

4.2.1. *Age and Sex*

In a study conducted by Addass *et al.* (2012) on indigenous chickens, it was reported that age group effect was observed on PCV, RBC and WBC where the 150d age group recorded highest WBC, PCV; higher RBC value was observed for age group 90d. For WBC, the 90d age group had the highest. A significant sex effect was also observed, with males having higher values of PCV and RBC and females have shown higher value on WBC. A significant age effect was observed for MCV and MCHC. Significant sex effect was evident with females having highest value on MCHC while males had higher MCV. A significant sex effect was observed on Hb concentration. Addass *et al.* (2012) reported that the majority of haemotological parameters for indigenous chickens increase with advancing age, males generally report higher value than females. Peters *et al.* (2011) reported that male chickens generally had higher mean values than their female counterpart across all genotypes. Another study conducted by Egbe-Nwiyi, Nwaosu, and Salami (2000) revealed the influence of age and sex on haematological values of goats and sheep; age and sex had remarkable influence on the RBC counts of goats, age influenced the Hb and PCV values, age and sex greatly influenced the MCV and age influenced MCHC. Age and sex influenced neutrophil (increased with age) and eosinophil counts (gradually decreased with age and males had higher counts) in sheep. Sex and age influenced the RBC values of sheep. PCV and MCHC values of sheep were influenced by both sex and age. The MCV was influenced by age. Sex significantly influenced the total WBC (the highest value in males and females were observed at 3 -5 years and 6-9 months respectively in goats) and monocyte counts (which was higher in males and females). Daramola *et al.* (2005) reported that age was observed to have a significant effect on HB, RBC and MCHC of West African Dwarf goat which suggested that the oxygen carrying capacity of the blood was high in adult goats. Daramola *et al.* (2005) observed that sex had significant effect on lymphocyte and neutrophils; the male WAD goats had increased lymphocyte values compared to the female animals, whereas the female had increased neutrophil values compared to the male animals, which was similar to observations reported for Red Sokoto goats (Tambuwal, Agale, & Bangana, 2002). Daramola *et al.* (2005) further documented that the PCV values obtained for female WAD goats in other studies were comparable to those obtained for WAD goats which was in contrast to the values obtained for Red Sokoto goats in Nigeria (Tambuwal *et al.,* 2002) in which male animals had higher values than females.

In a study conducted by Isaac *et al.* (2013) on haematological properties of different sexes of rabbits, it was observed that the males had the highest values of WBC, neutrophil, monocyte, lymphocyte, basophils, RBC, Hb, Hct, Mcv, MCHC and platelets while females had the highest values in MCH; there was no significant difference among the sexes. Özkan, Kaya, and Akgül (2012) conducted a research on haematology of New Zealand white rabbits and observed no significant differences between male and female animals for parameters analyzed except Hct, Hb and granulocyte %. Chineke *et al.* (2006) reported a non-significant sex effect on the haematological variables of rabbit except ESR where females recorded higher significant mean values than males which corroborated earlier study conducted by Schalm *et al.* (1975) which found no sex effect on rabbit and sheep haematology but contrasted with the sex significant effect reported in dogs (where the males have higher significant mean values than the females) (Awah & Nottidge, 1998). Several haematological reports involving farm animals showed no sex effect (Nottidge, Taiwo, & Ogunsanmi, 1999; Singh, Pal, Mandal, Singh, & Pathak, 2002; Chineke *et al.,* 2006). According to Chineke *et al.* (2006) age has significant influences on HBC, WBC, MCHC and ESR. Similar age effect had been reported in various animal species (Schalm *et al.,* 1975; Chineke *et al.,* 2006). As reported by Schalm *et al.* (1975) and Chineke *et al.* (2006) in horses, the MCV, MCH and MCHC consistently increased with age but WBC was highest in the youngest group. Ologunowa *et al.* (2011) reported that age and sex had no significant effects on blood parameters.

