



## Research Article

### Seasonal Variations in the Clinical, Haematological and Biochemical Parameters of Horses in Maiduguri, Nigeria

Esther Solomon Mshelia<sup>1</sup>, Stephen Bitrus Balami<sup>3</sup>, ThankGod, E. Onyiche<sup>2</sup> and Abdullahi Abubakar Biu<sup>2</sup>,

<sup>1</sup>Department of Veterinary Medicine, Faculty of Veterinary Medicine, University of Maiduguri, P. M. B. 1069, Maiduguri, Nigeria

<sup>2</sup>Department of Veterinary Parasitology and Entomology, Faculty of Veterinary Medicine, University of Maiduguri, P. M. B. 1069, Maiduguri, Nigeria

<sup>3</sup>Veterinary Teaching Hospital, Faculty of Veterinary Medicine, University of Maiduguri, P. M. B. 1069, Maiduguri, Nigeria

\*Corresponding author's Email: [biuвет@yahoo.com](mailto:biuвет@yahoo.com), [doi.org/10.55639/607.02010033](https://doi.org/10.55639/607.02010033)

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#### ABSTRACT

The clinical, haematological and biochemical parameters of horses may vary according to geographical location. Consequently, this study was undertaken to evaluate the clinical, haematological and biochemical parameters of Horses in Maiduguri, Nigeria. One hundred and sixty horses of both sexes were sampled for this study during the dry and rainy season. They were mainly from stables of the State Royal Palace, Nigeria Police Force, University of Maiduguri and those of Private Ownership within the metropolis. Horses were examined for wounds, various clinical signs or any abnormalities and vital parameters of respiratory rate, pulse rate and rectal temperatures were evaluated. Haematological parameters such as packed cell volume (PCV), haemoglobin (Hb) concentration, differential leucocytes, red blood cell (RBC), and white blood cell (WBC) counts were determined. The mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH) and mean corpuscular volume (MCV) were also calculated. Serum enzyme alkaline phosphatase and serum metabolites of total protein, albumin, direct bilirubin, total bilirubin, creatinine, urea nitrogen and glucose were also evaluated. The findings revealed that there was a statistically significant difference ( $P < 0.05$ ) between the temperatures of horses sampled during the dry and rainy seasons but were all within the normal range. The associated clinical signs observed were cough, diarrhea and weakness. The haematological parameters were within the normal range during the two seasons, with the exception of packed cell volume (PCV) and haemoglobin concentration (Hb) which were lower during the dry season. The biochemical parameters were also within the normal range with the exception of albumin and alkaline phosphatase which were lower during the dry season. The haematological, biochemical and vital parameters of horses in this study were within the normal range of reference values and are comparable with others in the world.

Corresponding author: Abdullahi Abubakar Biu, Email: [biuвет@yahoo.com](mailto:biuвет@yahoo.com)  
Department of Veterinary Parasitology and Entomology, University of Maiduguri, Nigeria

## INTRODUCTION

Horses (*Equus equus caballus*) are hoofed herbivorous mammals that belong to the family *Equidae*. They are described in numerous ways in the world, based on their breed, blood type and colour. They are well known for being affectionate and bounding with humans (Keaveney, 2008; Payne *et al.*, 2016). Horses are used as an important means of transportation, as well as for sports, security and traditional and military ceremonies (Abiola *et al.*, 2016; Ola-Fadunsin *et al.*, 2018). Horses, among most domestic animals are resistant but reported to be susceptible to a large number of diseases including bacterial, viral, fungal and parasitic (Takele and Nibret, 2013).

In the clinical assessment of animals, the evaluation of the clinical signs, vital, haematological and serum biochemical parameters is an important medium for diagnosis of various diseases, assessing the efficacy of therapy and the toxicity of drugs and chemical substances especially in monitoring recovery during treatment of animals including horses (Radostits *et al.*, 1994). Any deviations from the normal caused by either invasion by pathogens into the body, other forms of injury, deprivation and/or stress are commonly reflected by changes in these parameters (, 2004; Stockham and Scott, 2008). The level of these parameters and serum enzymes gives an indication of the health status of horses (Tyson and Sawhney, 1985; Coles, 1986; Stockham and Scott, 2008).

