Scientific Research Publishing

Open Journal of Veterinary Medicine, 2021, 11, 226-245
https://www.scirp.org/journal/ojvm
ISSN Online: 2165-3364
ISSN Print: 2165-3356

Determination of Hemobiochemical Profiles of Apparently Healthy Exotic Breed of Dogs in Jos, Plateau State, Nigeria

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How to cite this paper: Ogbu, K.I., Ezema, K.U., Adieme, I.C., Malgwi, R.I., Sabo, J.A., Ayuba, P.N., Tion, M.T., Nguety, S.A., Atuna, S.T., Emeribe, F.O., Shallmizhili, J.J. and Anene, B.M. (2021) Determination of Hemobiochemical Profiles of Apparently Healthy Exotic Breed of Dogs in Jos, Plateau State, Nigeria. *Open Journal of Veterinary Medicine*, **11**, 226-245.
https://doi.org/10.4236/ojvm.2021.116015

Received: May 20, 2020
Accepted: June 25, 2021
Published: June 28, 2021

Abstract

The hematological and serum biochemical profiles of apparently healthy exotic breed of dogs in Jos, Plateau state, Nigeria was studied in this research. One hundred and seven exotic breed of dogs were examined from October - December, 2018. The results from physical, clinical examinations and parasitological examinations were used to determine apparently healthy exotic breed of dogs which were used in this study. The parameters measured were rectal temperature, parasitaemia, hematology which included red blood cells count, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin and hemoglobin content; total white blood cell count, including eosinophils, neutrophils, lymphocytes, monocytes, granulocytes counts, and platelets; serum biochemical parameters also included Aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, total proteins, albumin, globulin, blood urea nitrogen, creatinine, cholesterol and triglyceride, using standard methods. Data generated from the study were

statistically analyzed using students t-test one-way analysis of variance while the level of significance was measured at $p < 0.05$. From this study, hematological and serum biochemical values were comparable to and not different from those reported for dogs in available literature, but the upper and lower reference limits (minimum and maximum values) were different for most parameters. Sex-related significant difference ($p < 0.05$) occurred only in WBC and total protein while age-related significant difference occurred only in total protein and urea level. Breed affected the MCHC and total bilirubin level which was evident in higher MCHC level in Neapolitan mastiff than Alsatian breed while total bilirubin was higher in Alsatian breed than Bull mastiff ($p < 0.05$). The present study has presented preliminary information on the range of hematological and serum biochemistry profile of exotic breed of dogs in Jos, Plateau state, Nigeria which may be useful to biomedical researchers and veterinary clinicians.

Keywords

Hematology, Serum Biochemical Profiles, Apparently Healthy, Exotic Breed, Dogs, Jos, Plateau State

1. Introduction

The blood is an important medium in assessing the health condition of animals [1]. Both the normal and abnormal conditions of animals can be assessed by the evaluation of hematological and biochemical parameters of the blood [2] [1]. Blood consists of plasma, blood cells (leukocytes and erythrocytes) and platelets [3]. Blood is an important index of physiological and pathological changes in an organism [4]. The primary function of the blood is to transport oxygen from respiratory organs to body cells [5] distributing nutrients and enzymes to cells and carrying away waste products [6] thereby maintaining homeostasis of the internal environment [7]. The various functions of the blood are carried out by the individual and collective actions of its constituents—the hematological and biochemical components [8].

Hematology can be defined as the study of the structure, form and number of blood cells such as erythrocytes, leucocytes, and thrombocytes for physiological or medical assessment [9]. Diagnosis and pathological analysis can be achieved through hematological evaluation [10] [11]. Hematological evaluation also plays a role in determining the effect of environment on the blood features which could be of ecological and physiological importance [12] especially in selection of animals that are genetically resistant to certain diseases and environmental conditions [13] [14]. Hematological parameters are good indicators of the physiological status of animals [15]. Hematological parameters are those parameters that are related to the blood and blood forming organs [16] [17].

An evaluation of the serum biochemistry is important because of the predic-

tive value of serum biochemical alterations in the assessment of pathological changes in vital internal organs of the body such as liver, kidney, pancreas, heart and muscles, thus serum biochemistry assays are indispensably important in arriving at a diagnosis, assessing the efficacy of therapy and the toxicity of drugs and chemical substances [18] [19] [20]. Serum bio-chemical and hematological references constitute important panels in the diagnosis, prognosis and treatment of livestock diseases via the investigations of myriads of parameters influencing blood and serum biochemical indices among which are packed cell volume (PCV), mean corpuscular volume (MCV), total blood glucose (TBG), total protein (TP), urea, creatinine, uric acid, alanine aminotransferase or alanine transaminase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), lactate dehydrogenase (LDH), creatinine kinase (CK), albumin (Alb), c-glutamyl transpeptidase (GGT), amylase, globulin, cholesterol, very low density lipoprotein (VLDL), triglyceride, folate, vitamin A and E, triiodothyronine (T3), thyroxine (T4), free triiodothyronine (fT3) and free thyroxine (fT4) concentrations, serum retinol and α-tocopherol concentration in livestock animals [21].

The following parameters namely: species, breed, sex, age, malnutrition, illness, reproductive status, season, nutrition, management systems etcetera, can affect hematology and serum biochemistry of animals [22] [23] [24] [25]. The parameters influencing the hematology and serum bio-chemistry of various animals are typically under two broad categories e.g. genetic and non-genetic parameters. Genetic parameters include the breed and genotype of the animal while the non-genetic parameters include the age, sex, management system, medication, health status and environmental factors such as nutrition, hormone and climate [25]. Hematological values of farm animals are also influenced by geographical location, season, climate, day length, time of day, life habit of species, nutritional status, physiological status of individual animal and other non-genetic factors [26] [25]. Laboratory blood tests would be a vital tool to help detect any deviation from normal State of wellbeing of animals [27] [28] hence, it is important to establish standard values for the various blood parameters based on age aforementioned genetic and non-genetic parameters [29].

In Veterinary Medicine, reference values are necessary for useful interpretation of laboratory results. Reference values specific for the species tested and the equipment and reagents used are essential for accurate interpretation [30]. Many Veterinary reference laboratories use historic or published values rather than establishing their own, because of the time and expense involved. Many of the references in the literature are outdated, and the analyses were performed on older equipment and reagents. Use of these values perpetuates inaccuracies and hampers correct and early diagnosis [31]. The evaluation of the hematological profile is of utmost importance in the clinical assessment of animals because the blood is the major transport system of the body, and both the input and output substances of almost all the body's metabolic processes and any deviations from normal caused by the invasion of the body by pathogens, other forms of injury,

deprivation and/or stress are commonly reflected by changes in the blood picture [32] [19] [33] [34]. Hematological evaluations are therefore helpful to clinicians in making a diagnosis, assessing the efficacy of therapy and the toxicity of drugs and chemical substances [32] [19] [20]. Although, blood metabolites may vary within the same species due to many factors, mainly, feeding, age, environmental temperature and physiological status [35], few studies in Nigeria have documented the variations in blood profile of healthy dogs. Paucity of knowledge of variations on blood profiles in specific populations of dogs may contribute to poor interpretation of clinical hematological data [22]. The aim of this study was to determine the hematological and serum biochemical profile of apparently healthy exotic breed of dogs in Jos, Plateau State, Nigeria.

2. Materials and Methods

Study Area

Jos is a city in the middle belt region of Nigeria. The city has a population of 873,943 people based on the 2006 census. It is the administrative capital of Plateau State. Its bearing is 9˚56'N 8˚53'E. The city is located on the Jos Plateau at an elevation of about 1238 meters or 4062 feet above sea level. Jos has an average monthly day temperature of 21˚C - 25˚C and a low night temperature of 11˚C as from mid-November to late January. It covers 8600 km^2 and is bounded by Bauchi State to the North, Barkin Ladi, Riyom and Bassa Local Government Areas all of Plateau State to the East, South and West respectively [36].