4.2.2 *Influence of Management/Animal Husbandry Systems on Haematological Parameters*

Addass *et al.* (2012) reported that management system had significant effect on PCV indicating a higher effect on semi-intensively kept chicken recording higher values. According to Addass *et al.* (2012) intensively kept chickens recorded higher values for most haematological parameters than semi-intensively kept chickens. Olayemi, Farotimi, and Fagbohun (2000) conducted a study to determine the haematology of the West African Dwarf (WAD) sheep under intensive and extensive management systems in Nigeria. The intensively reared animals showed higher PCV, Hb concentration and MCV than those under extensive management. Both groups of animals had similar MCH, MCHC, Red Blood Cell, (RBC) Total White Blood Cell, lymphocyte, neutrophil, eosinophil and monocyte counts. In another study conducted by Olayemi *et al.* (2000) on the influence of management on the haematology of the white Fulani cattle. The intensively reared animals showed higher Packed Cell Volume (PCV), Red and White cell counts but lower Mean Corpuscular Haemoglobin than those under extensive management.

Furthermore, Coles (1986) and Schalm *et al.* (1975) reported that regardless of age, sex and climate, sheep and goats reared under traditional husbandry system have low haematological values compared to those reared under modern husbandry.

4.2.3 *Others*

Chineke *et al.* (2006) reported that apart from genotype, age, sex, differences in haematological indices may be caused by nutritional, environmental and hormonal factors. According to Radostits, Blood, and Gay (1994) low nutritional grassland, pasture, stress, parturition, climatic factors among others greatly alter the blood values of goats and sheep, as well as other farm animals.

5. Conclusion

Haematological parameters and its knowledge can be used to assess the health as well as the physiological status of farm animals under consideration. Changes of these parameters have been studied in cattle, sheep and red Sokoto goats. There is great variation in the haematological parameters as observed between breeds, ages, sexes, management systems among others in farm animals. These differences have further underlined the need to establish appropriate physiological baseline values for livestock in Nigeria which could help in realistic evaluation of the management practice, nutrition, diagnosis of health as well as in determining the physiological status of farm animals. Moreover, it is important to establish a baseline indices for haematological parameters on the basis of the factors studied and also carry out further studies to determine the effects of these factors on these indices.

References

[1] Addass, P. A., David, D. L., Edward, A., Zira, K. E., & Midau, A. (2012). Effect of Age, Sex and Management System on Some Haematological Parameters of Intensively and Semi-Intensively Kept Chicken in Mubi, Adamawa State, Nigeria. *Iranian Journal of Applied Animal Science, 2*(3), 277-282.

[2] Aderemi, F. A. (2004). Effects of replacement of wheat bran with cassava root sieviate supplemented or unsupplemented with enzyme on the haematology and serum biochemistry of pullet chicks. *Tropical Journal of Animal Science, 7,* 147-153.

[3] Afolabi, K. D., Akinsoyinu, A. O., Olajide, R., & Akinleye, S. B. (2010). *Haematological parameters of the Nigerian local grower chickens fed varying dietary levels of palm kernel cake* (p.247). Proceedings of 35th Annual Conference of Nigerian Society for Animal Production.

[4] Agaie, B. M., & Uko, O. J. (1998). Effect of season, sex, and species difference on the packed cell volume (P.C.V.) of Guinea and domestic fowls in Sokoto, Sokoto state of Nigeria. *Nigerian Veterinary Journal, 19*, 95-99.

[5] Alodan, M. A., & Mashaly, M. M. (1999). Effect of induced molting in laying hens on production and immune parameters. *Poultry Science, 78*(2), 171-177.

[6] Anonymous (1980). *Guide to the care and use of experimental animal* (Vol. 1, Canadian Council of Animal Care, p.185-190). Ottawa Ontario, Canada.

[7] Aster, J. C. (2004). Anaemia of diminished erythropoiesis. In V. Kumar, A. K. Abbas, N. Fausto, S. L. Robbins, & R. S. Cotran (Eds.), *Robbins and Cotran Pathologic Basis of Disease* (7th ed., p.638-649). Saunders Co. Philadelphia.

[8] Awah, J. N., & Nottidge, H. O. (1998). Serum biochemical parameters in clinically healthy dogs in Ibadan. *Tropical Veterinarian, 16*(3-4), 123-129.