Clinical and haematological parameters of horses have been studied and reported from many countries (Graber, 1970; Keenan, 1979; Lekeux *et al.*, 1991; Reilley, 1993; Onyiche *et al.*, 2022), including Nigeria particularly in Ibadan and Enugu (Okon, 1976, Nwosu *et al.*, 1990). Due to the variability from one geographical location to the other in the reference values of horses as with other animals, every laboratory and/or clinic requires the need to establish reference values for its indigenous horse populations (Stockham and Scott, 2008; Krimer, 2011). Furthermore, the success of any clinical treatment is hinged on proper diagnosis following adequate clinical examination, haematological and serum biochemical assessment for possible biological deviations (Agina, 2017; Onyiche *et al.*, 2022). In view of

this, this study evaluated the clinical signs, vital, haematological and serum biochemical parameters of horses in Maiduguri, Nigeria and to ascertain the possible role of season for any biological deviation

## MATERIALS AND METHODS

The 160 horses of both sexes used for this study were sampled by convenient sampling method (Thrushfield, 2005). They were mainly from the State royal stable, Nigeria Police Force stable, University of Maiduguri stable and other individually owned stables within the metropolis. Horses were examined for wounds, clinical signs or abnormalities and vital parameters of respiratory rate, pulse rate and rectal temperatures were evaluated. Animals were observed individually while at rest for respiratory rate (breath/minute) using costo-abdominal movement, pulse rate (beats/minute) from pulsation of external maxillary artery in the medial aspect of mandibular angle and rectal temperature in degrees Celsius ( $^{\circ}\text{C}$ ) using digital clinical thermometer as reported by Wosu (2002).

### Collection of Blood Sample and Analysis

Blood samples (10 mls) were collected from the jugular vein of each of the sampled horses using a hypodermic syringe with 18-gauge needle in the morning. 5mls of the collected blood was put into appropriately labeled sample bottles containing ethylene diamine tetra-acetic acid (EDTA) as an anti-coagulant for haematology, while 5mls of blood samples for biochemical examination were collected in appropriately labeled sample bottles without anticoagulant, and centrifuged at 400g for 3 minutes. The sera samples obtained were stored at  $-20^{\circ}\text{C}$  for further use.

Haematological parameters such as packed cell volume (PCV), total differential leucocytes comprising of neutrophils, eosinophils, lymphocytes, monocytes and basophils, red blood cells (RBC), white blood cells (WBC) counts and haemoglobin (Hb) concentration were determined as described by Coles (1980). Standard formulae of Schalm *et al.* (1975) were used to determine the mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH) and mean corpuscular volume (MCV).

### Determination of Biochemical Parameters

The parameters evaluated consisted of the serum enzyme alkaline phosphatase and serum metabolites of total protein, albumin, direct bilirubin, total bilirubin, creatinine, urea nitrogen and glucose by colorimetric methods using commercial reagent kits (Randox Lab Ltd, Co. Antrim, UK).

### Statistical Analysis

Data obtained were summarized as mean  $\pm$  standard deviation or standard error. All hematological and serum biochemical parameters used for the analysis were first tested for normality using the Kolmogorov-Smirnov test. Further analysis by comparing the hematological and biochemical parameters between the infected and uninfected groups for each species of equid was carried out using unpaired-sample student t test or Mann-Whitney U test depending on the distribution of the data (symmetry or asymmetry). Two-tailed significance level was set at 0.05. All analyses were carried out using GraphPad Prism version 5.

### RESULTS

The vital parameters of horses in the dry and rainy seasons in Maiduguri and its environs are shown in Table 1. No statistically significant ( $P > 0.05$ ) difference was observed with respect to temperature, respiratory rate and pulse rates across seasons. Table 2 shows the observed clinical signs in horses during the dry and rainy seasons in Maiduguri. Of the total of 160 horses examined for both seasons, 3(1.9%), 55 (34.4%), 24(15.0%), 29 (18.1%) and 49 (30.6%) showed signs of cough, diarrhoea, weakness, diarrhoea / weakness and diarrhoea / weakness / cough

