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THE HAEMATOLOGICAL PARAMETERS OF APPARENTLY HEALTHY WEST AFRICAN DWARF (WAD) GOATS ON FREE RANGE IN UMUAHIA, SOUTH EASTERN NIGERIA

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Abstract

The effects of age and gender (sex) on the haematological parameters of 140 apparently healthy WAD goats consisting of 70 adults (35 Does and 35 Bucks) and 70 young ones (35 Doe-kids and 35 Buck-kids) were studied. The goats were selected from a flock of goat at Olokoro in Umuahia and assigned into four groups I, II, III, IV in a completely randomized design (CRD) experiment of thirty five (35) animals each according to their ages and sexes. Groups I, II, III and IV represent the Doe-kid, Buck-kid, Doe and Buck respectively. The study lasted for 90 days and animals had no visible signs of ectoparasities. The haemoglobin concentration (Hb) was significantly ($P<0.05$) lower in Doe-kid (8.46±1.32 g/dl) when compared to Buck-kid (9.18±0.51g/dl), Doe (10.1±0.35g/dl) and Buck (12.26±0.11g/dl). The packed cell volume (PCV) was significantly ($P<0.05$) lower in Buck-kid (18.48±0.12%) when compared to Doe-kid (19.68±0.65%) but showed no significant ($P>0.05$) difference when compared to the Doe and Buck respectively. The lymphocyte count was significantly ($P<0.05$) lower in Buck (6.90±0.22 10^3/µl) when compared to Buck-kid (5.07±0.60 10^3/µl) and Doe-kid (5.40±0.40 10^3/µl) but showed no significant ($P>0.05$) difference when compared to Doe (7.31± 0.75 10^3/µl). The neutrophil count was significantly ($P<0.05$) lower in Doe (2.97 ±0.30 10^3/µl) when compared to Buck-kid (4.53±0.42 10^3/µl) and Doe-kid (4.39±0.4210^3/µl) but showed no significant ($P>0.05$) difference when compared to Buck (3.94 ±0.51 10^3/µl). The monocyte count was significantly ($P<0.05$) higher in Doe-kid when compared to Buck but showed no significant ($P>0.05$) difference when compared to Buck-kid and Doe respectively. The mean corpuscular haemoglobin (MCH) was significantly ($p<0.05$) lower in Doe-kid when compared to Doe and Buck but showed no significant ($p>0.05$) difference when compared to Buck-kid. The mean corpuscular haemoglobin concentration (MCHC) was significantly ($p<0.05$) higher in Buck (32.32±1.20g/dl) when compared to Doe-kid (28.46±1.34g/dl) but showed no significant ($p<0.05$) difference when compared to Buck-kid (29.12±0.77g/dl) and Doe (31.14±0.68g/dl). There were however no significant ($p>0.05$) differences in the mean red blood cell (RBC) count, white blood cell (WBC) count, eosinophil count, basophil count and mean corpuscular volume (MCV) among all the groups. It was concluded that age and sex of WAD goat have significant influences on their haematological values such as Hb, PCV, lymphocyte count, neutrophil count, monocyte count, MCH and MCHC but have no effects on their RBC count, WBC count, eosinophil count, basophil count and MCV.

Keywords: Age, Apparently Healthy, Gender, Haematology, WAD goat

Introduction

Small ruminants such as sheep and goats play an important role in the livestock subsector of Nigeria Agricultural Economy (Lakpini, 2002). They have contributed immensely towards the growth and development of the economy and provision of domestic meat for the teaming population. Sheep and goats also play an important role in the livelihood resources of farmers as they provide a vast range of products and services such as meat, milk, hides and skin, horns, mane, bones, (bone meal), manure, gifts, religious rituals, payment of dowry and medicine (Anyanwu, 1998; Sertse and Wossene, 2007).

The West African Dwarf (WAD) goat is the dominant breed of all ruminants and makes

up 38% of about three million goats found in the West African humid Zone (Gall, 1996). West African Dwarf goats are capable of breeding at 6 (six) months (Devendra and Burns, 1970). Multiple births are very common with twinning being normal and triplets frequent. These goats are typically kept as livestock by families who use or sell the milk and meat (Wilson, 1991). WAD goats are important in the rural village economy of West Africa. Nigeria WAD goats are trypanotolerant and haemonchotolerant (Chiejina *et al.*, 2015).