[9] Awodi, S., Ayo, J. O., Atodo, A. D., & Dzende, T. (2005). *Some haematological parameters and the erythrocyte osomotic fragility in the laughing dove (Streptopella senegalensis) and the village weaner bird (Ploceus cucullatus)* (p.384-387). Proceedings of the 10th Annual Conference of Animal Science Association of Nigeria.

[10] Bamishaiye, E. I., Muhammad, N. O., & Bamishaiye, O. M. (2009). Haematological parameters of albino rats fed on tiger nuts (Cyperus esculentus) tuber oil meal-based diet. *The International Journal of Nutrition and Wellness, 10*(1). Retrieved from http://ispub.com /IJNW/10/1/9293.

[11] Burke, J. (1994). *Clinical care and medicine of pet rabbit* (p.49-77). Proceedings of the Michigan Veterinary Conference.

[12] Carlson, G. P. (1996). Clinical chemistry tests. In B. P. Smith (Ed.), *Large Animal Internal Medicine* (2nd ed.). USA: Mosby Publisher.

[13] Chineke, C. A., Ologun, A. G., & Ikeobi, C. O. N. (2006). Haematological parameters in rabbit breeds and crosses in humid tropics. *Pakistan Journal of Biological Sciences, 9*(11), 2102-2106.

[14] Coles, E. H. (1986). *Veterinary clinical pathology* (4th ed.). Philadelphia, Pa.: Saunders.

[15] Daramola, J. O., Adeloye, A. A., Fatoba, T. A., & Soladoye, A. O. (2005). Haematological and biochemical parameters of West African Dwarf goats. *Livestock Research for Rural Development, 17*(8), 95. Retrieved January 22, 2014, from http://www.lrrd.org/lrrd17/8/dara17095.htm.

[16] Doyle, D. (2006). William Hewson (1739-74). The father of haematology. *British Journal of Haematology, 133*(4), 375-381.

[17] Dukes, H. H. (1955). *The physiology of domestic animals* (7th ed.). Baillers Tindall and Co. London.

[18] Durai, P. C., Maruthai, T. P. T., Arumugam, S. S., & Venugopal, O. A. (2012). Haematological Profile and Erythrocyte Indices in Different Breeds of Poultry. *International Journal of Livestock Research, 2*(3), 89-92.

[19] Egbe-Nwiyi, T. N., Nwaosu, S. C., & Salami, H. A. (2000). Haematological Values of Appararently Healthy Sheep and Goats as Influenced by Age and Sex in Arid Zone of Nigeria. *African Journal of Biomedical Research, 3*(2), 109-115.

[20] Ekiz, E. E., & Yalcintan (2013). Comparison of certain haematological and biochemical parameters regarding pre-slaughter stress in saanen, maltese, gokceada and hair goat kids. *Journal of the faculty of veterinary medicine, istanbul university, 39*(2), 189-196.

[21] Forlan, R. L., Macari, M., Malheiros, R. D., Moraes, V. M. B., & Malheiros, E. B. (1999). Effect of age and strain on haematology and blood-biochemical parameters in broiler chickens. *Revista Brasileira de Ciencia Avicola, 1*(2), 117-122.

[22] Graczyk, S., Pliszczak-Król, A., Kotonski, B., Wilczek, J., & Chmielak, Z. (2003). Examination of haematological and metabolic changes mechanism of acute stress in turkeys. *Electronic Journal of Polish Agricultural Universities: Veterinary Medicine, 6*(1), 1-10.

[23] Iheukwumere, F. C., & Herbert, U. (2002). Physiological Responses of Broiler Chickens to Quantitative Water Restrictions: Haematology and Serum Biochemistry. *International Journal of Poultry Science, 2*(2), 117-119.

[24] Isaac, L. J., Abah, G., Akpan, B., & Ekaette, I. U. (2013). *Haematological properties of different breeds and sexes of rabbits* (p.24-27). Proceedings of the 18th Annual Conference of Animal Science Association of Nigeria.

[25] Islam, M. S., Lucky, N. S., Islam, M. R., Ahad, A., Das, B. R., Rahman, M. M., & Siddiui, M. S. I. (2004). Haematological Parameters of Fayoumi, Assil and Local Chickens Reared in Sylhet Region in Bangladesh. *International Journal of Poultry Science, 3*(2), 144-147.