respectively. However, during the dry season only 3(3.8%), 33 (41.3%), 24(30.0%), 0(0.0%) and 20(25.0%) showed signs of cough, diarrhoea, weakness, diarrhoea / weakness and diarrhoea / weakness / cough. Table 3 shows the observed clinical signs in stallions and mares in Maiduguri. Of the 141 stallions examined, 3(2.1%), 46 (32.6%), 24(17.0%), 25 (17.7%) and 43 (30.4%) had signs of cough, diarrhoea, weakness, diarrhoea/weakness and diarrhoea/weakness/cough, while the 19 mares examined, 0(0.0%), 9(47.3%), 0(0.0%), 4(20.1%) and 6(4.3%) had signs of cough, diarrhoea weakness, diarrhoea/weakness and diarrhoea/weakness /cough respectively. Furthermore, the results on Table 4 shows the mean haematological parameters in horses during dry and rainy seasons in Maiduguri. The values of the PCV, MCHC, RBC count and Hb were higher in the dry season compared to the rainy season. Statistically significant difference ( $P < 0.05$ ) was observed with respect to neutrophil, monocytes and lymphocytes between dry and rainy seasons. Lastly, table 5 shows the mean serum biochemical parameters in horses during dry and rainy seasons in Maiduguri. Statistically significant difference ( $P < 0.05$ ) was observed with respect to urea, total bilirubin and alkaline phosphatase levels between dry and rainy seasons. The mean values of glucose, albumin, alkaline phosphatase and Urea was higher during the rainy season compared to the dry season

These values included the mean glucose, protein, albumin, alkaline phosphatase, urea, creatinine, direct bilirubin and total bilirubin.

**Table 1:** Vital Parameters of Horses in Dry and Rainy Seasons in Maiduguri against Normal Values

Vital Parameters	Mean $\pm$ SD Values		Normal Values
	Dry	Rainy	
Temperature ( $^{\circ}$ C)	37.25 $\pm$ 0.08 <sup>a</sup>	37.92 $\pm$ 0.08 <sup>a</sup>	(37.2 - 39.8 $^{\circ}$ C)
Respiratory Rate (cycle/minute)	11.23 $\pm$ 0.21 <sup>a</sup>	11.55 $\pm$ 0.20 <sup>a</sup>	(8-16 cycle/minute)
Pulse Rate (beat/minute)	31.58 $\pm$ 0.67 <sup>a</sup>	31.21 $\pm$ 0.60 <sup>a</sup>	(22-44 beat/minute)

**Table 2:** Observed Clinical Signs in Horses during the Dry and Rainy Seasons in Maiduguri

Parameters	Number (%) of horses			95% CI	
	Dry Season (n =80)	Rainy Season (n =80)	Total (n=160)	Lower	Upper
Cough	3 (3.8)	0 (0)	3 (1.9)	0.64	5.37
Diarrhoea	33 (41.3)	23 (28.8)	55 (34.4)	27.46	42.03
Weakness	20 (25.0)	29 (36.3)	49 (30.6)	24.01	38.16
Diarrhoea and Weakness	0 (0)	29 (36.3)	29 (18.1)	12.93	24.82
Diarrhea/ Weakness/Cough.	24 (3.0)	0 (0)	24 (15)	10.29	21.35

**Table 3:** Observed Clinical Signs in Stallions and Mares in Maiduguri

Parameters	Number (%) of horses			95% CI	
	Stallions (n =141)	Mares (n =19)	Total (n=160)	Lower	Upper
Cough	3 (2.1)	0 (0)	3 (1.9)	0.64	5.37
Diarrhoea	46 (32.6)	9 (47.3)	55 (34.4)	27.46	42.03
Weakness	43 (30.4)	6 (4.3)	49 (30.6)	24.01	38.16
Diarrhoea and Weakness	25 (17.7)	4 (20.1)	29 (18.1)	12.93	24.82
Diarrhea/ Weakness/Cough	24 (17.0)	0 (0)	24 (15)	10.29	21.35