The significance of determining haematological indices of domestic animals has been well documented (Oduye and Adadevoh, 1976; Oduye and Otesile, 1977; Obi and Anosa, 1980) and changes of these parameters have been studied in cattle (Ghergariu *et al.*, 1984), Sheep (Kaushish and Arora, 1977; Vihan and Rai, 1987) and Red sokoto goats (Tambuwal *et al.*, 2002). Haematological profiles provide reliable information on the health status of animals (Kral and Suchy, 2000; Cetin *et al.*, 2009). They also reflect the responsiveness of an animal to its internal and external environments (Esonu *et al.*, 2001). Haematological tests have been widely used for the diagnosis of various diseases (Tibbo *et al.*, 2004, Cetin *et al.*, 2009). The information obtained from blood parameters substantiates physical examinations and coupled with medical history, provides excellent basis before onset of surgical exercise and for selection of appropriate treatment regimen, for instance haematocrit or packed cell volume (PCV), haemoglobin (Hb), total protein (TP) leucocyte counts and whole blood coagulation time are important indices of animal health and production. Also packed cell volume (PCV) is a reliable indicator of the value of haemoglobin and circulating erythrocytes (RBC) (Oladele *et al.*, 2005).

Afolabi (2010) reported that the haematological values of farm animals are influenced by age, sex, breed, climate, geographical location, season, day length, time of the day, nutritional status, life habits of species, health status of individual animal (example if the animal is currently healthy or ill) among other factors.

There is dearth of information on the haematological profile of WAD goats kept in this eco-zone, therefore, the objective of this study was to establish the haematological profile of WAD goats reared under extensive husbandry system in Umuahia and its surroundings and determine how age and gender (sex) affect them.

Materials and Methods

Experimental Location

The WAD goats used in this study were obtained from Olokoro in Umuahia, Abia State, South Eastern Nigeria. Abia State is located on the Latitude 4-6ºN, Longitude 7.8ºE and altitude of 244-305m (highest point) above sea level. Mean annual rainfall is 187.7mm. The experiment was conducted during the raining season. The animals were left with their owners and were on free range during the day while shelter was provided to them after grazing at night. One hundred and forty (140) goats were maintained on the

same ratio throughout the period of the study and they were fed on fresh supplies of *Panicum maximum* (PM), *Centrosema pubescens* (CP) and their combinations (PM + CP) together with other grass and legume forages. Clean water was given to the animals *ad libitum*.

Age of the animals used in this study

One hundred and forty (140) apparently healthy WAD goats aged 4-6 months old for Doe-kids and Buck-kids and 1 year old for Bucks and Does respectively were used for this study. The age of the animals was determined using dentition and farm records respectively.

Data collections

Blood samples were collected from the external Jugular vein after proper restraint and local disinfection using methylated spirit, of one hundred and forty (140) apparently healthy WAD goats of different ages and sexes consisting of seventy (70) adults (35 bucks, 35 does) and seventy (70) young ones (35 Buck-kids and 35 Doe-kids) from randomly selected herds using disposable needle and syringes. Sampling was done between 8.00 hours and 10.00 hours for each day of sample collection. Three milliliters (3mls) of blood was collected from each of the WAD goats and stored in clean grease free plastic sample bottles containing ethylene diamine tetra-acetic acid (EDTA) and used immediately for haematological analysis.

Haematology:

The Red Blood Cell (RBC) and White Blood cell (WBC) counts were determined using the haemocytometer method (Schalm *et al.*, 1975). The packed cell volume (PCV) was determined using the microhaematocrit method (Coles, 1986) while Haemoglobin concentration was evaluated using the Cyanomethaemoglobin method (Brar *et al.*, 2000). The differential white blood cell (DWBC) counts were determined using the Leishman Staining Technique (Schalm *et al.*, 1975). Erythrocytic indices including mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and the mean corpuscular haemoglobin concentration (MCHC) were obtained by calculation.

Statistical analysis

The data collected for each of the haematological parameters were subjected to One Way Analysis of Variance (ANOVA) using SPSS statistical package (version 20.0). Variations in means were separated using Duncan's New Multiple Range Test (Steel and Torrie, 1980). Probability values < 0.05 were considered significant.