Materials

The materials that were used in this study included dogs, blood samples, serum samples, fecal samples, Sterile syringe and needle, microscope, microscope slide, cover slip, haematocrit centrifuge, capillary tube, plaster-seal, pipette rack, test tubes, cooler, ice pack, refrigerator, deep freezer, Ethylene Diamine Tetra acetic Acid (EDTA) sample bottles, non-Ethylene Diamine Tetra acetic Acid (Non-EDTA) sample bottles, Randox test kits, spectrophotometer, micro-pipettes, micro-tips, incubator, cuvette.

Experimental Design

Sampling was done for three months (October - December, 2018) on dogs belonging to some dog breeders Jos who were randomly selected. History of the dogs were evaluated which was followed by physical and clinical examinations of the dogs carried out after proper restraining. Fecal and blood samples were collected from the exotic breed of dogs that appeared apparently healthy for parasitological examinations in the Parasitological laboratory of National Veterinary Research Institute (NVRI) Vom. Whole blood and serum samples were also collected from the suitable dogs for hematological and serum-biochemical analysis in the Hematology laboratory, Central Diagnostic Laboratory and Clinical Biochemistry Laboratory of Biochemistry Division, National Veterinary Research Institute Vom respectively. The results from physical, clinical examinations and parasitological examination were used to determine apparently healthy exotic

breed of dogs which were finally used to study the hematological and serum biochemical profile of dogs in the study area after proper history evaluations.

Inclusion Criteria: Dogs that were not under medications or just completed its medications; dogs not in her estrus period, dogs not having fever or showing any clinical sign of diseases, and dogs devoid of parasitic infestations from the parasitic examinations.

Sample Population and Size

The study population was determined using focal point census of the study area while the sample size was determined using a percentage of the census population of the study area. The total number of dogs in Jos metropolis is estimated to be about 2506 [37]. Using 4% of this population, 107 dogs was used as the sample size according to Boll and Gall model cited in Uzoagulu, [38].

Blood Sample Collection

The site for blood collection was prepared aseptically (thoroughly swabbed with cotton wool soatked methylated spirit). Blood samples for parasitology and haematology (2 ml each) was collected into vacutainer tubes using ethylene-diamine tetra acetic acid (EDTA) as an anticoagulant while blood samples for serum biochemical analysis (3 ml) was allowed to cloth in a sterile non-EDTA vacutainer tubes and centrifuged at 3000 rpm for 10 minutes at 25˚C to obtain sera.

Parameters

The parameters measured were rectal temperature (37.5˚C - 39.4˚C) was regarded as normal according to Hassan and Hassan [39], parasitaemia, hematology which included red blood cells (RBC) count, haematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin (MCHC) and hemoglobin content; total white blood cell (WBC) count, including eosinophils, neutrophils, lymphocytes, monocytes, granulocytes counts, and platelets; serum biochemical parameters also included Aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, total proteins, albumin, globulin, BUN, creatinine, cholesterol and triglyceride.

Rectal Temperature

Rectal temperature was measured using digital clinical thermometer as described by Coles [19]. The bulb of the clinical thermometer was carefully inserted into the anus of each dog after cleaning withcotton wool soaked with methylated spirit. This was anchored to an angle so that the thermometer was in contact with the wall of the rectum to avoid taking the faecal temperature. This was kept in place for about 2 mins (until a beep sound was heard from the digital clinical thermometer). The values were read and recorded in degree Celsius (°C).

Parasitic Screening

The blood parasites were detected by wet blood film [40] and buffy coat dark phase contrast microscopy method [41]. The buffy coat technique was done by filling a microhematocrit capillary tube with blood sample of the dogs through capillary action. The capillary tubes were then centrifuged. The tubes were cut

and the buffy coats/plasma interfaces were expressed on to a microscopic slide and viewed using a dark phase contrast microscope.

Faecal samples were collected directly from the rectum of each animal with the use of disposable hand gloves. Prior to stool collection, animals were identified, restrained and the perineum thoroughly prepared by cleaning to prevent contamination. The samples were transported in a food flask containing cold-packs to the parasitology laboratory, National Veterinary Research Institute (NVRI) Vom for analysis. Faecal samples were processed and screened using two methods: the formol ether concentration and the sodium chloride flotation techniques as describe by Foreyt [42].

Hematology

Two millilitres of blood was collected for haematology from each of the dogs by cephalic venipuncture. The blood was dispensed into a sample bottle containing 2 mg of ethylene diamine tetra-acetic acid (EDTA) to prevent clotting. The Hematological determinations followed standard procedures. The packed cell volume (PCV) was determined by the micro-haematocrit method [43]. The hemoglobin concentration (Hb) was determined by the cyanomethemoglobin method [44]. The red blood cell (RBC) and total leukocyte counts (TLC) done by the haemocytometer method, while thin blood smear made on clean grease-free glass slides for differential leukocyte count stained following the Leishman technique and enumerated by the meander counting method [43]. The mean corpuscular values—mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) calculated using the standard formulae [43] [20]. The erythrocyte sedimentation rate (ESR) was determined by the microhaematocrit Wintrobe method [19]. The platelet count (PC) was done following the Rees and Ecker direct counting method [45].

Serum Biochemistry

Serum biochemistry determinations were carried out using commercial test kits; Randox test kits (Randox, UK) for all serum biochemistry determinations. Serum ALT and AST activities was determined by the Reitman–Frankel method [46]. Serum ALP activity was determined by the phenolphthalein monophosphate method [47], while total serum proteins were determined by the direct Biuret method [48]. Serum albumin was determined by the Bromocresol green method [49]. Serum globulin was calculated as the difference between serum total proteins and serum albumin [50], while serum total bilirubin as determined by the Jendrassik–Grof method [51]. Blood urea nitrogen was determined by the Berthelot–Searcy method [52], while serum creatinine was determined by the modified Jaffe method [53]. Serum cholesterol and triglyceride were determined by the enzymatic colorimetric method [54].

Data Analyses

The data of the research generated was using statistical package for social sciences (SPSS) version 23 where it was analysed. The effects of sex and age of

hematological and serum biochemical parameters were analyzed using student's t-test while breed-related effect was subjected to one way analysis of variance (ANOVA). The level of significance was measured at $p < 0.05$. Results were presented in tables and graph.

3. Results

Hematological Profile of Apparently Healthy Exotic Breed of Dogs in Jos, Plateau State

Table 1 shows the overall mean and the minimum-maximum values of the hematological profile of apparently health exotic breed of dogs in Jos metropolis. The erythrocytic profile showed pack cell volume, red blood cell count counts and hemoglobin concentration of the dogs were 4. 45.43% ± 0.79%, 7.80 ± 092 (10^{12}/L) and 15.00 ± 0.28 (g/dl), respectively. The mean erythrocytic corpuscular values which included mean corpuscular volume, mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration were also 69.47 ± 1.07 (fl), 23.86 ± 0.66 (Pg) and 33.14 ± 0.11 (g/dl) respectively. The leucocytic profile showed that the overall mean of white blood cell count counts was 7.55 ± 0.92 ($\times 10^9$/L) while that of the differential white blood cell counts namely: Neutrophil, Lymphocyte, Eosinophil, Monocyte and Basophils were 58.10% ± 1.38%, 35.29% ± 1.30%, 3.32% ± 0.28%, 2.60% ± 0.34% and 0.00% ± 0.00% respectively.

Hematological Profile of Apparently Healthy Exotic Breed of Dogs based on Sex in Jos, Plateau State

Table 2 shows the mean of hematological profile of apparently healthy exotic breed of dogs based on sex in Jos metropolis. The mean white blood cell count was significantly higher ($p < 0.05$) in males than in females while there was no

Table 1. Overall Hematological Profile of apparently Healthy Exotic Breed of Dogs in Jos, Plateau State (n = 100).