[26] Iwuji, T. C., & Herbert, U. (2012). *Haematological and serum biochemical characteristics of rabbit bucks fed diets containing garcimiola kola seed meal* (p.87-89). Proceedings of 37th Annual Conference of Nigerian Society for Animal Production.

[27] Johnston, J. K., & Morris, D. D. (1996). Alterations in blood proteins. In B. P. Smith (Ed.), *International Animal Medicine* (2nd ed.). USA: Mosby Publishers.

[28] Kabir, M., Akpa, G. N., Nwagu, B. I., Adeyinka, I. A., & Bello, U. I. (2011). *Sexual dimorphism, breed and age characteristics of rabbits in Zaria, Nigeria* (p.133-137). Proceedings of the 16th Annual Conference of Animal Science Association of Nigeria.

[29] Khan, M. Z., Szarek, J., Koncicki, A., & Krasnodebska-Depta, A. (1994). Oral administration of monensin and lead to broiler chicks: effect on haematological and biochemical parameters. *Acta Veterinaria Hungarica, 42*(1), 111-120.

[30] Khan, T. A., & Zafar, F. (2005). Haematological Study in Response to Varying Doses of Estrogen in Broiler Chicken. *International Journal of Poultry Science, 4*(10), 748-751.

[31] Kleinbeck, S. N., & McGlone, J. J. (1999). Intensive indoor versus outdoor swine production systems: genotype and supplemental iron effects on blood hemoglobin and selected immune measures in young pigs. *Journal of Animal Science, 77*(9), 2384-2390.

[32] Kurtoğlu, F., Kurtoğlu, V., Celik, I., Keçeci, T., & Nizamlioğlu, M. (2005). Effects of dietary boron supplementation on some biochemical parameters, peripheral blood lymphocytes, splenic plasma cells and bone characteristics of broiler chicks given diets with adequate or inadequate cholecalciferol (vitamin D3) content. *British Poultry Science, 46*(1), 87-96.

[33] Lamošová, D., Máčajová, M., & Zeman, M. (2004). Effects of short term fasting on selected physiological functions in adult male and female Japanese quail. Acta *Veterinaria Brno, 73*(1), 9-16.

[34] Maton, A., Hopkins, R. L. J., McLaughlin, C. W., Johnson, S., Warner, C. W., LaHart, D., & Wright, J. D. (1993). *Human Biology and Health*. Englewood Cliffs, New Jersey, USA: Prentice Hall.

[35] Merck Manual (2012). *Haematologic reference ranges*. Mareck Veterinary Manual. Retrieved from http://www.merckmanuals.com/.

[36] Mitruka, B. M., & Rawnsley, H. M. (1977). *Clinical biochemical and hematological reference values in normal experimental animals* (p.134-135). USA: Masson Publishing Inc.

[37] Mmereole, F. U. C. (2008). The Effects of Replacing Groundnut Cake with Rubber Seed Meal on the Haematological and Serological Indices of Broilers. *International Journal of Poultry Science, 7*(6), 622-624.

[38] Nottidge, H. O., Taiwo, V. O., & Ogunsanmi, A. O. (1999). Haematological and serum biochemical studies of cats in Nigeria. *Tropical Veterinarian, 17*(1-2), 9-16.

[39] Odunsi, A. A., Onifade, A. A., & Babatunde, G. M. (1999). Response of broiler chicks to virginmycin and dietary protein concentration in the humid tropics. *Arch. Zoot., 48*(183), 317-325.

[40] Ogunbajo, S. O., Alemede, I. C., Adama, J. Y., & Abdullahi, J. (2009). *Haematological parameters of Savannah brown does fed varying dietary levels of flamboyant tree seed meal* (p. 88-91). Proceedings of 34th Annual Conference of Nigerian Society for Animal roduction.

[41] Oguz, H., Kececi, T., Birdane, Y. O., Önder, F., & Kurtoglu, V. (2000). Effect of clinoptilolite on serum biochemical and haematological characters of broiler chickens during aflatoxicosis. *Research in Veterinary Science, 69*(1), 89-93.