Results

The haemoglobin concentration (Hb) was significantly (P<0.05) lower in Doe-kid (8.46±1.32 g/dl) when compared to Buck-kid (9.18±0.51g/dl), Doe (10.1±0.35g/dl) and Buck (12.26±0.11g/dl). The packed cell volume (PCV) was significantly (P<0.05) lower in Buck-kid (18.48±0.12%) when compared to Doe-kid (19.68±0.65%) but showed no significant (P>0.05) difference when compared to the Doe and Buck respectively. The lymphocyte count was significantly (P<0.05) lower in Buck (6.90±0.22 10^3/µl) when compared to Buck-kid (5.07±0.60 10^3/µl) and Doe-kid (5.40±0.40 10^3/µl) but showed no significant (P>0.05) difference when compared to Doe (7.31± 0.75 10^3/µl). The neutrophil count was significantly (P<0.05) lower in Doe (2.97 ±0.30 10^3/µl) when compared to Buck-kid (4.53±0.42 10^3/µl) and Doe-kid (4.39±0.4210^3/µl) but showed no significant (P>0.05) difference when compared to Buck (3.94 ±0.51 10^3/µl). The monocyte count was significantly (P<0.05) higher in Doe-kid when compared to Buck but showed no significant (P>0.05) difference when compared to Buck-kid and Doe respectively. The mean corpuscular haemoglobin (MCH) was significantly (p<0.05) lower in Doe-kid when compared to Doe and Buck but showed no significant (p>0.05) difference when compared to Buck-kid. The mean corpuscular haemoglobin concentration (MCHC) was significantly (p<0.05) higher in Buck (32.32±1.20g/dl) when compared to Doe-kid (28.46±1.34g/dl) but showed no significant (p<0.05) difference when compared to Buck-kid (29.12±0.77g/dl) and Doe (31.14±0.68g/dl). There were however no significant (p>0.05) differences in the mean red blood cell (RBC) count, white blood cell (WBC) count, eosinophil count, basophil count and mean corpuscular volume (MCV) among all the groups.

Table 1 Haematological values of West African Dwarf goats according to Sex and age groups

Parameters	**Animals**			
Parameters	Doe-kid	Buck-kid	Doe	Buck
RBC (10^6/µl)	11.37±0.64	10.59±0.36	11.80±0.25	11.87±0.25
Hb (g/dl)	8.46±1.32^b	9.18±0.51^b	10.1±0.35^b	12.26±0.11^a
PCV (%)	19.68±0.65^b	18.48±0.12^a	20.56±0.04^a	20.14±0.07^a
WBC (10^3/µl)	8.88±1.04	7.21±0.60	7.06±0.51	8.46±0.39

^{ab}Mean values in the same row with different superscripts are significantly different (P<0.05)

Table 2 Differential Leucocyte Counts of West African Dwarf goats according to Sex and age groups

Parameters	**Animals**			
Parameters	Doe-kid	Buck-kid	Doe	Buck
Lymphocyte (10^3/ µl)	5.40±0.40^c	5.07±0.60^{bc}	7.31±0.75^{ab}	6.90±0.22^a
Neutrophil (10^3/µl)	4.39±0.42^b	4.53±0.42^b	2.97±0.30^a	3.94±0.51^a
Eosinophil (10^3/µ)	1.24±0.20	1.27±0.16	1.02±0.01	1.16±0.13
Monocyte (10^3/µ)	0.03±0.01^b	0.01±0.00^{ab}	0.01±0.00^{ab}	0.03±0.00^a
Basophil (10^3/µ)	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00

^{abc}Mean values in the same row with different superscripts are significantly different (P<0.05)

Table 3. Shows the Erythrocytic Indices of West African Dwarf goats according to Sex and age groups

Parameters		**Animals**		
Parameters	Doe-kid	Buck-kid	Doe	Buck
MCV(fl)	18.68±1.99	18.91±0.26	29.58±7.93	23.52±0.39
MCH(pg)	5.48±1.19[b]	5.74±0.85[b]	9.64±0.22[a]	7.72±0.19[a]
MCHC(g/dl)	28.46±1.34[b]	29.12±0.77[ab]	31.14±0.68[ab]	32.32±1.20[a]