S/N	Hematological Parameters	Mean ± SEM	Minimum value - Maximum value
1	Pack cell volume (%)	45.43 ± 0.79	25.00 - 65.00
2	Red blood cell count ($\times 10^{12}$/L)	7.80 ± 092	4.00 - 18.00
3	Hemoglobin concentration. (g/dl)	15.00 ± 0.28	8.00 - 22.00
4	Mean corpuscular volume (fl)	69.47 ± 1.07	40.00 - 90.00
5	Mean corpuscular hemoglobin (Pg)	23.86 ± 0.66	17.00 - 32.00
6	Mean corpuscular hemoglobin concentration (g/dl)	33.14 ± 0.11	25.00 - 39.00
7	White blood cell count ($\times 10^9$/L)	7.55 ± 0.92	3.00 - 14.00
8	Neutrophil (%)	58.10 ± 1.38	43.00 - 86.00
9	Lymphocyte (%)	35.29 ± 1.30	17.00 - 47.00
10	Eosinophil (%)	3.32 ± 0.28	1.00 - 9.00
11	Monocyte (%)	2.60 ± 0.34	1.00 - 3.00
12	Basophil (%)	0.00 ± 0.00	0.00 - 0.00

Table 2. Hematological Profile of Apparently Healthy Exotic Breed of Dogs Based on Sex in Jos, Plateau State (n = 100).

S/N	Hematological Parameters	Mean ± Standard Error		P-value
		Male (N = 43)	Female (N = 57)	
1	Pack cell volume (%)	44.88 ± 1.24	45.84 ± 0.79	0.552
2	Red blood cell count ($\times 10^{12}$/L)	9.37 ± 2.13	6.61 ± 0.926	0.141
3	Hemoglobin concentration (g/dl)	14.79 ± 0.42	15.16 ± 0.28	0.509
4	Mean corpuscular volume (fl)	69.19 ± 1.62	69.68 ± 1.07	0.819
5	Mean corpuscular hemoglobin (Pg)	23.33 ± 0.45	24.26 ± 0.66	0.438
6	Mean corpuscular hemoglobin concentration (g/dl)	33.26 ± 0.16	33.05 ± 0.11	0.351
7	White blood cell count ($\times 10^{9}$/L)	9.77 ± 2.07	5.88 ± 0.92	0.036
8	Neutrophil (%)	60.12 ± 2.01	56.58 ± 1.38	0.205
9	Lymphocyte (%)	33.63 ± 0.78	36.54 ± 1.30	0.269
10	Eosinophil (%)	2.88 ± 0.39	3.66 ± 0.28	0.913
11	Monocyte (%)	2.50 ± 1.50	2.67 ± 0.60	0.165
12	Basophil (%)	0.00 ± 0.00	0.00 ± 0.00	0.000

significant difference ($p > 0.05$) based on sex in all other hematological parameters.

Hematological Profile of Apparently Healthy Exotic Breed of Dogs Based on Age in Jos, Plateau State

Figure 1 shows the mean of hematological profile of apparently healthy exotic breed of dogs based on age in Jos metropolis. There were no significant age-related differences in all hematological parameters.

Hematological Profile of Apparently Healthy Exotic Breed of Dogs Based on Breed in Jos, Plateau State

Table 3 shows the mean of hematological profile of apparently healthy exotic breed of dogs based on breed in Jos metropolis. There was no significant difference ($p > 0.05$) in the hematological parameters of all breeds except in the mean corpuscular hemoglobin concentration of Neapolitan mastiff breed which showed significantly ($p < 0.05$) higher when compared with Alsatian breed.

Serum Biochemical Profile of Apparently Healthy Exotic Breed of Dogs in Jos, Plateau State

Table 4 shows the overall mean and the minimum-maximum values of the overall serum biochemical profile of healthy exotic breed of dogs in Jo, Plateau State. The overall mean values of aspartate aminotransferase, alanine aminotransferase and alkaline phosphatase were 24.38 ± 1.19 u/l, 19.78 ± 0.81 u/l and 60.24 ± 2.86 u/l respectively. For the proteins namely: total protein, albumin and globulin, their overall means were respectively 65.43 ± 0.99 g/l, 32.55 ± 0.79 g/l and 33.43 ± 2.99 g/l. the overall means of total bilirubin, urea, creatinine, cholesterol and triglyceride were 17.46 ± 1.62 mmol/l, 4.35 ± 1.23 mmol/l, 70.84 ± 1.79 mmol/l, 4.82 ± 1.16 mmol/l and 1.59 ± 0.89 mmol/l respectively.

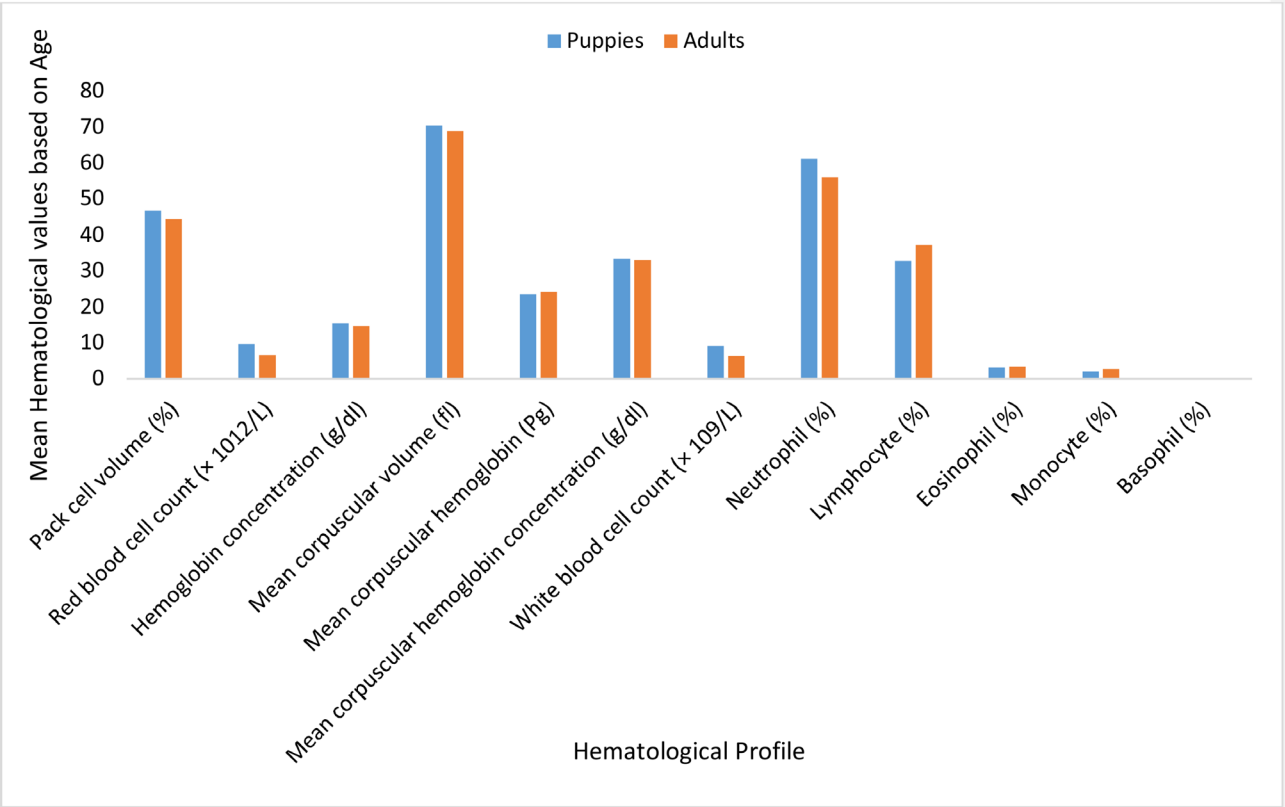

Figure 1. Hematological Profile of Apparently Healthy Exotic Breed of Dogs Based on Age in Jos, Plateau State (Puppies are < 1 year while adults are ≥ 1 year of age).