**Table 4:** Haematological Parameters in Horses during Dry and Rainy Seasons in Maiduguri

Parameters	Mean $\pm$ S.E		Reference Values
	Dry	Rainy	
Mean corpuscular volume (fl)	45.76 $\pm$ 0.91 <sup>a</sup>	45.48 $\pm$ 1.05 <sup>a</sup>	37.0-58.5
Mean corpuscular haemoglobin (pg)	16.70 $\pm$ 0.22 <sup>a</sup>	15.06 $\pm$ 0.33 <sup>a</sup>	12.3-19.7
Mean corpuscular haemoglobin concentration (g/d)	36.93 $\pm$ 0.45 <sup>a</sup>	33.32 $\pm$ 0.36 <sup>a</sup>	31.0-38.6
Packed cell volume (%)	32.21 $\pm$ 0.60 <sup>a</sup>	31.15 $\pm$ 0.46 <sup>a</sup>	32.0-53.0
Red blood cell count ( $10^6/\text{mm}^3$ )	7.36 $\pm$ 0.24 <sup>a</sup>	7.19 $\pm$ 0.22 <sup>a</sup>	6.8-12.9
Haemoglobin concentration (g/dl)	12.06 $\pm$ 0.33 <sup>a</sup>	10.37 $\pm$ 0.18 <sup>a</sup>	11.0-19.0
White blood cell count ( $10^3/\text{mm}^3$ )	9.01 $\pm$ 0.20 <sup>a</sup>	9.47 $\pm$ 0.11 <sup>a</sup>	5.4-14.3
Neutrophils (%)	3331.44 $\pm$ 111.63 <sup>a</sup>	3268.84 $\pm$ 63.09 <sup>b</sup>	2,260-8,580
Eosinophils (%)	625.08 $\pm$ 23.81 <sup>a</sup>	682.64 $\pm$ 22.54 <sup>a</sup>	0- 1,000
Basophils (%)	0.00 $\pm$ 0.00 <sup>a</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	0- 290
Monocytes (%)	287.88 $\pm$ 16.71 <sup>a</sup>	300.60 $\pm$ 13.28 <sup>b</sup>	0- 1000
Lymphocytes (%)	4755.53 $\pm$ 122.88 <sup>a</sup>	5165.66 $\pm$ 106.38 <sup>b</sup>	1500-7,700

<sup>a, b</sup>. Columns with different superscript differs significantly

**Table 5:** Biochemical Parameters in Horses during Dry and Rainy Seasons in Maiduguri

Parameters	Mean $\pm$ S.E		Reference Values
	Dry	Rainy	
Glucose (mmol/L)	4.83 $\pm$ 0.12 <sup>a</sup>	5.59 $\pm$ 0.15 <sup>a</sup>	4.16 - 6.38
Protein (g/dl)	6.03 $\pm$ 0.93 <sup>a</sup>	6.41 $\pm$ 0.87 <sup>a</sup>	5.57 - 7.74
Albumin, (g/dl)	2.46 $\pm$ 0.47 <sup>a</sup>	3.38 $\pm$ 0.52 <sup>a</sup>	2.77 - 4.06
Alkaline phosphatase ( $\mu/\text{L}$ )	63.64 $\pm$ 1.62 <sup>a</sup>	75.65 $\pm$ 3.11 <sup>b</sup>	20.0 - 350.0
Urea (mmol/L)	5.25 $\pm$ 0.14 <sup>a</sup>	7.42 $\pm$ 0.18 <sup>b</sup>	3.9 - 9.60
Creatinine (mmol/L)	94.90 $\pm$ 2.03 <sup>a</sup>	92.86 $\pm$ 4.60 <sup>a</sup>	35.0 - 194.0
Direct bilirubin (mmol/L)	6.29 $\pm$ 0.64 <sup>a</sup>	4.07 $\pm$ 0.31 <sup>a</sup>	3.42 - 8.55
Total bilirubin ( $\mu\text{mol/L}$ )	35.38 $\pm$ 1.55 <sup>a</sup>	11.30 $\pm$ 0.65 <sup>b</sup>	36.94 - 80.37

## DISCUSSION

Climate is one of the main factors affecting animal productivity (Marai and Haebe 2010). The findings of this study revealed no statistically significant difference between the temperatures, respiratory and pulse rates of horses sampled during the dry and rainy seasons but were all within the normal range. However, variations of these parameters have been observed in previous studies on horses in Nigeria (Garba *et al.*, 2015) and Saudi Arabia (Shawaf *et al.*, 2018). These differences could be attributed to environmental conditions such as heat stress imposed by seasonal weather changes. These horses were handled in a similar manner irrespective of gender and findings are in line with Garba *et al.* (2015), who observed that bio-variations in breeds and environmental conditions such as stress imposed by seasonal weather changes could influence variations in values of normal respiratory rate, pulse rate and rectal temperature of equids in Zaria-Nigeria.