[ab]Mean values in the same row with different superscripts are significantly different (P<0.05)

DISCUSSION

The PCV in this study was significantly (P<0.05) higher in adult WAD goats than the young WAD goats. Similarly, PCV was significantly (p<0.05) higher in female WAD goats than in male WAD goats. The rise in PCV in females in comparison with males is often attributed to the effect of androgens, which stimulate erythropoiesis and, thus, cause increase in the number of circulating RBCs and PCV (Villiers and Dunn, 1998). Higher PCV values were observed in old than young goats (Addass *et al.,* 2010) and this agrees with the result of this study. Jabbar *et al.* (2012) concluded that higher erythrocyte count was responsible for increased PCV value in old WAD goat as compared to young WAD goats apparently due to high basal metabolic rate, leading to increased rate of erythropoiesis and hence increase in erythrocyte count. The PCV obtained in this study was lower than 25.7±3.1% obtained for red Sokoto goats (Tambuwal *et al.,* 2002) and 27.25±0.59% obtained for Baladi goats (Azab and Abdal-Mak-sound, 1999). In Red Sokoto goats, the males have been shown to have a higher PCV values than the females (Tambuwal *et al.,* 2002; Okonkwo, 2011) and this is in total disagreement with the findings of this work where the reverse is the case. The haemoglobin (Hb) concentration was within the ranges of values obtained for Red Sokoto goats in Nigeria (Tambuwal *et al.,* 2002). The Hb was higher in adult WAD goats than the young WAD goats as well as higher in males than in female WAD goats. This indicates that the oxygen carrying capacity of the blood was higher in adults than the young WAD goats. It was also higher in male WAD goats than in female WAD goats. Similar higher Hb concentration was reported in the male than female (Chineke *et al.,* 2006) and this agrees with the result of this study. In goats like in other ruminants, there are more lymphocytes than neutrophils in circulation (Olusanya *et al.,* 1976). However the values observed in this study were within the broad range recorded for WAD goats (Okpara *et al.,* 2010) and red sokoto goats (Tambuwal *et al.,* 2002) thus suggestive of a well developed immune system in the WAD goats with an increased number of immune cells.

Sex evidently influenced lymphocyte and neutrophil counts in WAD goats in this study, where female WAD goats had increased lymphocytes values compared to their male counterparts which are in contrast to the findings by Onasanya *et al.* (2015) where the reverse was the case. Adult WAD goats had significantly higher values than the young WAD goats showing age influence on lymphocyte counts. The age difference in number of lymphocytes may be as a result of

well developed immune response in adult WAD goats compared to the young ones with developing or lower immune responses. Higher lymphocyte values observed in this study might be also attributed to stress and immune response to the environmental stressors (Coles, 1986) as a result of harbouring various detectable and undetectable parasitic, bacterial or fungal organisms. There was also an observable age influence on the neutrophil values with the younger WAD goats having higher values than the older ones. This may be because of age related decline in either the neutrophil supply and or functional deficiency in adults. The values of MCH and MCHC were significantly ($p<0.05$) increased in adult WAD goats when compared with the young WAD goats. These values are of optimum use in diagnosing anaemia and also serve as a useful index of estimating the capacity of the bone marrow to produce red blood cells (Awodi *et al.*, 2005). Sex also evidently influenced MCH and MCHC in WAD goats in this study, where male WAD goats had increased MCH and MCHC values compared to their female counterparts. The increased MCH and MCHC values in male WAD goat compared to the female WAD goats agrees with the report of Egbe Nwiyi *et al.* (2000).

Conclusion:

It can be concluded from this study that the majority of the haematological parameters for WAD goats studied fall within the normal range for the species. The few differences observed may be as a result of nutritional and environmental effects. There was a remarkable age and sex influence on the haematology of investigated animals in this study. The findings of this study will serve as reference values for WAD goats in Umuahia South East Nigeria.

References

Addass, P.A.; Midau, A. and Babale, D.M. (2010). Haemato-biochemical findings of Indigenenous goats in Mubi, Adamawa State, Nigeria. Journal of Agriculture and Social Sciences. 6(1): 14 – 16.