Table 3. Hematological Profile of Apparently Healthy Exotic Breed of Dogs Based on Breed in Jos, Plateau State (n = 100).

S/N	Hematological Parameters	Mean ± Standard Error					P-value
		Alsatian (N = 15)	Bull Mastiff (N = 15)	Caucasian (N = 32)	Neapolitan Mastiff (N= 21)	Rottweiler (N = 16)	
1	Pack cell volume (%)	44.44 ± 1.70	46.47 ± 2.32	43.38 ± 1.35	47.33 ± 1.84	47.06 ± 1.90	0.341
2	Red blood cell count (× 10^{12}/L)	6.35 ± 0.35	6.52 ± 0.38	10.30 ± 2.85	6.72 ± 0.27	7.17 ± 0.28	0.545
3	Hemoglobin concentration (g/dl)	14.79 ± 0.60	15.79 ± 0.75	14.28 ± 0.45	15.77 ± 0.65	14.99 ± 0.75	0.269
4	Mean corpuscular volume (fl)	69.81 ± 4.11	72.07 ± 1.73	69.19 ± 1.78	70.51 ± 2.41	65.94 ± 1.79	0.591
5	Mean corpuscular hemoglobin (Pg)	27.69 ± 3.76	23.80 ± 0.58	23.19 ± 0.58	23.42 ± 0.46	22.00 ± 0.57	0.127
6	Mean corpuscular hemoglobin concentration (g/dl)	32.44 ± 0.51^{a}	33.29 ± 0.13^{ab}	33.19 ± 0.07^{ab}	33.52 ± 0.29^{b}	33.13 ± 0.09^{ab}	0.047
7	White blood cell count (× 10^{9}/L)	6.313 ± 0.65	5.73 ± 0.80	10.51 ± 2.76	6.29 ± 0.52	6.31 ± 0.50	0.303
8	Neutrophil (%)	61.25 ± 2.00	53.33 ± 4.48	59.66 ± 2.07	57.05 ± 3.63	57.69 ± 3.81	0.536
9	Lymphocyte (%)	28.25 ± 1.32	40.47 ± 4.29	33.59 ± 1.52	37.90 ± 3.40	37.44 ± 3.98	0.060
10	Eosinophil (%)	13.77 ± 0.53	7.46 ± 0.60	8.38 ± 0.51	6.21 ± 0.58	8.00 ± 0.83	0.114
11	Monocyte (%)	2.00 ± 0.10	4.00 ± 0.01	0.00 ± 0.00	4.00 ± 0.10	1.50 ± 0.50	0.332
12	Basophil (%)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	

Different superscripts in a row (a and b) indicate significant difference between the group mean at ($P < 0.05$).

Serum Biochemical Profile of Apparently Healthy Exotic Breed of Dogs Based on Sex in Jos, Plateau State

Table 5 shows the mean of serum biochemical profile of apparently healthy exotic breeds of dogs based on sex in Jos, Plateau State. There were no significant sex-variations in mean values of aspartate aminotransferase, alanine aminotransferase and alkaline phosphatase ($p > 0.05$). The mean total protein of male dogs were significantly higher ($p < 0.05$) than in females dogs but there was no other significant difference ($p > 0.05$) in the serum biochemical parameters based on sex.

Table 4. Overall Serum Biochemical Profile of Apparently Healthy Exotic Breed of Dogs in Jos, Plateau State (n = 100).

S/N	Serum Biochemical Parameters	Mean ± SEM	Minimum value - Maximum value
1	Aspartate aminotransferase (u/l)	24.38 ± 1.19	11.00 - 71.00
2	Alanine aminotransferase (u/l)	19.78 ± 0.81	9.00 - 45.00
3	Alkaline phosphatase (u/l)	60.24 ± 3.86	19.00 - 79.00
4	Total Protein (g/l)	65.43 ± 0.99	44.00 - 97.00
5	Albumin (g/l)	32.55 ± 0.79	20.00 - 55.00
6	Globulin (g/l)	33.43 ± 0.99	8.00 - 44.00
7	Total Bilirubin (mmol/l)	17.46 ± 1.62	11.00 - 36.00
8	Urea (mmol/l)	4.35 ± 0.23	1.00 - 9.00
9	Creatinine (mmol/l)	70.84 ± 3.79	40.00 - 132.00
10	Cholesterol (mmol/l)	4.82 ± 0.16	0.00 - 8.00
11	Triglyceride (mmol/l)	1.59 ± 1.89	1.00 - 6.00

Table 5. Serum Biochemical Profile of Apparently Healthy Exotic Breed of Dogs Based on Sex in Jos, Plateau State (n = 100).

S/N	Serum Biochemical Parameters	Mean ± Standard Error		Sig.
		Male (N = 43)	Female (N = 57)	
1	Aspartate aminotransferase (u/l)	23.80 ± 1.99	24.85 ± 1.44	0.664
2	Alanine aminotransferase (u/l)	19.98 ± 1.20	19.63 ± 1.10	0.833
3	Alkaline phosphatase (u/l)	55.37 ± 6.10	63.91 ± 4.96	0.276
4	Total Protein (g/l)	68.26 ± 1.57^{b}	63.27 ± 1.21^{a}	0.012
5	Albumin (g/l)	33.81 ± 1.33	31.56 ± 0.95	0.151
6	Globulin (g/l)	34.23 ± 1.56	32.82 ± 1.28	0.481
7	Total Bilirubin (mmol/l)	17.49 ± 0.95	17.44 ± 0.82	0.968
8	Urea (mmol/l)	4.65 ± 0.29	4.12 ± 0.34	0.266
9	Creatinine (mmol/l)	112.00 ± 5.47	115.23 ± 5.26	0.676
10	Cholesterol (mmol/l)	4.81 ± 0.28	4.82 ± 0.20	0.974
11	Triglyceride (mmol/l)	1.42 ± 0.12	1.72 ± 0.13	0.094

Different superscripts in a row (a and b) indicate significant difference between the group mean at ($P < 0.05$).

Serum Biochemical Profile of Apparently Healthy Exotic Breed of Dogs Based on Age in Jos, Plateau State

Table 6 shows the mean of serum biochemical profile of apparently healthy exotic breed of dogs based on age in Jos, Plateau State. There were no significant age-differences in mean values of aspartate aminotransferase, alanine aminotransferase and alkaline phosphatase ($p > 0.05$). The mean total protein of male dogs were significantly higher ($p < 0.05$) than in female dogs but there was no significant difference ($p > 0.05$) in albumin and globulin based on age (Table 7). Also, male dogs showed a significantly higher ($p < 0.05$) mean urea level when compared with female dogs but no significant difference ($p > 0.05$) occurred in total bilirubin, creatinine, cholesterol and triglyceride.

Serum Biochemical Profile of Apparently Healthy Exotic Breed of Dogs Based on Breed in Jos, Plateau State

Table 7 shows the mean of serum biochemical profile of apparently healthy exotic breed of dogs based on breed in Jos, Plateau State. There were no significant breed-differences in mean values of aspartate aminotransferase, alanine aminotransferase and alkaline phosphatase ($p > 0.05$). The mean total protein, albumin and globulin also compared favorably among all breeds ($p > 0.05$). The mean total bilirubin was significantly higher ($p < 0.05$) in Alsatian breed compared to Bull mastiff breeds while other comparisons of serum biochemical parameters among breeds were favorable ($p > 0.05$).

4. Discussion

The means and ranges of hematological and serum biochemical values of exotic

Table 6. Serum Biochemical Profile of Apparently Healthy Exotic Breed of Dogs Based on Age in Jos, Plateau State (n = 100).