[42] Okunlola, D. O., Olorunisomo, A. O., Aderinola, A. O., Agboola, A. S., & Omole, O. G. (2012). *Haematology and serum quality of red Sokoto goats fed Baobab (Adansonia digitata) fruit meal as supplement to guinea grass (Panicum maximum)* (p.427-433). Proceedings of the 17th Annual Conference of Animal Science Association of Nigeria.

[43] Olafedehan, C. O., Obun, A. M., Yusuf, M. K., Adewumi, O. O., Oladefedehan, A. O., Awofolaji, A. O., & Adeniji, A. A. (2010). *Effects of residual cyanide in processed cassava peal meals on haematological and biochemical indices of growing rabbits* (p.212). Proceedings of 35th Annual Conference of Nigerian Society for Animal Production.

[44] Olayemi, F. O., Farotimi, J. O., & Fagbohun, O. A. (2000). Haematology of the West African Dwarf Sheep under Two Different Management Systems in Nigeria. *African Journal of Biomedical Research, 3*(2), 197-198.

[45] Ologunowa, E. O., Chineke, C. A., Lasehinde, E. A. O., Ogunsusi, R. A., Aletor, V. A., Ologun, A. G., . . . Agbede, J. O. (2000). Rabbit breeds analysis for haematological indices. Theses and Dissertations (Animal Production and Health). Federal University of Technology, Akure. Retrieved from http://dspace.futa.edu.ng:8080/jspui/handle/123456789/1642.

[46] Omiyale, C. A., Yisa, A. G., & Ali-Dunkrah, L. A. (2012). *Haematological characteristics of Yankasa sheep fed fonio (Digitaria iburua) straw based diets* (p. 87-89). Proceedings of 37th Annual Conference of Nigerian Society for Animal Production.

[47] Onyeyili, P. A., Egwu, G. O., Jibike, G. I., Pepple, D. J., & Ohaegbulam, J. O. (1992). Seasonal variation in haematological indices in the grey-breasted guinea fowl (*Numida mealagris Gallata pallas*). *Nigerian Journal of Animal Production, 18*(2), 108-110.

[48] Ovuru, S. S., & Ekweozor, I. K. E. (2004). Haematological changes associated with crude oil ingestion in experimental rabbits. *African Journal of Biotechnology, 3*(6), 346-348.

[49] Oyawoye, B. M., & Ogunkunle, H. N. (2004). *Biochemical and haematological reference values in normal experimental animals* (p. 212-218). New York: Masson.

[50] Özkan, C., Kaya, A., & Akgül, Y. (2012). Normal values of haematological and some biochemical parameters in serum and urine of New Zealand White rabbits. *World Rabbit Science, 20*(4), 253-259.

[51] Peters, S. O., Gunn, H. H., Imumorin, I. G., Agaviezor, B. O., & Ikeobi, C. O. (2011). Haematological studies on frizzled and naked neck genotypes of Nigerian native chickens. *Tropical Animal Health Production, 43*(3), 631-638.

[52] Poole, T. B. (1987). *The UFAW Handbook on the Care and Management of Laboratory and other research Animals* (6th ed.). Universities Foundation for Animal Welfare, Longman Scientific and Technical, Harlow, U.K.

[53] Postgraduate Committee in Veterinary Sciences [PCVS] (1990, September 24-28). Rabbits & rodents laboratory animal science. Proceedings No.142., Postgraduate Committee in Veterinary Science, University of Sydney, Australia. Retrieved from http://openagricola.nal.usda.gov/Record/CAT92986046.

[54] Purves, W. K., Sadava, D., Orians, G. H., & Heller, H. C. (2003). *Life: The science of Biology* (7th ed., p.954). Sinauer Associates and W. H. Freeman.

[55] Radostits, O. M., Blood, D. C., & Gay, C. C. (1994). *Veterinary Medicine: A textbook of disease of cattle, sheep, pigs, goats and horses* (8th ed., p. 304). W B Saunders Co.

[56] Research Animal Resource [RAR]. (2009). *Reference values for laboratory animals: Normal haematological values*. RAR Websites, RAR, University of Minnesota. Retrieved from http://www.ahc.umn.edu/rar/refvalues.html.