Afolabi, K. D.; Akinsoyinu, A. O.; Oladije, R. and Akinleye, S. B (2010). Haematological Parameters of the Nigerian local grower chickens fed varying dietary levels of palm kernel cake. Proceedings of 35th Annual Conference of Nigerian Society for Animal Production, Ibadan, 14-17 March 2010, pp. 247.

Anyanwu, W. (1998). Agricultural Science for West African Colleges. Ibadan University Press, Nigeria, Pages: 224.

Awodi, S; Ayo, J.O; Atodo, A. D and Dzende, T. (2005). Some haematological parameters and the Erythocyte Osmotic fragility in the laughing Dove (Streptopella Senegalensis) and the village weaver bird (Ploceus scucullatus). In: Chineke, C. A.

Azab, M. E and Abdal-Maksoud, H. A. (1999). Changes in Some haematological and biochemical parameters during pre-partum and post partum periods in female Baladi goats. Small Ruminant Research, 34, 77-85.

Brar, R. S.; Sandhu, H. S. and Singh, A. (2000). Veterinary clinical diagnosis by laboratory methods. New Delhi: Kalyani Publishers, pp. 50.

Cetin, N.; Bekyurek, T. and Cetin, E. (2009). Effect of sex, pregnancy and season on some haematological and biochemical blood values in Angora rabbits. Scandinavian Journal of Laboratory Animal Science, 36(2):155-162.

Chiejina, S. N.; Behnke, J. M. and Fakae, B. B. (2015). "Haemonchotolerance in West African Dwarf goats: Contribution to sustainable, anthelmintics-free helminth control in traditionally managed Nigerian dwarf goats". Parasite. 22:7. Doi:10.1051/parasite/2015006.ISSN 1776-1042.

Chineke, C.A.; Ologun, A.G. and Ikeobi, C.O.N. (2006). Haematological parameters in rabbit breeds and crosses in humid tropics. Pakistan Journal of Biological Science. 9 (11): 2102 – 2106.

Coles, E. H. (1986). *Veterinary Clinical Pathology*. 4thedn., W.B Saunders Co., Philadelphia.

Devendra, C. and Burns, M. (1970). Goat production in the tropics. Common Wealth Agricultural Bureaux, Famham Royal Bucks. England.

Egbe-Nwiyi. T. N.; Nwaosu, S. C. and Salami, H. A. (2000). Haematologic Values of Apparently Healthy Sheep and Goats as Influenced by Age and Sex in Arid Zone of Nigeria. *African journal of Biomedical Research*, 3(2): 109-115.

Esonu, B.O.; Emenalom, O.O.; Udedebie, A. B. I.; Herbert, U.; Ekpor, C. F.; Okolie I.C. and Iheukwumere, F. C. (2001). Performance and Blood Chemistry of Weaner Pigs Fed Raw *Mucuna* (Velvet Bean). *Tropical Animal Production Investigations*, 4, 49-54.

Gall, C. (1996). Goat breeds of the world. CTA-Margraf, Weikersheim, Germany. Pp186.

Ghergariu, S.; Rowlands, G.J.; Popand, N. and Moldova, A. (1984). A comparative study of metabolic profiles obtained in dairy herds in Romania. British Veterinary Journal, 140: 600-608.

Jabbar, L.; Cheena, A. and Riffat, S. (2012). Effect of different dietary energy levels, season and age on haematological indices and serum electrolytes in growing buffalo heifers. Journal of Animal and Plant Science, 22(3 Suppl), 279-283.

Kachmar, J.F. (1970). Determination of blood heamoglobin by the cyanomethaemoglobin procedure. In: Tietz NW Ed, Fundamentals of Clinical Chemistry, W. B. Sanders Company, Philadelphia, Pages 268-269.

Kaushish, S.K. and Arora, K.L. (1977). Studies on reproduction in sheep: Blood and plasma contents before and

after parturition in Nali sheep. Haryna Veterinarian, 16(2): 74-77.

Kral, L. and Suchy, P. (2000). Haematological studies in adolescent breeding cocks. Acta. Veterinaria Brno, 69(3):189-194.