S/N	Serum Biochemical Parameters	Mean ± Standard Error		Sig.
		Puppy (N = 43)	Adult (N = 57)	
1	Aspartate aminotransferase (u/l)	23.29 ± 1.85	25.22 ± 1.56	0.425
2	Alanine aminotransferase (u/l)	19.73 ± 1.12	19.81 ± 1.13	0.960
3	Alkaline phosphatase (u/l)	56.37 ± 6.27	62.93 ± 4.93	0.406
4	Total Protein (g/l)	67.66 ± 1.70	63.86 ± 1.16	0.059
5	Albumin (g/l)	33.71 ± 1.26	31.18 ± 1.01	0.224
6	Globulin (g/l)	33.83 ± 0.47	33.16 ± 1.34	0.738
7	Total Bilirubin (mmol/l)	17.20 ± 0.79	17.64 ± 0.89	0.722
8	Urea (mmol/l)	3.95 ± 0.22^{a}	4.93 ± 0.46^{b}	0.039
9	Creatinine (mmol/l)	118.42 ± 6.79	110.66 ± 4.38	0.317
10	Cholesterol (mmol/l)	5.05 ± 0.28	4.66 ± 0.19	0.244
11	Triglyceride (mmol/l)	1.59 ± 0.15	1.59 ± 0.11	0.966

Different superscripts in a row (a, b) indicate significant difference between the group mean at ($P < 0.05$). Puppies are < 1 year while adults are ≥1 year of age.

Table 7. Serum Biochemical Profile of Apparently Healthy Exotic Breed of Dogs Based on Breed in Jos, Plateau State (n = 100).

S/N	Serum Biochemical Parameters	Mean ± Standard Error					Sig.
		Alsatian (N = 15)	Bull Mastiff (N = 15)	Caucasian (N = 32)	Neapolitan Mastiff (N= 21)	Rottweiler (N = 16)	
1	Aspartate aminotransferase (u/l)	23.10 ± 4.13	24.43 ± 3.27	20.78 ± 1.17	25.80 ± 3.47	24.20 ± 2.15	0.260
2	Alanine aminotransferase (u/l)	22.69 ± 2.52	18.73 ± 2.01	18.88 ± 1.21	19.48 ± 1.91	20.06 ± 1.93	0.602
3	Alkaline phosphatase (u/l)	52.28 ± 6.58	62.00 ± 13.26	64.87 ± 7.37	56.18 ± 7.77	62.51 ± 8.91	0.837
4	Total Protein (g/l)	65.80 ± 1.99	64.19 ± 2.78	62.76 ± 1.56	68.79 ± 2.27	56±59 ± 2.97	0.221
5	Albumin (g/l)	31.34 ± 1.78	30.97 ± 1.62	34.06 ± 1.49	30.52 ± 1.75	35.21 ± 2.10	0.259
6	Globulin (g/l)	36.63 ± 3.02	34.19 ± 2.32	30.37 ± 1.42	37.12 ± 2.17	30.73 ± 2.40	0.053
7	Total Bilirubin (mmol/l)	21.05 ± 2.39^{b}	14.52 ± 1.37^{a}	17.46 ± 1.04^{ab}	16.44 ± 0.98^{ab}	18.21 ± 0.81^{ab}	0.045
8	Urea (mmol/l)	4.16 ± 0.43	4.04 ± 0.45	4.99 ± 0.58	3.56 ± 0.31	4.59 ± 0.45	0.206
9	Creatinine (mmol/l)	108.02 ± 8.91	99.90 ± 11.04	120.72 ± 6.85	111.33 ± 8.45	122.39 ± 7.92	0.370
10	Cholesterol (mmol/l)	4.67 ± 0.31	4.14 ± 0.43	5.17 ± 0.29	4.57 ± 0.41	5.41 ± 0.32	0.127
11	Triglyceride (mmol/l)	1.48 ± 0.16	1.79 ± 0.28	1.53 ± 0.17	1.77 ± 0.22	1.49 ± 0.15	0.461

Different superscripts in a row (a and b) indicate significant difference between the group mean at ($P < 0.05$).

breed of dogs recorded in this study were comparable to and not different from those reported for dogs as stated by Ariyibi *et al.* [55] in Alsatian and local breeds in Ibadan, Nigeria, Muhsen and Hasso [1] in local dogs, Kahn and Line [9] in exotic breeds, Adekola *et al.* [56] in Alsatian, Rottweiler, Boerbull in Ibadan and local breeds, Atata *et al.* [57] in Local dogs Zaria, Kaduna state, Nigeria but there were differences between some of the minimum and maximum values recorded in this study and that reported by the different cited literature

Influence of Sex on Hematological and *S*erum Biochemical Profiles of Apparently Healthy Exotic Breed of Dogs in Jos, Plateau State

There was no statistical significant difference ($p > 0.05$) in the hematological and serum biochemical values except WBC and total protein where males had significantly higher values compared to females ($p < 0.05$) when compared based on sex (Table 2 and Table 5). The results in this study however disagreed with the findings of Bobade *et al.* [58] who observed a significantly higher PCV and Hb values in the female than male Nigerian local dogs. It also disagreed with a finding from Ibadan Nigeria that reported that male Alsatian had a significantly higher PCV, Hb and MCH values than female Alsatian dogs [59]. The lack of sexual differences in the erythrocyte values in the N'dama cattle [60] and the pangolin [61] has also been reported. These findings were similar to the findings of Olamide *et al.* [62] and Oduye [63], who observed no sexual dimorphism in the erythrocytes parameters of the Nigerian local dogs in Ibadan, Nigeria. This may be because the animals were kept under similar environmental conditions and management system (intensive care). The significant difference recorded in mean WBC disagreed with some authors who reported no observable differences between the hematological values in sexes of dog breeds [64] [22] [65]. The re-

sult however agreed with Ihedioha *et al.* [33] who reported significant difference ($p < 0.05$) in the WBC of juvenile laboratory rat and Neutrophils constituting the majority of WBC counts while basophils were not observed at all. Furthermore, the result disagreed with Muhsen and Hasso, [1] who reported no sex-related difference in serum biochemistry of dogs but agreed with Awah and Nottidge [22] and Ariyibi *et al.* [55] who reported significant difference ($p < 0.05$) in total protein in dogs based on sex. The significantly higher values observed in males may be due to androgenic effects on the physiological parameters and/or may be attributed to gender-related hormonal influences on hepatic synthesis of total protein [50].

Influence of Age on Hematological and *S*erum Biochemical Profiles of Apparently Healthy Exotic Breed of dogs in Jos, Plateau State

In the present study, the findings showed no significant differences ($p > 0.05$) in the hematological parameters between the adult and the puppy of dogs (**Figure 1**) but adults recorded significantly ($p < 0.05$) higher urea level than puppies (**Table 6**). This finding is in consonance with the observations in the Nigerian local guinea pigs [66]; rats, rabbits, temperate guinea pigs [67]; Nigerian local cats [68] and the Cameroun goats [69] where no age variations were reported in hematological parameters. The result also disagreed with the study that showed that the RBC, Hb, PCV MCV, MCH and MCHC values were significantly higher in the adult Alsatian and Nigerian local dogs than the young Alsatian and Nigerian local dogs in Ibadan, Nigeria [65]. This may be due to common environmental factors/climatic condition in the area. Furthermore, the significant difference ($p < 0.05$) that occurred based on the age in urea level agreed with [70] [71] [72] who report significant difference ($p < 0.05$) in the mean total protein and urea level in mice, goats and horses respectively but disagreed with Olayemi and Nottidge [73] [68] [1] who reported no significant difference ($p > 0.05$) in urea level but in other serum biochemical parameters of dogs. The significantly higher serum urea recorded for the adult dogs relative to puppy may be attributed to ageing-related impairment of renal function [74] [75].