The clinical signs observed in horses in this study during the dry and rainy seasons were cough, diarrhoea, weakness, diarrhoea/weakness and diarrhoea/weakness/cough. The samples collected during the two different seasons (dry and rainy) revealed a decrease in the number of affected horses in the rainy season with the exception of weakness and diarrhoea/weakness which was on the increase. It is unclear whether this is as a result of a change in weather as a factor or as a result of treatment and the non-recovery of some horses that were affected in the dry season, and the appearance of newly affected horses in the rainy season. Clinical signs encountered in stallions were more severe than that in mares, and this may be associated with the fact that stallions in developing countries usually perform strenuous work in resource limited conditions that predisposes them to disease conditions. Al-Qudari *et al.* (2015), in a similar study reported clinical signs associated with horses in the Eastern province of Saudi Arabia as colic, emaciation, cough, itching and nasal discharge. Most seen sign according to frequency was cough then followed by emaciation. Colic, itching and nasal discharges were of lesser frequencies. This may be due to

the mixed rearing of horses and donkeys that are raised on the same premises in this region.

Accurate interpretations of hematological and serum biochemical parameters are sometimes difficult since numerous factors influence these parameters. These include age, sex, breed, season, work, exercise, sub-clinical disease, and health status in horses and donkeys (Melo *et al.*, 2013; Zakari *et al.*, 2016). Most of the haematological parameters of horses during the dry and rainy season were within the normal range, which agrees with the normal values from horses elsewhere (Schalm *et al.*, 1975). However, the packed cell volume (PCV) and haemoglobin concentration (Hb) were within the normal range in the dry season but appeared lower in the rainy season. These possibly among other things could be attributed to the compound effects of intravascular haemolysis of parasitized red blood cells producing haemoglobinemia and reduced population of circulating erythrocytes (Saeed *et al.*, 2010), since PCV helps to determine anaemia in animals while Hb is the oxygen carrying capacity of the blood. Concurrent parasitic infections, poor nutrition, sex, age and environmentally induced factors (Salaheldin *et al.*, 1979a) might be significant enough to affect the interpretation of animal physiology. The serum biochemical parameters in horses during the dry and rainy seasons in this study were within the normal ranges and are comparable with those values reported in other clinically healthy horses in Northern Nigeria and some parts of the world (Ebge-Nwiyi *et al.*, 2012). However, albumin and alkaline phosphatase were lower during the dry season, but were normal during the rainy season, while total bilirubin appeared lower in both seasons. The low albumin and alkaline phosphatase for the horses during the dry season in comparison to the rainy season may be attributed to the dehydration status of the horses during the dry season as a result of higher environmental temperatures and greater water loss through sweating and some diseases that involve destruction of red blood cells. The lower appearance of total bilirubin in both seasons might be associated with nutritional factors, sex, age, diseases and environmental conditions as

reported by Zongping *et al.* (1995), who also had a strong opinion that the low or high values of some biochemical parameters of domestic animals may vary according to geographic and dietary factors. The report of this study disagreed with the earlier reports on the seasonal variations in the serum activity of these enzymes in horses (Ihedioha and Aina, 2013), goats (Tibbo *et al.*, 2008a, Gwaze *et al.*, 2012), rabbits (Okab *et al.*, 2008), sheep (Tibbo *et al.*, 2008b), humans (Miyake *et al.*, 2009) and cattle (Hadzimusic and Krnic, 2010), but is in consonance with the findings of Ebge-Nwiyi *et al.* (2012) on the preliminary studies on some haematological and serum parameters of healthy adult horses in Maiduguri - Nigeria.

It can be concluded from this study that the haematological, biochemical and vital parameters of horses in this study were within the normal range of reference values and are comparable with others in the world.

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#### AUTHORS CONTRIBUTION

Abdullahi Abubakar Biu, Stephen Bitrus Balami, and ThankGod, E. Onyiche conceived, designed and coordinated the study, while Esther Solomon Mshelia conducted the experiments assisted by the appropriate laboratory staff.