Lakpini, C.A.M. (2002). Feed and feeding strategies for small ruminants in various physiological states in: Lakpini, C. A. M., Adamu, A. M., Ehoche, O. W. and Gefu, J. O (eds). Manual for small Ruminants production in Nigeria. Workshop at National Animal Production Research Institute Ahmadu Bello University, Shika, Nigeria. 13th– 18th January, Pp 40 -48.

Obi, T. U. and Anosa, V. O. (1980). Haematological Studies of Domestic animals in Nigeria IV: Clinico-haematological features of Bovine Trypanosomiasis, Theileriosis, Anamplasmosis, Eperythrozoonosis and Helminthiasis. Zentra /b/ Veterinaries. 27:789-797.

Oduye, O. O and Adadevoh, B. K. (1976). Biochemical values of apparently Normal Nigerian Sheep. Nigerian Veterinary Journal, 5(1): 43-50.

Oduye, O. O and Otesile, E. B. (1977). Studies on the Canine Anaemia in Ibadan. Journal of Small Animal Practice, 18: 429-443.

Okonkwo, J.C.; Omeje, J.S. and Okonkwo, I.F. (2011). Effect of source and sex on blood protein fractions of West African dwarf goats (WADG). Research Opinions in Animal and Veterinary Sciences, 1(3): 158-161.

Okpara, M. N.; Udevi, N. and Okoli, J. C. (2010). Haematological parameters and Blood Chemistry of Apparently Healthy West African Dwarf (WAD) Goats in Owerri, South Eastern Nigeria. New York Science Journal, 3(8): 68-72.

Oladele, S.B.; Ayo, J.O.; Ogundipe, S.O. and Esievo, K.A.N. (2005). Seasonal and sex variations in packed cell volume, haemoglobin and total protein of the guinea fowl (*Numida meleagris)* in Zaria, Northern Guinea Savannah Zone of Nigeria. Journal of Tropical Biosciences, 5(2): 67-71.

Olusanya, S. K.; Edewor E. E. and Health, E. (1976). Studies on the Blood Chemistry and other Haematological Parameters in Buffaloes in a Ranch in Nigeria. Nigerian Veterinary Journal, 5(1): 27–31.

Onasanya, G. O.; Oke, F. O.; Sanni, T. M. and Muhammad, A. I. (2015). Parameters Influencing Haematological, Serum and Bio-chemical References in Livestock Animals under Different Management Systems. Open Journal of Veterinary Medicine, 5: 181-189. http://dx.doi.org/10.4236/Ojvm.2015.58025.

Schalm, O. W.; Jain, N. C. and Carroll, E. J. (1975). Veterinary haematology (3rd ed., P. 15-218). USA: Lea and Fabiger, Philadelphia.

Sertse, T. and Wossene, A. (2007). Effect of ectoparasites on quality of pickled skins and their impact on the tanning industry in Amhara regional state, Ethiopia. Small Ruminant Research, 69(1): 55-61.

Steel, R. G. D. and Torrie, J. H. (1980). Principles and procedures of

statistics, Second Edition, New York: McGraw-Hill Book Co.

Tambuwal, F. M.; Agaie, B. M. and Bangana, A. (2002). Haematological and Biochemical values of apparently healthy Red Sokoto goats. Proceeding of 27th Annual Conference Nigeria Society of Animal Production (NSAP), March, 17-21, 2002, FUTA. Akure, Nigeria. Pp. 50-53.

Tibbo, M.; Jibril, T.; Woldemeskel M.; Dawo, F.; Aragaw, K. and Rege J. E. O. (2004). Factors affecting haematological profiles in three Ethiopian indigenous goat breeds. International Journal of Applied Research in Veterinary Medicine, 2(4): 297 – 309.

Vihan, V. S. and Rai, P. (1987). Certain haematological and biochemical attributes during pregnancy, parturition and post-parturition periods in Sheep and goats. Indian Journal of Animal Science, 57(11): 1200-1204.

Villiers, E. and Dunn, J.K. (1998). Basic haematology. In: Davidson, M., Else, R. and Lumsden, J. (Editors). Manual of Small Animal Clinical Pathology, Shurdngton, Cheltenham, United Kingdom. pp. 33-60.

Wilson, R. T. (1991). Small Ruminant production and the Small Ruminant Genetic Resource in Tropical Africa. Food and Agricultural Organization. Pp. 106-114. ISBN 978-92-5102998-5.