Influence of Breed on Hematological and *S*erum Biochemical Profiles of Apparently Healthy Exotic Breed of Dogs in Jos, Plateau State

There was no statistical significant difference ($p > 0.05$) in the values in all the hematological and serum biochemical parameters except MCHC and total bilirubin respectively where significant differences occurred ($p < 0.05$) when compared based on breed (**Table 3** and **Table 7**). Based on breed, Neapolitan mastiff showed higher MCHC value when compared with all the breeds but was significant ($p < 0.05$) when compared with Alsatian. This is in disagreement with Olamide *et al.* [62] who revealed that the erythrocyte values: PCV, RBC count, HB conc. MCV, MCH and MCHC are similar for both the Nigerian local dog and the German Rottweiler in Ibadan, Nigeria. It has also been reported by Jain [67] that there was no significant breed difference in the RBC, PCV, Hb, MCV, MCH, and MCHC values in swine. The study agreed with the studies of Ariyibi

et al. [55] and Olayemi and Ighagbon [65] who reported significant MCHC values between Alsatian and Nigerian local dogs. The study is also in consonance with Isaac *et al.* [14] in a study on hematological properties of different breeds (Chinchilla, New Zealand White and Dutch) of rabbit which 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. Schalm [32] also reported significant breed differences in hematological values for New Zealand White and wild jack rabbit. Durai *et al.* [76] conducted a study on hematological profile and erythrocyte indices of different breeds of poultry and observed variation in results which was suggested to be due to differences in breeds. Furthermore, the significant difference ($p < 0.05$) that occurred based on breed in total bilirubin agreed partially with Ariyibi *et al.* [55] who reported significant difference in the total bilirubin between local and Alsatian breed of dogs. The significant high value of MCHC value of Neapolitan mastiff compared to Alsatian breed and that of total bilirubin of Alsatian breed compared to Bull mastiff may be due to their genetic composition and body size as breed is part of genetic factors that affects blood pictures [25].

5. Conclusions

From this study, it was concluded that:

1) Hematological and serum biochemical values studied were comparable to and not different from those reported for dogs in available literature, but the upper and lower reference limits (minimum and maximum values) were different from those in available literature for most parameters.

2) Sex-related significant differences occurred only in WBC and total protein while age-related significant differences occurred only in total protein and urea level.

3) Breed affected the MCHC and total bilirubin level which was evident in higher MCHC level in Neapolitan mastiff than Alsatian breed while total bilirubin was higher in Alsatian breed than Bull mastiff. Other parameters compared favorably with the variables.

6. Recommendations

1) Small animal clinicians and researchers can use the values generated from this research as a baseline for analyses of physiological status of dogs in Jos which could help in realistic evaluation of the management practice, nutrition and diagnosis of diseases.

2) More so, the hematological and serum biochemical profile generated from this study can be used for clinical analyses of blood profile of dogs in Jos.

3) Furthermore, it is important for relevant stake-holders like the Universities, Research Institutes, NGOs and other government agencies in Veterinary/ Agriculture field to fund and intensify research into the development of a more de-

tailed physiological profile for companion animals in Jos. This will go a long way in providing better quality animal healthcare system delivery in Jos and Nigeria at large.

Contributions to Knowledge

1) The mean hematological and serum biochemical values in this study did not differ from those reported for dogs in available literature except the upper and lower reference limits (minimum and maximum values) which differed from those in available literature for most parameters.

2) Male dogs among the dogs used in this study had higher white blood cell counts and total protein values than the females

3) It was also observed that adult dogs also had higher total protein and urea level than puppies among dogs used.

4) Neapolitan mastiff recorded higher MCHC and total bilirubin levels than other breeds while Alsatian had higher total bilirubin than other breeds.

Ethical Statement

The authors confirm that the experimental protocol adhered to the standard animal welfare guideline with approval number: UNN/eTC/15/32 obtained from the Animal Ethics Committee of the University of Nigeria.

Acknowledgements

The authors are grateful to the following clinicians Dr. Obinna Nwankiti, Mr. Pam Dung, Mr. Joseph Ibekwe, Hon. Gideon Dangreng and other dog breeders for their concent to sample their pets; Dr. Moses Gyang and Mr. Shailong Daniel Danjuma of National Veterinary Research Institute (NVRI), Vom Plateau State, Nigeria for their technical support.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Muhsen, R.K. and Hasso, S.A. (2010) Effect of Age and Sex on the Serum Biochemical Profile of Local Dogs. *AL-Qadisiya Journal of Veterinary Medical Sciences*, **9**, 1-3. https://doi.org/10.29079/vol9iss1art89

[2] Kaneko, J.J., Harvey, J.W. and Bruss, M.L. (2008) Clinical Biochemistry of Domestic Animals. 6th Edition, Academic Press, San Diego, 493, 889-895.

[3] Adebiyi, O.E., Ajayi, J.O. and Olayemi, F.O. (2014) Hematology of Rottweiler Dog in a Tropical Environment. *New York Science Journal*, **7**, 1-4.

[4] Mitruka, B.M. and Rawnsley, H.M. (1977) Clinical Biochemical and Hematological Reference Values in Normal Experimental Animals. Masson Publishing Inc., New York, 134-135.

[5] Duke, H.H. (1975) Duke's Physiology of Domestic Animals. 8th Edition, Theca and

London Cornstock Publishing Associates, a Division of Cornell University Press, London, 33.

[6] Njidda, A.A., Shuai'bu, A.A. and Isidahomen, C.E. (2014) Hematological and Serum Biochemical Indices of Sheep in Semi-Arid Environment of Northern Nigeria. *Global Journal of Science Frontier Research*: *Agriculture and Veterinary*, **14**, 48-56.

[7] Bentrick, S. (1974) Hematology. Textbook of Veterinary Pathology. Williams and Co, Baltimore, 217-224.

[8] Akinmutimi, A.H. (2004) Evaluation of Sword Bear (*Canavalia gladiate*) as an Alternative Feed Resources for Broiler Chickens. Ph.D. Thesis, Michael Okpara University of Agriculture, Umudike, 1-289.

[9] Kahn, C.M. and Line, S. (2006) The Merck Veterinary Manual [Online]. Merck and Co, Whitehouse Station. http://www.merckvetmanual.com/mvm/index.jsp?cfile=htm/bc/10413.htm

[10] Onyeyili, P.A., Egwu, G.O., Jibike, G.I., Pepple, D.J. and Ohaegbulam, J.O. (1992) Seasonal Variation in Hematological Indices in the Grey-Breasted Guinea Fowl (*Numida mealagris* and *Gallata pallas*). *Nigerian Journal of Animal Production*, **18**, 108-110. https://doi.org/10.51791/njap.v18i.2007

[11] Togun, V.A., Oseni, B. S.A., Ogundipe, J.A., Arewa, T.R., Hammed, A.A., Ajonijebu, D.C. and Mustapha, F. (2007) Effects of Chronic Lead Administration on the Hematological Parameters of Rabbits—A Preliminary Study. *Proceedings of the* 41*st Conferences of the Agricultural Society of Nigeria*, Zari, 22-26 October, 341.

[12] Ovuru, S.S. and Ekweozor, I.K.E. (2004) Hematological Changes Associated with Crude Oil Ingestion in Experimental Rabbits. *African Journal of Biotechnology*, **3**, 346-348. https://doi.org/10.5897/AJB2004.000-2064

[13] Mmereole, F.U.C. (2008) The Effects of Replacing Groundnut Cake with Rubber Seed Meal on the Hematological and Serological Indices of Broilers. *International Journal of Poultry Science*, **7**, 622-624. https://doi.org/10.3923/ijps.2008.622.624

[14] Isaac, L.J., Abah, G., Akpan, B. and Ekaette, I.U. (2013) Hematological Properties of Different Breeds and Sexes of Rabbits. *Proceedings of the* 18*th Annual Conference of Animal Science Association of Nigeria*, Abuja, 8-12 September, 24-27.

[15] Khan, T.A. and Zafar, F. (2005) Hematological Study in Response to Varying Doses of Estrogen in Broiler Chicken. *International Journal of Poultry Science*, **4**, 748-751. https://doi.org/10.3923/ijps.2005.748.751

[16] Waugh, A., Grant, A.W. and Ross, J.S. (2001) Ross and Wilson Anatomy and Physiology in Health and Illness. 9th Edition, Churchill Livingston, an Imprint of Elsevier Science Limited, Amsterdam, 59-71.