#### CONFLICT OF INTEREST

There is no conflict of interest as regards to this manuscript

#### REFERENCES

- Abiola, .O.J., Olaogun, S.C. , Emedoh, O.M. and Olalekan, T.J.(2016). A retrospective study of ruminant cases presented between 1996 and 2005 at the Veterinary Teaching Hospital, University of Ibadan, Nigeria. *International Journal of Livestock Research*, 6(7): 16-23.
- Agina, O. A. (2017). Haematology and clinical biochemistry findings associated with equine diseases-a review. *Notulae Scientia Biologicae*, 9(1), 1-21.
- Al-Qudari, A., Al-Ghamdi, G. and Al- Jabr, O. (2015). Prevalence of Gastrointestinal

Parasites in Horses in the Eastern Province of Saudi- Arabia. *Scientific Journal of King Faisal University Basic and Applied Sciences* 16 (2): 39-43

- Byford, R.L., Loftin, K.M., Loftin, M.J. and Craig, M.E. (1875). American Horse Riders and Horse Information: Origination of the Arabian Breed <http://www.horsesandhorseinformation.com> retrieved, May 28, 2008.
- Coles, H.E. (1980). *Veterinary Clinical Pathology*, 2<sup>nd</sup> Edition published by W.B. Saunders Company. Pp. 110-111.
- Ebge-Nwiyi, T.N., Kalu, N.A. and Naphtali, C. (2012). Preliminary Studies on some Haematological and Serum Biochemical Parameters of Apparently Healthy Adult Horses in Maiduguri, Nigeria; *African Journal Biomedical Research* 15 (1): 49-53
- Garba, U.M., Sackey, A.K.B., Lawal, A.I. and Esievo, K.A.N. (2015). Baseline vital haematological and serum biochemical parameters of donkeys. *Journal of Veterinary Medicine and Animal Health* 7(3): 94-98.
- Gwaze, F.R., Chiminyo, M. and Drama, K. (2012). Effect of season and age on blood minerals, liver enzyme levels, and faecal egg counts in Nguni goats of South Africa. *Czech of Animal Science*, 57:443-453.
- Hadzimusic, N. and Krnic, J. (2010). Activities of alanine aminotransferases (ALT), aspartate aminotransferases (AST), alkaline phosphatase (ALP) and lactate dehydrogenase (LHD) enzymes in cattle blood plasma depending on reproductive cycle and seasonal changes. *Veterinaria*, 59:47-57.
- Ihedioha, J. I. (2004). Haematopoietic system. In: Ihedioha, J. I. and Chineme, C. N. (Editors.) *Fundamentals of Systemic Veterinary Pathology. Volume 1*, Great AP Express Publishers Limited, Nsukka, Nigeria. . Pp 107-160.
- Ihedioha, J.I. and Aina, O.A. (2013). Serum Biochemical Profile of Nigerian Horses (*Equus caballus*, Linnaeus 1758).