[57] Schalm, O. W., Jain, N. C., & Carroll, E. J. (1975). *Veterinity haematology* (3rd ed., p.15-218). USA: Lea & Fabiger, Philadelphia.

[58] Seiser, P. E., Duffy, L. K., David, M. A., Roby, D. D., Golet, G. H., & Litzow, M. A. (2000). Comparison of pigeon guillemot, Cepphus columba, blood parameters from oiled and unoiled areas of Alaska eight years after the Exxon Valdez oil spill. *Marine Pollution Bulletin, 40*(2), 152-164.

[59] Sidell, B. D., & O' Brien, K. M. (2006). When bad things happen to good fish: the loss of haemoglobin and myoglobin expression in Antarctic icefishes. *The Journal of Experimental Biology, 209*, 1791-1802.

[60] Singh, A. S., Pal, D. T., Mandal, B. C., Singh, P., & Pathak, N. N. (2002). Studies on Changes in Some of Blood Constituents of Adult Cross-bred Cattle Fed Different Levels of Extracted Rice Bran. *Paksitan Journal of Nutrition, 1*(2), 95-98.

[61] Soetan, K. O., Akinrinde, A. S., & Ajibade, T. O. (2013). *Preliminary studies on the haematological parameters of cockerels fed raw and processed guinea corn (Sorghum bicolor)* (p. 49-52). Proceedings of 38th Annual Conference of Nigerian Society for Animal Production.

[62] Svoboda, M., Eichlerova, K., Horak, V., & Hradecky, J. (2005). Development of Haematological Indices in Melanoma-bearing Liběchov Minipigs. *Acta Veterinaria Brno, 74*(4), 603-611.

[63] Swenson, M. J. (1970). Physiological properties, cellular and chemical constituents of blood. In M. J. Swenson (Ed.), *Dukes' physiology of domestic animals* (8th ed., p.75-83). Cornstock Publishing Associates, Cornell University Press, Ithaca, London.

[64] Tambuwal, F. M., Agale, B. M., & Bangana, A. (2002, March 17-21). *Haematological and serum biochemical values of apparently healthy red Sokoto goats* (p. 50-53). Proceeding of 27th Annual Conference of Nigerian Society of Animal Production.

[65] Togun, V. A., Oseni, B. S. A., Ogundipe, J. A., Arewa, T. R., Hammed, A. A., Ajonijebu, D. C., . . . Mustapha, F. (2007). *Effects of chronic lead administration on the haematological parameters of rabbits – a preliminary study* (p. 341). Proceedings of the 41st Conferences of the Agricultural Society of Nigeria.

[66] Tras, B., Inal, F., Bas, A. L., Altunok, V., Elmas, M., & Yazar, E. (2000). Effects of continuous supplementations of ascorbic acid, aspirin, vitamin E and selenium on some haematological parameters and serum superoxide dismutase level in broiler chickens. *British Poultry Science, 41*(5), 664-666.

[67] Ugwuene, M. C. (2011). Effect of Dietary Palm Kernel Meal for Maize on the Haematological and Serum Chemistry of Broiler Turkey. *Nigerian Journal of Animal Science, 13*, 93-103.

[68] Vecerek, V., Strakova, E., Suchy, P., & Voslarova, E. (2002). Influence of high environmental temperature on production and haematological and biochemical indexes in broiler chickens. *Czech Journal of Animal Science, 47*(5), 176-182.

[69] Waugh, A., Grant, A. W., & Ross, J. S. (2001). *Ross and Wilson Anatomy and Physiology in Health and Illness* (9th ed., p. 59-71). Churchill Livingston, an imprint of Elsevier Science Limited.

[70] Xie, L., Xu, F., Liu, S., Ji, Y., Zhou, Q., Wu, Q., . . . Xie, P. (2013). Age- and Sex-Based Hematological and Biochemical Parameters for Macaca fascicularis. *PLoS ONE, 8*(6), e64892, doi:10.1371/journal.pone.0064892.

[71] Yeong, S. W. (1999). *Effect of dietary protein level on growth performance of village chicken* (p.519-520). Proceedings of the National IRPA. Seminar Agriculture Sector.

Copyrights