[17] Bamishaiye, E.I., Muhammad, N.O. and Bamishaiye, O.M. (2009) Hematological Parameters of Albino Rats Fed on Tiger Nuts (*Cyperus esculentus*) Tuber Oil Meal-Based Diet. *The International Journal of Nutrition and Wellness*, **10**, 1-5. https://doi.org/10.5580/187b

[18] Tyson, C.A. and Sawhney, D.S. (1985) Organ Function Tests in Toxicology Evaluation. Noyes Publications, New York, 30-37.

[19] Coles, E.H. (1986) Veterinary Clinical Pathology. 4th Edition, W.B. Sounders Company, Philadelphia, 220-239.

[20] Stockham, S.L. and Scott, M.A. (2008) Fundamentals of Veterinary Clinical Pathology. 2nd Edition, Blackwell Publishing, Ames, 61-64.

[21] Yokus, B., Cakir, D.U., Kanay, Z., Gulten, T. and Uysal, E. (2006) Effects of Seasonal and Physiological Variations on the Serums Chemistry, Vitamins and Thyroid

Hormone Concentrations in Sheep. *Journal of Veterinary Medicine*, **53**, 271-276. https://doi.org/10.1111/j.1439-0442.2006.00831.x

[22] Awah, J.N. and Nottidge, H.O. (1998) Some Biochemical Parameters in Clinically Healthy Dogs in Ibadan. *Tropical Veterinarian*, **16**, 123-129.

[23] Nazifi, S., Saeb, M., Rowghani, E. and Kaveh, K. (2003) The Influences of Thermal Stress on Serum Biochemical Parameters of Iranian Fat-Tailed and Their Correlation with Triiodothyronine, Thyroxine and Cortisol Concentrations. *Comparative Clinical Pathology*, **12**, 135-139. https://doi.org/10.1007/s00580-003-0487-x

[24] Swanson, K.S., Kuzmuk, K.N., Schook, L.B. and Fahey, G.C. (2004) Diet Affects Nutrient Digestibility, Hematology, and Serum Chemistry of Senior and Weanling Dogs. *Journal of Animal Science*, **82**, 1713-1724. https://doi.org/10.2527/2004.8261713x

[25] Etim, N.N., Williams, M.E., Akpabio, U. and Offiong, E.E.A. (2014) Hematological Parameters and Factors Affecting Their Values. *Agricultural Science*, **2**, 37-47. https://doi.org/10.12735/as.v2i1p37

[26] Afolabi, K.D., Akinsoyinu, A.O., Olajide, R. and Akinleye, S.B. (2010) Hematological Parameters of the Nigerian Local Grower Chickens Fed Varying Dietary Levels of Palm Kernel Cake. *Proceedings of* 35*th Annual Conference of Nigerian Society for Animal Production*, 247.

[27] Ogunbajo, S.O., Alemede, I.C., Adama, J.Y. and Abdullahi, J. (2009) Hematological Parameters of Savannah Brown Does Fed Varying Dietary Levels of Flamboyant Tree Seed Meal. *Proceedings of* 34*th Annual Conference of Nigerian Society for Animal Production*, 88-91.

[28] Menon, D.G., Bennett, D.C., Schaefer, A.M. and Cheng, K.M. (2013) Hematological and Serum Biochemical Profile of Farm Emus (*Dromaius novaehollandiae*) at the Onset of Their Breeding Season. *Poultry Science*, **92**, 935-944. https://doi.org/10.3382/ps.2012-02870

[29] Onasanya, G.O., Oke, F.O., Sanni, T.M. and Muhammad, A.I. (2015) Parameters Influencing Hematological, Serum and Bio-Chemical References in Livestock Animals under Different Management Systems. *Open Journal of Veterinary Medicine*, **5**, 181-189. https://doi.org/10.4236/ojvm.2015.58025

[30] Solberg, H.E. (1999) Establishment and Use of Reference Values. In: Burtis, C.A. and Ashwood, E.R., Eds., *Tietz' Textbook of Clinical Chemistry*, 3rd Edition, W.B. Saunders, Philadelphia, 336-356.

[31] Klaassen, J.K. (1999) Reference Values in Veterinary Medicine. *Laboratory Medicine*, **30**, 1-4. https://doi.org/10.1093/labmed/30.3.194

[32] Schalm, O.W., Jain, N.C. and Caroll, E.J. (1975) Veterinary Hematology. 3rd Edition, Hea and Febiger, Philadelphia, 19-25.

[33] Ihedioha, J.I., Okafor, C. and Ihedioha, T.E. (2004) The Hematological Profile of the Sprague Dawley Outbred Albino Rat in Nsukka, Nigeria. *Animal Research International*, **1**, 125-132. https://doi.org/10.4314/ari.v1i2.40755

[34] Ihedioha, J.I., Ugwuja, J.I., Noel-Uneke, O.A., Udeani, I.J. and Daniel-Igwe, G. (2012) Reference Values for the Hematology Profile of Conventional Grade Albino Mice (*Mus musculus*) in Nsukka, Eastern Nigeria. *Animal Research International*, **9**, 1601-1612.

[35] Walton, R.N. (2001) Establishing Reference Intervals: Health as a Relative Concept. *Seminars in Avian and Exotic Pet Medicine*, **10**, 66-71. https://doi.org/10.1053/S1055-937X(01)80026-8

[36] Nigerian Postal Agency (NIPOST) (2009) Post Offices with Maps of Local Government Areas. https://en.wikipedia.org/wiki/Plateau_State

[37] Ogbu, K.I., Bangshik, H.B., Jock, R.J., Akila, F., Lar, D.P., Damina, P.S. and Choji, E.J. (2020) Ecological Survey of Dog Population and Ownership Care System in JOS-South Local Government Area of Plateau State. *Journal of Animal Science and Veterinary Medicine*.

[38] Uzoagulu, A.E. (2011) Practical Guide to Writing Research Project Report in Tertiary Institutions. Cheston Publishers, Enugu, 45.

[39] Hassan, A.Z. and Hassan, F.B. (2003) An Introduction to Veterinary Practice. Ahmadu Bello University Press Limited, Zaria, 47.

[40] Woo, P.T. (1970) The Haematocrit Centrifuge Technique for the Diagnosis of African Trypanosomiasis. *Acta Tropica*, **27**, 384-386.

[41] Murray, M., Trail, J.C.M., Turner, D.A. and Wissocq, Y. (1983) Livestock Productivity and Trypanotolerance. Network Training Manual for International Livestock Center for Africa. 4-10.

[42] Foreyt, W.J. (2013) Veterinary Parasitology Reference Manual. Wiley and Sons, New York.

[43] Thrall, M A. and Weiser, M.G. (2002) Hematology. In: Hendrix, C.M., Ed., *Laboratory Procedures for Veterinary Technicians*, 4th Edition, Mosby Inc., Missouri, 29-74.

[44] Higgins, T., Beutler, E. and Doumas, B.T. (2008) Measurement of Hemoglobin in Blood. In: Burtis, C.A., Ashwood, E.R. and Bruns, D.E., Eds., *Tietz Fundamentals of Clinical Chemistry*, 6th Edition, Saunders Elsevier, Missouri, 514-515.

[45] Brown, B.A. (1976) Direct Methods for Platelet Counts-Rees and Ecker Method. In: Brown, B.A., Ed., *Hematology*: *Principles and Procedures*, 2nd Edition, Lea and Febiger, Philadelphia, 101-103.