- Animal Research International* 10(3): 1826-1833.
- Keaveney, S. M. (2008). Equines and their human companions. *Journal of business research*, 61(5), 444-454.
- Keenan, D.M. (1979). Changes of blood metabolites of horses after racing with particular reference to uric acid *Australian Veterinary Journal*, 55:54-57.
- Krimer, P. M. (2011). Generating and interpreting test results: test validity, quality control, reference values and basic epidemiology. Pp. 365 – 382. In: Latimer, K.S.(Ed). *Duncan and Prasse, Veterinary Laboratory Medicine: Clinical Pathology*, 5th Edition, Wiley-Blackwell, Iowa, USA.
- Lekeux. P., Art, T., Linden, A., Desmecht, D. and Amory, H. (1991). Heart rate, haematological and serum biochemical responses to show jumping. *Equine Exercise Physiology* 3: 385-390.
- Marai, I. F. M., & Haebe, A. A. M. (2010). Buffalo's biological functions as affected by heat stress—A review. *Livestock Science*, 127(2-3), 89-109.
- Melo, S.K.M., de Lira, L.B., de Almeida, T.L.A.C., Rego, E.W., Manso, H.D.C., and Manso, F., (2013). Hematological parameters and blood biochemistry in pleasure horses in tropical region. *Ciência Animal Brasileira*, 14(2):208-215.
- Miyake, K., Miyake, N., Kondo, S., Tabe, Y., Ohsaka, A. and Milda, T. (2009). Seasonal variation in liver function tests: a time series analyses of outpatient data. *Annals of Clinical Biochemistry*, 46: 377-384.
- Nwosu, C.O., Strivastava, G.C. and Abdullahi, A.N.J. (1990). Helminth parasites of equines in Borno State, Nigeria. *Tropical Animal Production and Health* 1: 9-13.
- Okab, A.B., EL-Banna, S.G. and Koriem, A.A. (2008). Influence of environmental temperatures on some physiological and biochemical parameters of New Zealand male rabbits. *Slovak Journal of Animal Science*, 41:12-19.
- Okon, E.D. (1976). Helminth parasites of horses in Ibadan. *Journal of Nigerian Veterinary Medical Association*, 5:32-34.
- Ola-Fadunsin, S.D., Ganiyu. I.A., Hussain, K. and Rabi, M. (2018). Occurrence of parasitic diseases of horses in Osun State, Nigeria: A retrospective evaluation. *Alexandria Journal of Veterinary Sciences*, 56(1):175-181.
- Onyiche, T. E., Igwenagu, E., Malgwi, S. A., Omeh, I. J., Biu, A. A., & Thekiso, O. (2022). Hematology and biochemical values in equines naturally infected with *Theileria equi* in Nigeria. *Tropical animal health and production*, 54(2), 103.
- Payne, E., DeAraugo, J., Bennett, P., & McGreevy, P. (2016). Exploring the existence and potential underpinnings of dog–human and horse–human attachment bonds. *Behavioural processes*, 125, 114-121.
- Radostits, O.M., Blood, O.C. and Gay, C.C. (1994). *Veterinary Medicine*, 8th Edition, Bailliere Tindall, Pp. 1212-1224.
- Reilly, G.A.C. (1993). Two fatal cases of diarrhea in horses associated with larvae of the small *Strongyles*. *Veterinary Record*, 132: 267-268.
- Saeed, K, Qadir, Z., Ashral K and Ahmed, N. (2010). Role of intrinsic and extrinsic epidemiological factors on strongylosis in horses. *The Journal of Animal and Plant Sciences*, 20(4): 277-280.
- Salaheldin, E.A., Wahbi, A.G.A. and Idris, O.F. (1979a). A note on the haematology of adult Sudanese dromedaries. *The Camelid, an all purpose animal*. Pp: 444-8.
- Schalm, O.W., Jain, N.C. and Carroll, E.J. (1975). *Veterinary Haematology*, 3<sup>rd</sup> Edition, Lea and Febiger, Philadelphia. pp.807.
- Shawaf, T., Hussien, J., Al-Zoubi, M., Hamaash, H., & Al-Busadah, K. (2018). Impact of season, age and gender on some clinical, haematological and serum



- parameters in Shetland ponies in east province, Saudi Arabia. *International Journal of Veterinary Science and Medicine*, 6(1), 61-64.
- Stockham, S. L. and Scott, M. A. (2008). *Fundamentals of Veterinary Clinical Pathology*. 2<sup>nd</sup> Edition, Blackwell Publishing Iowa, USA. Pp. 908.
- Takele, B. and Nibret, E. (2013). Prevalence of gastrointestinal helminthes of donkeys and mules in and around Bahir Dar, Ethiopia. *Ethiopian Veterinary Journal*, 17(1): 13-30
- Thrusfield, M. (2005). *Veterinary Epidemiology*, Blackwell Publishing Oxford, UK. Pp. 483.
- Tibbo, M., Jibril, Y., Woldemeskel, M., Dawo F., Aragaw, K. and Rege, J.E. (2008<sup>a</sup>). Serum enzymes levels and influencing factors in indigenous Ethiopian goat breeds. *Tropical Animal Health and Production*, 40:657-666.
- Tibbo, M., Woldemeskel, M., Aragaw, K. and Rege, J.E. (2008<sup>b</sup>). Serum enzymes levels and influencing factors in three indigenous Ethiopian sheep breeds. *Comparative Clinical Pathology*, 17:149-155.
- Tyson, C. A. and Sawhney, D. S. (1985). *Organ Function Tests In Toxicology*. Park Ridge, N.J., USA: Noyes publication Pp. 237
- Wosu, L.O. (2002). *The Veterinarian's Handbook*. First edition, Mike Social Press, Nsukka, Nigeria. Pp 268.
- Zakari, F.O., Ayo, J.O., Rekwot, P.I., and Kawu, M.U., (2016). Effect of age, sex, physical activity and meteorological factors on haematological parameters of donkeys (*Equus asinus*). *Comparative Clinical Pathology*, 25(6):1265-1272.
- Zongping, L., Qinbing, Z. and Li, H. (1995). Serum biochemical values and mineral counts of tissues in Yaks. *Veterinary Research Communications*, 19: 473-473.