[46] Reitman, S. and Frankel, S. (1957) A Colorimetric Method for Determination of Serum Glutamic Oxaloacetic and Glutamic Pyruvic Transaminase. *American Journal of Clinical Pathology*, **28**, 56-62. https://doi.org/10.1093/ajcp/28.1.56

[47] Babson, A.L., Greeley, S.J., Coleman, C.M. and Philips, G.E. (1966) Phenolphthalein Monophosphate as a Substrate for Serum Alkaline Phosphatase. *Clinical Chemistry*, **12**, 482-490. https://doi.org/10.1093/clinchem/12.8.482

[48] Lubran, M.M. (1978) The Measurement of the Serum Total Proteins by the Biuret Method. *Annals of Clinical Laboratory Sciences*, **8**, 106-110.

[49] Doumas, B.T., Watson, W. and Biggs, H.G. (1971) Albumin Standards and the Measurement of Serum Albumin with Bromocresol Green. *Clinical Chemistry Acta*, **31**, 87-96. https://doi.org/10.1016/0009-8981(71)90365-2

[50] Colville, J. (2002) Blood Chemistry. In: Hendrix, C.M., Ed., *Laboratory Procedures for Veterinary Technicians*, 4th Edition, Mosby, St. Louis, 75-103.

[51] Doumas, B.T., Perry, B.W., Sasse, E.A. and Straumfjord, J.V. (1973) Standardization in Bilirubin Assays: Evaluation of Selection Methods and Stability of Bilirubin Solutions. *Clinical Chemistry*, **19**, 984-993. https://doi.org/10.1093/clinchem/19.9.984

[52] Fawcett, J.K. and Scott, J.E. (1960) A Rapid and Precise Method for the Determination of Urea. *Journal of Clinical Pathology*, **13**, 156-159. https://doi.org/10.1136/jcp.13.2.156

[53] Blass, K.G., Thiebert, R.J. and Lam, L.K. (1974) A Study of the Mechanism of the Jaffe Reaction. *Journal of Clinical Biochemistry*, **12**, 336-343.

[54] Allain, C.C., Poon, L.S., Chan, C.S., Richmond, W. and Fu, P.U. (1974) Enzymatic Determination of Total Cholesterol. C*linical Chemistry*, **20**, 470-475. https://doi.org/10.1093/clinchem/20.4.470

[55] Ariyibi, A.A., Oyeyemi, M.O. and Ajadi, R.A. (2002) A Comparative Study of Some Hematological and Biochemical Parameters of Clinically Healthy Alsatian and Local Dogs. *African Journal of Biomedical Research*, **5**, 145-147. https://doi.org/10.4314/ajbr.v5i3.54004

[56] Adekola, A.A., Jagun, A.T., Emikpe, B.O. and Antia, R.E. (2015) Baseline Hematology and Erythrocyte Morphological Changes of Apparently Normal Dogs Raised in Ibadan, Oyo State. *Nigerian Journal of Physiological Sciences*, **30**, 111-118.

[57] Atata, J.A., Esievo, K.A.N., Adamu, S. and Abdulsalam, H. (2018) Baseline Hematological, Serum Biochemical and Some Urine Parameters in Nigerian Indigenous Dogs. *Savannah Veterinary Journal*, **1**, 48-52.

[58] Bobade, P.A., Oduye, O.O., Helen, O. and Aghoma, O. (1985) Hemogram of Clinically Normal Dogs with Particular Reference to Local (Nigerian) and German Shepherd Dogs. *Nigeria Veterinary Journal*, **14**, 7-11.

[59] Olayemi, F.O., Azeez, I.O., Ogunyemi, A. and Ighagbon, F.O. (2009) Study on Erythrocyte Values of the Nigerian Indigenous Dog. *Folia Veterinaria*, **53**, 65-67.

[60] Olayemi, F.O. (2007) The Effect of Sex on the Erythrocyte Osmotic Fragility, Hematological and Plasma Biochemical Parameters of the N'dama Cattle. *Tropical Veterinary*, **25**, 106-111.

[61] Oyewale, J.O., Olayemi, F.O. and Oke, O.A. (1998) Hematology of the Wild Adult African Giant Rat (*Cricetomys gambianus*, Waterhouse). *Veterinarski Archive*, **68**, 91-99.

[62] Olamide, E., Adebiyi, J.O. and Ajayi, F.O.O. (2014) Hematology of Rottweiler Dog in a Tropical Environment. *New York Science Journal*, **7**, 1-4

[63] Oduye, C.O. and Dipeolu, O.O. (1976) Blood Parasites of Dogs in Ibadan-Nigeria. *Journal of Small Animal Practice*, **17**, 331-334. https://doi.org/10.1111/j.1748-5827.1976.tb06966.x

[64] Michaelson, S.M. and Lin, J.C. (1987) Biological Effects and Health Implication of Radiofrequency Radiation Effects on Hematopoiesis and Hematology. Springer, Berlin, 489-512. https://doi.org/10.1007/978-1-4757-4614-3

[65] Olayemi, F.O. and Ighagbon, F.O. (2009) Hematology of the German Shepherd Dog in a Humid Tropical Environment. *Compendium of Clinical Pathology*, **20**, 61-64. https://doi.org/10.1007/s00580-009-0935-3

[66] Oluwaniyi, J.O., Taiwo, V.O., Nottidge, H.O. and Ogunsanmi, A.O. (2001) Hematological and Serum Biochemical Studies of Guinea Pig in Nigeria. *Tropical Veterinary*, **19**, 183-187.

[67] Jain, N.C. (1986) Schalm's Veterinary Hematology. 4th Edition, Lea and Febiger, Washington Square, Philadelphia, 600.

[68] Nottidge, H.O., Taiwo, V.O. and Ogunsanmi, A.O. (1999) Hematological and Serum Biochemical Studies of Cats in Nigeria. *Tropical Veterinarian*, **17**, 9-16.

[69] Pospisil, J., Kase, F. and Vahala, J. (1987) Basic Hematological Values in the Cameroon Goats. *Compendium of. Biochemistry and Physiology*, **88**, 451-454. https://doi.org/10.1016/0300-9629(87)90062-4

[70] Rodgers, J.D. and Gass, G.H. (1983) The Effect of Age on Serum Proteins in Mice. *Experimental Gerontology*, **18**, 39-45. https://doi.org/10.1016/0531-5565(83)90049-9

[71] Alberghina, D., Casella, S., Vazzana, I., Ferrantelli, V., Giannetto, C. and Piccione, G. (2010) Analysis of Serum Proteins in Clinically Healthy Goats (*Capra hircus*) Using Agarose Gel Electrophoresis. *Veterinary Clinical Pathology*, **39**, 317-321. https://doi.org/10.1111/j.1939-165X.2010.00226.x

[72] Ihedioha, J.I and Agina, O.A. (2013) Serum Biochemistry Profile of Nigerian Horses (*Equus caballus*, *linnaeus* 1758). *Animal Research International*, **10**, 1826-1833.

[73] Olayemi, F.O. and Nottidge, H.O. (2007) Effect of Age on Blood Profile of the New Zealand Rabbit in Nigeria. *African Journal Biomedical Research*, **10**, 99-102. https://doi.org/10.4314/ajbr.v10i1.48976

[74] Ju, J.C., Cheng, S.P., Fan, Y.K., Hsu, J.C., Chiang, S. K., Chen, E.V., Chang, S.H. and Chiou, S.C. (1993) Investigation of Equine Hematological Constituents in Central Taiwan. *Asian-Australasian Journal of Animal Science*s, **6**, 147-153. https://doi.org/10.5713/ajas.1993.147

[75] Gupta, A.K., Kumar, S. and Pal, Y. (2002) Biochemical, Hematological and Thyroid Hormone Profile in Healthy Indian Kathiawari Horses. *Asian-Australasian Journal of Animal Science*s, **15**, 1215-1221. https://doi.org/10.5713/ajas.2002.1215

[76] Durai, P.C., Maruthai, T.P.T., Arumugam, S.S. and Venugopal, O.A. (2012) Hematological Profile and Erythrocyte Indices in Different Breeds of Poultry. *International Journal of Livestock Research*, **2**, 89-92. https://doi.org/10.5455/ijlr.20120824083537